REGIONAL BACKGROUND REPORT

A Review of

Confined Aquatic Facilities

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Executive Summary

Sediment management in harbours and ports worldwide can be problematic due to the cost of sediment remediation and/or the cost of upland disposal. In the Pacific and Yukon Region, dredged sediment management options are presently limited to ocean (open water) disposal and upland placement (beneficial reuse and/or landfill). Sediment management options in other jurisdictions include upland placement, sediment remediation, ocean disposal and confined aquatic facilities.

Confined aquatic facilities include confined aquatic disposal (CADs) and confined disposal facilities (CDFs). CADs and associated *in-situ* capping projects, particularly in Canada, the United States of America and Europe are discussed. Although there are no marine CAD projects in Canada, there are several CADs in various stages of development in the United States. Projects in Boston and New York have been successfully completed and are monitored on an ongoing basis. In the Great Lakes, the Canadian and American governments are working cooperatively towards the clean-up of sediments using CDFs and other sediment management options. Examples of CADs and *in-situ* capping can be found in Puget Sound where government agencies are in the initial stages of developing a programmatic selection of ecosystem and cost effective options for managing contaminated sediments.

The feasibility of siting a CAD in Burrard Inlet was investigated in 1992. Due to the environmental regulatory framework governing dredging and disposal options in local waters, the importance of a multi-stakeholder approach is emphasized. Scientific support, funding and public involvement are also important factors governing the successful implementation of a CAD or CDF.

In order to determine the feasibility of siting a regional confined aquatic facility in British Columbia, the following questions need to be addressed:

- What volumes of contaminated sediments exist?
- Where is the contaminated material?
- What progress has been made on source control and treatment options for contaminated sediments?
- What is the projected long term need for contaminated sediment disposal?
- What are the constraints limiting the siting and operation of a confined aquatic facility?

Progress in sediment disposal mechanisms in Canadian and other jurisdictions are reviewed in addition to the environmental regulatory framework in the Pacific and Yukon Region. This report is an update on current sediment management methods for contaminated sediments, however, particular attention is focused on aquatic disposal facilities such as CADs and CDFs. The feasibility of siting a regional aquatic disposal facility on the west coast of British Columbia is also discussed.

Sommaire

Dans le monde entier, la gestion des sédiments dans les havres et les ports peut être problématique en raison du coût de la restauration des sédiments et/ou de la mise en dépôt en milieu terrestre. Dans la Région du Pacifique et du Yukon, les options de gestion des sédiments de dragage sont actuellement limitées à l'immersion en mer (eaux libres) et à la mise en dépôt terrestre (réutilisation bénéfique et/ou enfouissement). Dans d'autres régions, les options comprennent notamment la mise en dépôt terrestre, la restauration des sédiments, l'immersion en mer et le confinement aquatique.

On retrouve des installations de confinement aquatique et des installations d'élimination en milieu confiné. Le présent rapport discute du confinement aquatique et des projets de recouvrement *in situ* associés, particulièrement au Canada, aux États-Unis et en Europe. Il n'existe pas de projets de confinement aquatique en milieu marin au Canada, mais il y en a plusieurs aux États-Unis, qui sont à divers stades de développement. Des projets menés avec succès à Boston et à New York sont surveillés sur une base continue. Dans les Grands Lacs, les gouvernements canadien et américain collaborent au nettoyage des sédiments en utilisant des installations d'élimination en milieu confiné. Ils ont aussi recours à d'autres options de gestion des sédiments. Des exemples de confinement aquatique et de recouvrement *in situ* peuvent être observés à Puget Sound, où des organismes gouvernementaux procèdent actuellement à la sélection programmatique d'options écologiques et économiques de gestion des sédiments contaminés.

En 1992, on a étudié la possibilité de construire une installation de confinement aquatique dans le bras de mer Burrard. À cause du cadre de réglementation en matière d'environnement qui régit les options de dragage et d'élimination dans les eaux locales, une approche multilatérale est privilégiée. Le soutien scientifique, le financement et la participation de la population sont aussi des facteurs importants qui garantissent la mise en œuvre fructueuse d'une installation de confinement aquatique ou d'élimination en milieu confiné.

Pour déterminer si la mise sur pied d'une installation de confinement aquatique régionale en Colombie-Britannique est réalisable, il faut répondre aux questions suivantes.

- Quel est le volume de sédiments contaminés?
- Où se trouvent les matériaux contaminés?
- Quels progrès ont été réalisés par rapport aux options de contrôle à la source et de traitement des sédiments contaminés?
- À long terme, quel est le besoin d'élimination des sédiments contaminés?
- Quelles sont les contraintes limitant la construction et l'exploitation d'une installation de confinement aquatique?

L'amélioration des mécanismes d'élimination des sédiments au Canada et ailleurs ainsi que le cadre de réglementation en matière d'environnement dans la Région du Pacifique et du Yukon sont revus. Le présent rapport constitue une mise à jour des méthodes actuelles de gestion des sédiments contaminés. Toutefois, une attention particulière est

accordée aux installations telles que les installations de confinement aquatique et d'élimination en milieu confiné. La faisabilité de la construction d'une installation régionale d'élimination aquatique sur la côte ouest de la Colombie-Britannique est également étudiée.

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1.0 Introduction

The need to dispose dredged sediments arises from the requirements of active harbours and ports to maintain or deepen navigable water depths within harbour limits. Appropriate disposal and use of dredged materials from dredging projects are issues in active ports worldwide. In heavily industrialized areas and those with historical industrial contamination, the disposal of contaminated sediments from both maintenance operations and site remediation projects may be problematic due to the cost of sediment remediation and/or cost of upland disposal. Dredged sediment management options in the Pacific and Yukon Region are presently limited to upland placement (beneficial reuse, and/or landfill) and ocean disposal. Management options that have been studied and applied in other jurisdictions include the use of sediments in remediation or disposal by landfill, ocean disposal, confined aquatic disposal facilities (CADs) and confined disposal facilities (CDFs).

Confined aquatic facilities include both CADs and CDFs. Both of these structures are means of isolating contaminated material and preventing contaminant release to the environment. CADs differ from CDFs in that contaminated sediments are dredged from a site, placed in a natural or constructed depression in the sea bed, followed with a cap of clean sediment. The CAD is an entirely subaqueous "in the sea bed" construction. CADs are similar to level bottom capping, another form of underwater sediment disposal in that both involve dredging contaminated sediments from one area and transporting it to another site. Level bottom capping differs from CADs in that there is no lateral confinement of the contaminated material. Unlike CADs, CDFs are not entirely subaqueous. CDFs may be constructed on upland sites, near shore (intertidal) sites with one or more sides in the water or as island containment areas (Miller, 1998).

In constructing a CAD, site evaluation issues are framed around the selection of an acceptable site for contaminated sediment placement and capping. The site evaluation for CDFs is framed around defining the acceptability of capping at a given site. Both CADs and CDFs serve to isolate exposure of contaminants to benthos by preventing the release of contaminants, preventing the re-suspension and transport of contaminants to other sites and by reducing the flux of dissolved contaminants in the water column.

To date, CADs have not been employed on the west coast of Canada but they have been used successfully in other jurisdictions such as Puget Sound in Washington State and the Great Lakes in Central Canada and the United States. CDFs are currently in use on the west coast of Canada, and the Great Lakes in both Canada and the United States, as an effective means of contaminated sediment disposal.

In all cases, the management options outlined above require closer examination to determine the most environmentally sound and economically defensible rational for sediment management.

This report is an update to a study conducted in 1992 for the Burrard Inlet Environmental Action Program (BIEAP) by Sandwell Inc. and Castor Consultants Ltd. which examined dredged material management options for Burrard Inlet (BIEAP 1992a and 1992b). This project was undertaken as part of the Ocean Disposal Control Program activities to determine actions and modes of sediment disposal and sediment management options currently in use in other jurisdictions. The regulatory framework governing the disposal of sediments on the west coast of British Columbia is also reviewed.

2.0 Review of Current Knowledge

The 1992 BIEAP study identified CADs as a possible management option for dredged sediments in Burrard Inlet. At that time CADs, were being implemented as a disposal mechanism in other jurisdictions. Recommendations from the BIEAP reports included:

- the implementation of a process to pursue the use of CADs by having an entity review the treatment of dredged material under the *Canadian Environmental Protection Act* (CEPA), Part 7 and;
- a review of the current approach to sediment quality criteria and guidelines be done in order to advance the feasibility of establishing a pilot CAD project.

Locally, work in this area has not progressed since 1992 when the BIEAP study was conducted but CADs in both freshwater and marine environments have been used successfully in other jurisdictions. This literature review focuses mainly on work done in Puget Sound, Washington but also includes available Canadian information. This report documents and updates the current background information on the application and use of CADs and CDFs and will assist in re-evaluating the need for a confined aquatic facility on the west coast of British Columbia.

2.1 Canada

2.1.1 West Coast

Two examples of contaminated sediment disposal on the west coast of British Columbia are located on Vancouver Island in Esquimalt Harbour and Crofton. The Esquimalt Harbour site was developed by the Department of National Defense while the site in Crofton was developed by Fisheries and Oceans Canada. Both are examples of CDFs. In each case, a near shore intertidal area was dyked, filled with the contaminated sediments and then capped.

2.2. North America Transboundary

2.2.1 Great Lakes

CAD and CDF projects in eastern Canada have been focused primarily in the Great Lakes Region. Extensive work by the Americans have also focused on the Great Lakes and some transboundary projects involving both Canadian and American authorities have also been conducted in the Great Lakes Region. As such, Canadian and American CAD and CDF projects are discussed together in this section.

The Great Lakes have been a focus of attention for CAD and CDF projects over the last decade in both Canada and the United States. Both the Canadian and American governments are working co-operatively towards the clean-up of sediments, using confined aquatic facilities and other sediment management options. Throughout the Great Lakes basin, local communities have been working to restore and protect environmental quality. Local involvement by community groups has been credited as being an integral part to the success of the remediation efforts in the Great Lakes basin (Mason, 1998). In Ontario, concerns in the Hamilton Harbour area resulted in the development of a capping demonstration project in the mid-1990s. A one hectare test site in Hamilton Harbour contaminated with trace metals and organic contaminants was capped with three layers of sand to produce a total cap thickness of approximately 35 cm. The monitoring results of the Hamilton Harbour *in-situ* capping project indicate that there has been a significant reduction of vertical fluxes of all trace elements, however, the concentration of some trace metals were also found to be elevated in the surficial sediments which originated from the recent deposition of fine-grained sediments on the sediment cap (Azcue *et al.*, 1998).

The use of a CDF was applied to a project in Collingwood Harbour in Ontario. From 1992 to 1993, approximately 8 000 m^3 of contaminated sediments were removed. The project was completed in two phases. The first phase involved the removal of approximately 5 000 m^3 of contaminated sediments in November 1992 and approximately 3 000 m^3 of harbour sediments were removed in the second phase of the project in November 1993. Sediments from both phases were removed using an airlift pumping system and transported through a pipeline to a CDF 1.2 km away. Approximately $650 000 was spend on this project with funding provided by the Ontario Ministry of Environment and Energy, Canada Steamship Lines, Transport Canada, and the Town of Collingwood (IJC, 1997).

In the United States, the US Environmental Protection Agency's (EPA) Region V identified the clean-up of contaminated sediment in the Great Lakes as one of its top six priorities in its 1997 fiscal year "Agenda for Action" and as one of its top five priorities in its 1998 and 1999 fiscal year "Agenda for Action".

There are a number of reports dealing with *in-situ* capping and confined aquatic disposal facilities in the Great Lakes. Although *in-situ* capping is not the same as a CAD facility, some of its' functions are similar to those of a CAD and it is considered a potentially economical and effective means of isolating contaminated sediments. Palermo *et al.* (1998a) provide a detailed description and technical guidance for subaqueous, *in-situ* capping of contaminated sediments and identifies a number of sites, worldwide that have been remediated by *in-situ* capping. Several primary functions are served by *in-situ* caps, specifically:

- to physically isolate contaminated sediment from the marine benthic environment,
- to stabilize contaminated sediments by preventing the resuspension and transport of contaminated sediments to other sites; and
- to reduce the flux of dissolved contaminants into the water column.

Capping materials are constructed from clean sediments, sand, gravel, or they may involved more complex designs with geotextile liners and multiple layers. It is also noted that *in-situ* capping projects must be treated as an engineered project with careful consideration of design, construction and monitoring. Palmero *et al.* (1998b) lists general steps for *in-situ* cap design. These include:

- identifying candidate capping materials and the compatibility of these materials with the site;
- assessing the bioturbation potential of indigenous benthos and designing a cap component capable of physically isolating sediment contaminants from the benthic environment;
- evaluating potential cap erosion at the site and designing a cap component which can reduce the flux of dissolved contaminants into the water column;
- evaluating potential interactions and compatibility among cap components, including the consolidation of compressible materials;
- evaluating operational considerations and determining restrictions or additional protective measures needed to assure cap integrity.

Aspects of the Great Lakes sediment management experience appear to be applicable to potential plans for CADs and CDFs on the west coast of Canada. In the Great Lakes, it was recognized that much more effort should be placed on forecasting and assessing ecological recovery and restoration of beneficial water and sediment uses. As a result, it was recommended that greater emphasis be placed on post-project monitoring to determine the effectiveness of sediment remediation efforts. One way of achieving this would be for the responsible State/Provincial/Federal regulatory agencies to incorporate commitments and resources into settlements and co-operative agreements dedicated specifically for post project monitoring to assess the effectiveness of remediation efforts relative to the restoration of impaired water uses. This emphasizes the need to develop co-operative partnerships between stakeholders and regulatory agencies. Good examples of this include the Welland River project (Ontario), the settlement under the Natural Resource Damage Assessment for Saginaw River and Bay (Michigan), and the Thunder Bay cleanup project in Ontario (Palermo *et al.*, 1998b).

The American regulatory history of sediment disposal and current dredged material management alternatives, (including CAD and level bottom capping) and the current status of CDFs in the Great Lakes was reviewed in a draft report by Miller (1998). CDFs were identified as the most commonly used management practice for the disposal of contaminated sediments dredged for navigation and environmental remediation. The report also indicates that technical guidance on confined disposal is available from the

Corps, as are modeling programs to support CDF design and operation. Treatment technologies are discussed, acknowledging the varying advancements in treatment for different contaminants and the inability to address all contaminants often found in sediments. The report also notes that costs can be prohibitive. In terms of CDFs, the Corps has built 44 upland or near shore CDFs on the Great Lakes since the late 1960's. The program recognizes that in the last 30 years, improvements in waste water discharge quality has helped reduce sediment contamination in "new" sediments in shipping channels suggesting a reduced need for CDFs. The report also indicates that current contaminated sediment disposal options have been essentially reduced to multi-user facilities because of the financial and political advantages of forming partnerships with the Corps and other interested parties. This is in part driven by the high costs of environmental regulatory requirements in developing a CDF; however, the CDF program has provided an environmentally responsible alternative to unconfined, open water disposal (Miller, 1998).

The experience gained by the Americans in the Great Lakes has shown that achieving successful remediation at any site is dependent on the development of a strong and committed partnership of stakeholders. Stakeholders involved in the process must be able to pool their resources and expertise in addition to cooperating to overcome their differences (Palermo *et al.,* 1998b).

In an effort to address transboundary sediment management issues in the Great Lakes, the International Joint Commission (IJC) established the Sediment Priority Action Committee (SedPAC) in 1997 to examine Canadian and American progress in managing contaminated sediments and to identify obstacles to sediment remediation (IJC, 1997). The conclusions were that progress in sediment remediation were slow for several reasons. These ranged from the inability to:

- define the extent of the problem or the source of the problem;
- develop a strategy to address the problem;
- define the clean up standard; and/or acquire funding or partners to accomplish the clean up.

Technologies utilized for sediment remediation are often modifications of existing technologies in other aquatic and terrestrial environments (e.g. soil treatment technologies). Modifications to those techniques, along with increased application costs and insufficient verification of effectiveness were found to delay the application of these techniques to other locations.

Based on the SedPAC evaluation, several high priority options were identified. To assist in the development of a broad based understanding of sediment management issues, major obstacles to sediment remediation were identified and grouped into the following six categories:

- limited funding and resources;
- regulatory complexity;

- lack of a decision making framework;
- limited corporate involvement;
- insufficient development in research and technology; and
- limited public and local support.

It was recognized that there are linkages among the options listed above and a group of two or three related options done in concert would increase the probability of success or produce higher returns (IJC, 1997). The IJC provides a discussion of the obstacles to sediment remediation, the options available to deal with these obstacles and the probability of successful sediment remedieation using these options.

Overall, the results of the capping projects in the Great Lakes (Palermo *et al.,* 1998b) strongly suggests that there has been minimal long term transport of contaminants into the capping material. This was identified by the diminishing concentration gradients of contaminants from the contaminated sediments to the sediment cap.

2.3 United States of America

In the United States, an interagency approach to managing contaminated dredged material over the past two decades has resulted in the development of a regulatory framework which includes confined disposal and treatment of contaminated dredged material.

A key element in this approach is the development of a Programmatic Environmental Impact Statement (PEIS) for each study. The PEIS provides a broad initial environmental review and cost analyses of major alternatives for the confined disposal and treatment of contaminated dredged sediments from a regional area. Federal, state and local requirements are taken into consideration regarding confined disposal of contaminated sediments and, involve all regulatory agencies mandated to manage dredged sediments. The PEIS is prepared pursuant to the *National Environmental Policy Act* (NEPA) and other relevant state and local legislation by the environmental regulatory agencies. The PEIS is used to facilitate the development of any site-specific confined disposal or treatment environmental impact statement which may follow a project.

2.3.1 Puget Sound

As in all active ports, dredging in Puget Sound is required to maintain port accessibility and associated economic activity. Sediments are dredged from shipping channels, berths and waterfront developments to maintain or deepen navigable water depths and to remove contaminated sediments in habitat restoration and remediation projects. All of these activities result in the need to safely handle and dispose dredged material.

The Puget Sound Dredged Disposal Analysis (PSDDA) program was implemented in 1989. PSDDA established procedures and a testing program to evaluate the suitability of dredged material for unconfined, open-water disposal at designated disposal sites. Some sediments are not suited for unconfined disposal at a PSDDA site due to elevated contaminant levels. If dredged, these sediments require treatment or disposal in a confined setting to eliminate or minimize the risk of contaminant release to the environment. Historically, dredging and disposal of contaminated sediments in Puget Sound has been done on a project-by-project basis, much as is done in Canada. In some cases, contaminated sediments have been transported and disposed in existing landfills. In other cases, dredging proponents such as the ports of Seattle, Tacoma, and Everett have constructed near shore disposal sites capable of isolating contaminated sediments from the environment and creating usable uplands such as marine terminals along the waterfront. The available management options for contaminated sediments must be considered. Where limited disposal options exist, some of the factors which must be considered in contaminated sediment management include:

- the cost of siting and constructing an upland or near shore site,
- the cost of required habitat compensation,
- the time required to secure permits; and
- a general uncertainty associated with these projects.

Due to these factors, several proponents have concluded that the costs of disposing contaminated sediment outweigh the benefits of dredging contaminated material. This has resulted in redesigned, delayed, or abandoned projects. Similarly, the high costs and the anticipated length of time needed to obtain permit approvals discourages voluntary clean-up efforts. Uncertainty surrounding liability of shared potential disposal sites between multiple users has also stalled clean-up efforts. However, there have been a few small scale pilot projects undertaken in Puget Sound during the 1990s utilizing CADs and capping of *in-situ* contaminated sediments for which monitoring data is available.

Existing CAD and *in-situ* capping projects in Puget Sound have employed cap thickness ranging from 1 to 3 feet (Duwamish Waterway demonstration project) and from 2 to 12 feet (Denny Way, Simpson Tacoma Kraft project). The thickness of the cap is a major design criterion in dredged material capping projects. Monitoring at these sites indicate that the caps are effectively controlling contaminant migration (U.S. Army Corps of Engineers, Washington Department of Natural Resources, Washington Department of Ecology (Corps, DNR and DOE), 1999). Based on the monitoring results of the Puget Sound projects, Sumeri (1996) concluded CADs and marine sediment remediation were effective and economical sediment management options for contaminated sediments. The use of *in-situ* caps were shown to avoid risks involved in removing contaminated sediments by dredging.

The environmental and economic concerns and issues of dredging and managing sediments are recognized and shared by local, state, and federal permitting agencies in Puget Sound. The regulatory agencies also recognized the need for a multi-user disposal site for confined disposal of contaminated sediments which resulted in the initiation of the Puget Sound Confined Site Study (Corps, DNR and DOE, undated).

The Puget Sound Confined Disposal Site Study, also known as the MUDS (Multi-User Disposal Sites) project, was initiated in 1997 as a three year, $3.5 million project (Corps, DNR and DOE, undated). It was estimated that 6 to 13 million cubic yards of sediments will need to be dredged in Puget Sound over the next fifteen to twenty years (Corps, DNR and DOE, 1999). The MUDS project was undertaken to find environmentally sound and economically viable options to address regional needs for the disposal and/or treatment of contaminated sediments in Puget Sound.

Building on the initial work conducted in the 1980s and 1990s, the regulatory agencies in Puget Sound have developed detailed guidelines and a PEIS for the Puget Sound Confined Disposal Site Study. As part of the PEIS, the overall goal of the Puget Sound Confined Disposal Site Study was to find environmentally sound and practical solutions to address the lack of adequate confined disposal options for contaminated sediments. Potential solutions included construction of confined MUDS, dewatering of sediments for subsequent disposal in existing landfills, sediment treatment facilities and/or a combination of the three. Environmental impacts and the costs of the various alternatives for addressing the regional contaminated sediment issues were evaluated in the PEIS. These alternatives include the following:

- no action;
- disposal in constructed confined aquatic near shore or upland MUDs;
- disposal in existing solid waste landfills;
- multi-user disposal in large, privately developed confined disposal projects;
- sediment treatment; and/or
- a combination of alternatives.

The report identifies that with no action, contaminated sediments will remain exposed to marine life and continue to impact marine invertebrates and fish populations in Puget Sound. Over the past twenty years, the relationship between sediment contaminants and measurable biological effects to benthic invertebrates, demersal fish and salmonids in the Sound's industrial and urban waterways have been documented in numerous studies. The development of viable, regional disposal options for contaminated sediments would result in the reduction of these effects.

Due to the volume and distribution of contaminated sediments in Puget Sound, it was considered unlikely that the regional demand for contaminated sediment disposal or treatment could be met by a single multi-user facility. In addition to evaluating disposal alternatives, the PEIS identified geographic areas of interest for possible future efforts, outlined a potential siting process and a preliminary set of siting criteria for aquatic, near shore and upland multi-user disposal sites. For each constructed alternative (aquatic offshore, near shore and upland confined disposal), conceptual designs were developed to allow a thorough evaluation of each option. Common, basic assumptions (i.e. capacity of 500,000 cubic yards and 2,000,000 cubic yards and a 10 year operating period) were made while specific assumptions (i.e. design, shape and layout) were made within each alternative in each option.

The resulting alternatives presented in the Puget Sound Confined Disposal Site Study are plausible scenarios for a MUDS in Puget Sound, however, many other realistic design and operational options may not have been considered in the PEIS. When identified, other feasible configurations may be evaluated during site specific efforts.

The Puget Sound Confined Disposal Site Study PEIS addresses impacts common to the alternatives studied in this project. The report notes that the potential environmental consequences associated with dredging sediments for MUDS disposal and/or treatment are the same for each alternative. Potential environmental impacts and control measures associated with dredging contaminated sediments are considered to be site specific; however, they are discussed in general terms in the PEIS and include the need to examine a variety of characteristics. Project specific features such as local hydrodynamics, water depth and sediment characteristics need to be considered when evaluating management options for contaminated sediments. Potential environmental impacts, mitigation and the significance of the impacts associated with dredging contaminated sediments are summarized in the PEIS.

The development of a regional facility in Puget Sound is currently underway, recognizing that multifaceted disposal mechanisms may be utilized in the management of contaminated sediments. It has been recognized that advances in sediment treatment are being made and that some sediments can be treated or remediated. Recent communication with EPA staff suggests that CAD disposal mechanisms might be considered as a temporary storage facility until treatment options that can effectively deal with contaminated sediments are developed (Malek, J., *pers. comm.*, 2001).

The work being conducted in Puget Sound is essentially an extension of the type of work initiated by the BIEAP in the early 1990s in Burrard Inlet; however, the Puget Sound study takes the development work to a more detailed level on a coordinated and cost shared basis between the regulatory agencies and all stakeholders.

2.3.2 Boston

As part of the Boston Harbor Navigation and Improvement Project, approximately 1.3 million cubic yards of dredged sediments deemed unsuitable for unconfined open water disposal were placed in 10 pits excavated under existing navigation channels in Boston Harbor and then capped in place with three feet of sand (Cohen, A., 2000). Monitoring of this initial CAD cell was conducted a year before the full scale project was initiated to permit the investigation and refinement of construction techniques for subsequent cells (Fredette, 1999). Monitoring results from cell construction, material placement within the cell and cap placement and cap thickness in the initial phase of the project, were used to provide guidance on construction, operational, and monitoring modifications in the second phase of the project conducted in 1998 and 1999.

2.3.3 New York

Approximately 5 million cubic yards of sediment must be removed annually from the New York/New Jersey Harbor shipping channels for navigational purposes (Rowe *et al.*, 1999). Monitoring procedures for the capping of a MUDS in this area is detailed in Valente *et al.* (1998). Research at this site focuses on a process to determine the optimum thickness of the cap and capping design. Currently, no data on the cap effectiveness is available, however long term monitoring is planned to verify the effectiveness of the cap. The US EPA, Corps and the District of New York are currently investigating treatment and remediation technologies for sediments in the New York and New Jersey Harbors. Sediment decontamination technologies currently being tested in New York and New Jersey are summarised in Rowe *et al.* (1999).

2.4 Other International Jurisdictions

In Europe, the Permanent International Association of Navigation Congresses (PIANC) is currently examining the use of CAD and CDF options for sediment disposal. PIANC has developed a Contaminated Dredged Material Technical Framework (CDMTF) as an "international road map" for users involved in decision making processes. Appropriate options for dredging and managing materials from ports and inland waters were also evaluated in the CDMTF. The framework highlights the importance of the planning stage and the need to investigate all possible contaminant pathways, during the evaluation process of placement options for dredged material, while recognizing that such an evaluation is a case specific exercise. In addition, the framework highlights the importance of involving third parties which may either be significantly affected or have an interest in dredging and disposal activities. The PIANC framework essentially mirrors the Corps experience in the Great Lakes. In 1992, PIANC produced a practical guide to the beneficial uses of dredged material in which three main use categories are identified. These categories have since been included within the guidelines of the Oslo Paris (OSPAR) Convention and the "Dredged Material Assessment Framework" (DMAF) which was adopted in 1995 by the London Convention. The DMAF was derived from a general Waste Assessment Framework (WAF) which was developed to work alongside the 1996 *Protocol to the London Convention.* The intention of the DMAF is to provide generic guidelines for decision makers in managing dredged material and forms the basis on which a national licensing system can be developed. The DMAF was scheduled for review in 2000 to ensure it fully conforms to the other specific "Guidelines for Assessment of Wastes and Other Matters" presently under development (United Kingdom Department of the Environment, Transport and the Regions, 1998).

PIANC also identifies other alternatives, such as capping that may not be considered beneficial but which must also be considered. Capping with sand has been used to isolate contaminated material from the water column. Capping may not necessarily involve contaminated material but it can be used as part of a planned disposal operation. For example, disposal of dredged material may cause a change to the original sea bed characteristics at a disposal site. Capping with sediments similar to that found surrounding the disposal site can be used to restore characteristics of the sea bed, therefore minimizing any long term effects on the ecology of the area. To date, the most successful uses have been with sand, but experiments have been conducted using clay caps. Since the purpose of capping is to confine or isolate another material, the success of any method is highly dependent on the material type (both the capping and capped material) and the local hydrodynamic conditions.

One other international CAD application that should be discussed is the dredging and disposal of contaminated material in Hong Kong Harbour. For this project, disposal of 14 million cubic metres of dredged material was required for the construction of the new airport. The costs and associated details of sediment placement and capping are reported and post capping site management procedures are outlined in Shaw *et al.* (1998). The authors also reported that independent reviews of the post capping monitoring results indicate an absence of any adverse or cumulative impacts including risks to human health and the environment. Shaw *et al.* (1998) concluded that the disposal program effectively isolated the contaminated sediments from the marine environment.

3.0 Regulatory Aspects

3.1 Overview

The IJC white paper (IJC, 1997) indicates that there is a need for a framework outlining an appropriate decision making process to assist in the selection of management options for contaminated sediments. The framework must take ecosystem and cost factors into consideration, in addition to innovative sediment disposal mechanisms. It is imperative that any active intervention for sediment management beyond source control be aimed at restoring beneficial use of the site. A weight of evidence approach is used to determine whether action other than natural recovery is necessary. A realistic schedule should allow sufficient time for source control measures to take effect and the strategy must reflect the practical constraints of sediment remediation technologies.

Under the London Convention and associated commissions, options for material which exceeds the upper level criteria are provided. Options include:

1) Where the characteristics of the dredged material are such that normal sea disposal would not meet the requirements of the 1992 OSPAR Convention, treatment or other management options should be considered. These options can be used to reduce or control impacts to a level that will not constitute an unacceptable risk to human health, or harm living resources, damage amenities or interfere with legitimate uses of the sea.

2) Treatment, such as separation of contaminated fractions, may make the material suitable for a beneficial use and should be considered before opting for disposal at sea.

Disposal management techniques may include:

1. placement on or burial in the sea floor followed by clean sediment capping;
2. utilization of geochemical interactions and transformations of substances in dredged material when combined with sea water or bottom sediment and;
3. election of special sites such as abiotic zones, or methods of containing dredged material in a stable manner.

Advice on dealing with contaminated dredged material is available from PIANC.

In the Great Lakes Region in Canada and the United States, major sediment remediation projects have resulted from public and private partnerships, as discussed earlier. A list of these projects can be found on http://www.ijc.org/boards/wqb/sedrem.html. Other sediment remediation projects which have resulted in public and private partnerships can also be found in the United States, such as the Boston Harbor Navigation and Improvement Project.

3.2 Canadian Regulatory Framework

The following is a brief review of the regulatory framework governing confined aquatic disposal facilities and confined disposal facilities in Canada and British Columbia.

An important aspect in considering CAD as a disposal option is the federal and provincial regulatory framework governing dredged sediment management options. The legislative framework applied to siting and constructing a CAD has not changed since 1992, however, an update is provided.

Relevant federal legislation controlling the management and movement of harbour sediments include the *Canadian Environmental Protection Act* (CEPA), the *Fisheries Act* and the *Navigable Waters Protection Act*. Provincial legislation which may come under consideration is the *Waste Management Act* and the *Land Act*. From a federal environmental perspective, CEPA and the *Fisheries Act* are the basis of the regulatory framework governing the scope of dredged material management options within which CDF or CAD facilities might be considered.

Under the current system, the loading and disposal of sediments in marine waters are regulated by Environment Canada under CEPA Part 7, Division 3. A permit may be issued for ocean disposal of a substance if the substance meets the requirements set out in Schedules 5 and 6 of CEPA. The Minister shall comply with Schedule 6 and shall take into account any factors that the Minister considers necessary. Open water disposal of sediments is allowed at designated marine disposal sites provided that the sediments meet criteria specified by Environment Canada. Failure to meet these criteria would result in the prohibition of disposal of these sediments at the marine disposal sites. In these cases, other alternatives for dredged sediment management would have to be employed.

In order to assess the sediment quality, a tiered approach is currently used to characterise dredged material proposed for disposal of sediments in marine waters. When chemical screening limits for contaminants are exceeded, biological testing may be employed to determine the suitability of the substance for disposal at sea. This was known as the Rapidly Rendered Harmless (RRH) application of CEPA (1988). The former RRH provisions still exist but are now subsumed in Section 10 of Schedule 6 of CEPA 1999 under the National Action List. Under the National Action List:

- If the substance proposed for disposal at sea contains substances in excess of regulated or guideline levels but passes all biological tests, this substance can be considered acceptable for open water disposal;

- If the substance proposed for disposal at sea contains substances in excess of regulated or guideline levels and passes the acute toxicity test but fails one sublethal or bioaccumulation test, capping or confined aquatic disposal may be acceptable;

- If the substance proposed for disposal at sea fails the acute test or two or more additional tests including sublethal tests and the bioaccumulation test, the material will not be permitted for disposal at sea. The material may however, be treated further to reduce contaminant levels and re-tested for disposal at sea or upland disposal options may be employed.

Dredging activities are controlled under the habitat provisions of the *Fisheries Act* and the *Navigable Waters Protection Act*. The *Fisheries Act* requires considerations for the protection of fish habitat and associated riparian resources in addition to timing restrictions to reduce impacts of anthropogenic activities on fish populations and compensation requirements for the destruction of fish habitat. The *Navigable Waters Protection Act* requires the appropriate application and approval of works for the subject site. Concerns under the *Navigable Waters Protection Act* relate primarily to navigational safety in terms of the dredge site and the proposed disposal site as alterations of these sites may affect waterways.

3.2.1 Feasibility of Siting a Confined Aquatic Facility in British Columbia

The feasibility of establishing a CAD facility in Burrard Inlet was investigated in 1992. If a CAD were to be established in Burrard Inlet, the CAD would fall under federal jurisdiction. Under the Six Harbours Agreement of 1924, most of the harbour sea bed is regulated as federal Crown land by the Vancouver Port Authority, under the *Canada Marine Act* (1998) with the exception of a few small pockets situated close to the shore line which are either privately owned or regulated under the provincial crown (B. Hobby, *pers. comm.*, 2001). Establishing a CAD in Burrard Inlet would require the implementation of a consultation process with the Vancouver Port Authority and the Regional Ocean Disposal Advisory Committee (RODAC) which consists of representation from Environment Canada, Fisheries and Oceans Canada and the BC Ministry of Water, Land and Air Protection. In addition, the consultation process would include representation from the Navigable Waters Protection Agency, the regional office of the Ministry of Water, Land and Air Protection, the Greater Vancouver Regional District, the affected local regional governments, including First Nations, industry stakeholders, and public interest groups in Burrard Inlet.

Outside of Burrard Inlet, the same process currently in use to designate an open water ocean disposal site would be followed to designate a CAD. Again, the consultation process would include RODAC, the Navigable Waters Protection Agency, the local port authority and/or Transport Canada, the regional office of the Ministry of Water, Land and Air Protection, affected local regional governments, including First Nations, industry stakeholders and the public. This list does not preclude other federal, provincial, municipal or local regulatory agencies from the process.

Environmental, regulatory and economic constraints and conditions must be taken into consideration when siting a CAD. The details and issues discussed in BIEAP (1992a and 1992b) for Burrard Inlet are still valid and can be expanded to include the considerations which would need to be addressed in order to implement a regional CAD in British Columbia. Conditions that must be met include incorporating the same or a similar level of planning and implementation activities as demonstrated in other jurisdictions such as Puget Sound and the Great Lakes Region. The emphasis on scientific support, funding and public involvement in addition to a multi-stakeholder approach as outlined in other jurisdictions indicates their importance. The first step towards siting a CAD in British Columbia would be to update the dredged material management options assessment detailed in BIEAP (1992b).

The key questions to be addressed and updated are:

1. What is the current long term need for contaminated sediment disposal?
2. What volumes of contaminated materials exist?
3. Where is the contaminated material?
4. What progress has been made on source control?

At present, the current need for a CAD or MUDS has not been established. It must first be determined from potential stakeholders whether there is a demand for a CAD, MUDS or CDF and the most appropriate means of dealing with dredged contaminated sediments.

3.2.2 Regional Need for Confined Aquatic Facilities

As indicated in the BIEAP (1992b) dredged material management report and recent minutes of the Consolidated Environmental Management Plan for Burrard Inlet (S. Standing, *pers. comm.*) there are a number of steps to follow to determine whether a CAD, confined MUDS or CDF is warranted. This includes canvassing potential users (the ports and others) for information on current and future needs for contaminated sediment disposal. An inventory and estimate of contaminated sediments and soils in the Lower Mainland was conducted recently by O'Connor Associates Environmental Inc. (OAEI) in February 2001. OAEI (2001) evaluated options for disposal of contaminated sediments and soils from Vancouver and Victoria Harbours as part of a larger project which involved a market assessment of a proposed treatment facility and landfill at the Britannia Mine site. OAEI (2001) estimated that the majority of contaminated sediments are primarily from the Lower Mainland and Vancouver Island, however, the estimates provided in this report are for combined contaminated sediments and soils. The findings of this report indicated that based on Boyd *et al.,* (1997), the sediments in Vancouver Harbour may not be as contaminated as originally thought. OAEI suggests that source control efforts of stormwater contaminants are decreasing contaminant loadings to Burrard Inlet. OAEI also suggests that if source control of contaminants could be implemented in the harbour, two processes; namely sediment ejection into the Strait of Georgia and burial of contamination in the sediments could be expected in much of the inner harbour, thereby reducing the need to dredge of these areas. Based on these points, OAEI concluded that Burrard Inlet can be assumed to supply no or little contaminated sediment for disposal although they estimate that 3 000 m^3 of contaminated soils would need to be treated on an annual basis (OAEI, 2001).

Using the 1.4 million m^3 estimate of contaminated sediments in Burrard Inlet, OAEI estimates the cost of sediment disposal in a CAD would be $14.29 per cubic metre, although they note that no CAD facility currently exists. The volumes of contaminated sediments in Victoria and Esquimalt Harbours were estimated to total 556 000 m^3 of contaminated material of which 204 000 m^3 is primarily contaminated with trace metals.

It should also be noted that for contaminated sediments being considered for a CAD facility or open water capping project, Section 10 of Schedule 6 of CEPA (the former RRH provisions) will limit the amount of contaminated material considered acceptable for capping or inclusion in a CAD facility, based on the results of biological testing of the material. The results of the biological testing is used to define the upper level of the National Action List. Only sediments which pass the acute lethality test and at least one of the two sublethal tests or the bioaccumulation test approved by Environment Canada will be considered for capping or inclusion in a CAD facility. Sediments exceeding these criteria would not be considered for open water disposal, capping or disposal in a CAD facility, as is done in other jurisdictions. Section 10 of Schedule 6 will greatly reduce the utilization of CADs and capping of sediments as a management option for contaminated sediments and other management options will need to be considered for the management of these sediments.

4.0 Recommendations

Subject to feasibility, the recommendations set out in the 1992 BIEAP report for siting a confined aquatic disposal facility in Burrard Inlet are still valid.

The recommendations from the BIEAP report are as follows:

1. Review and clarify the treatment of dredged material under CEPA in such a way that the regulations and policies will permit the utilization of options outlined in the London Convention as applied to other jurisdictions.

2. Review and modify existing sediment quality criteria and guidelines in consideration of international precedents and local natural geochemical conditions and characteristics.

3. Undertake sufficient data collection on all aspects of the dredged material management issue to refine the understanding of the scope of the problem to a level which allows estimation of the expected cost within appropriate levels of accuracy. This should include the following elements:
   - physical, chemical and biological characteristics of sediments and candidate sites;
   - detailed definition of the technical processes and limitations of sediment treatment technologies and confined aquatic disposal facilities;
   - identification of operational constraints such as timing and sequence of third party demand on dredged material containment;
   - financial structure for cost recovery;
   - organizational framework and management of liability issues.

4. Incorporate an appropriate entity to undertake the design, construction and operation of an acceptable confined aquatic facility in Burrard Inlet. The objectives of this entity would be to operate the facility either as a permanent solution or as a temporary holding facility as such time as a practical and cost feasible option is available for treatment of the contaminated sediments.

5. In view of the uncertainties outlined in this report, the entity should initiate the above recommendations by submitting an application to Environment Canada for a confined aquatic facility as a pilot project.

However, there are several aspects as identified in the 1992 report recommendations that set out an initial framework that should be updated and addressed.

As a plan of action, the following steps, as outlined in the 1992 BIEAP report are suggested to provide the basic information requirements for an aquatic disposal facility. It will be essential to first of all, determine the need and if appropriate, to implement alternate disposal options to those which are currently in place, including details on what is involved in operating such facilities.

1. Determine whether there is a need for siting a (multi-user type) CAD (whether it be a regional CAD or one specific for a local area) by:
   - identifying the potential users;
   - determining the levels of contamination;
   - determining the sources of dredged material;
   - determining the sediment volumes;

- reviewing the current sediment management options.

2. Identify stakeholders and degree of interest in seeing the development of a confined aquatic facility.

3. Identify potential confined aquatic facility sites.

4. Assess environmental and economical feasibility.

5. Assess confined aquatic facility design options considering engineering and oceanographic conditions.

6. Develop a framework for the implementation of a confined aquatic facility.

7. Revisit and refine screening criteria to determine whether dredged material is suitable for placement in a confined aquatic facility.

8. Identify monitoring responsibilities, requirements, costs, and associated time frame.

9. Initiate the development and implementation of a pilot confined aquatic facility if warranted.

Depending on the need, public support, and cost, a pilot CAD could be developed to demonstrate the effectiveness and environmental utility of the system. The successful implementation of a CAD facility will require the co-operation and concerted effort of all stakeholders and regulatory agencies involved. Considerations will have to be given to issues associated with single or multi-use scenarios and the need for a CAD facility based on projected volumes of contaminated sediments and degree of contamination of these sediments.

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