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USE OF DREDGED MATERIAL FOR DEVELOPMENT PROJECTS AND APPLICABILITY OF THIS CONCEPT TO THE ST. LAWRENCE RIVER

Technical Report

PLAN D'ACTION SAINT-LAURENT
ST. LAWRENCE ACTION PLAN

CENTRE SAINT-LAURENT
ST. LAWRENCE CENTRE

USE OF DREDGED MATERIAL FOR DEVELOPMENT PROJECTS AND APPLICABILITY OF THIS CONCEPT TO THE ST. LAWRENCE RIVER

Technical Report

Jean-Claude Belles-Isles, Project Head
Roche Ltd.

Prepared for the St. Lawrence Centre
Conservation and Protection
Environment Canada

December 1989

Published by Authority of the Minister of the Environment

Cat. No. Em40-409/1991E
 ISBN 0-662-18740-7
Printed in Canada

MANAGEMENT PERSPECTIVE

This report is published as part of the St. Lawrence Action Plan whose main objective is to reduce by 90 percent the contaminant content of the liquid waste produced by the 50 industries considered to be the most serious polluters. The St. Lawrence Action Plan was initiated by Environment Canada in co-operation with Industry, Sciences and Technology Canada, and Fisheries and Oceans, with the goal of protecting, conserving, and restoring the St. Lawrence River.

PERSPECTIVE DE GESTION

Ce rapport est publié dans le cadre du Plan d'action Saint-Laurent, dont l'objectif est de réduire de 90 p.100 la teneur en substances toxiques des effluents rejetés dans le Saint-Laurent par les 50 établissements jugés les plus polluants. Le Plan d'action Saint-Laurent est une initiative d'Environnement Canada en collaboration avec Industrie, Sciences et Technologies Canada et Pêches et Océans. Il vise à protéger, conserver et restaurer le Saint-Laurent.

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Readers who wish to comment on the content of this report should contact the following address:

Technology Development Branch
St. Lawrence Centre
Conservation and Protection
Environment Canada
105 McGill, 4th Floor
Montréal, Quebec
H2Y 2E7

Cette publication est aussi disponible en français. S'adresser à :

Centre Saint-Laurent
Conservation et Protection
Environnement Canada
105, rue McGill, 4^{e} étage
Montréal (Québec) H2Y 2E7

ABSTRACT

A number of projects and studies have shown that dredged material can be a valuable resource for the creation or restoration of wildlife habitats and recreational and social facilities. This report is a review of the literature on the use of dredged material for these purposes. We address both the technical and social aspects of this question and discuss some Quebec, American, and European experiences in this area. We also describe the biophysical features of the St. Lawrence River. We have used this information to assess the feasibility of previous proposals and to propose new development sites. Finally, we have made some recommendations regarding the best avenues for research and development. We suggest that particular attention be paid to *(a)* the development of effective protection methods and structures which do not interfere with the anticipated use of the site by wildlife, *(b)* the development of techniques for maintaining plant cover, and *(c)* the study of the genuine toxicity risks involved with using highly contaminated dredged material.

For wildlife habitats, we favour the creation of islets in Lake Saint-Pierre. This proposal could be implemented as a short-term pilot project. As for recreational and social developments, we propose restoring beaches in the Québec City region. These projects will require follow-up studies. Their findings can be used to show the validity of using dredged material to restore wildlife habitats and create or improve recreational facilities.

RÉSUMÉ

Comme plusieurs projets et études l'ont démontré, les déblais de dragage peuvent servir à mettre en valeur certains milieux par la réalisation d'aménagements fauniques, récréatifs et à caractère social. Le présent travail se veut donc une revue de la documentation sur l'utilisation des matériaux dragués à des fins de restauration ou de création de sites favorables à la faune ou aux activités récréatives et sociales. Les aspects techniques et sociaux de la question font l'objet d'un examen et nous décrivons certaines expériences québécoises, américaines et européennes. L'information ainsi obtenue nous permet de juger de la pertinence des propositions antérieures à cette étude et de proposer de nouveaux sites pour de tels aménagements. Enfin, des recommandations sont faites concernant les principales avenues de recherche et de développement. Il est suggéré qu'une attention particulière soit apportée *a)* au développement de méthodes et d'ouvrages de protection efficaces qui n'entravent pas l'utilisation prévue par la faune; *b)* à la mise au point de techniques permettant le maintien d'un couvert végétal; *c)* à l'étude des dangers réels de toxicité liés à l'utilisation de déblais de dragage présentant des teneurs significativement élevées en polluants.

Nous favorisons, pour l'aménagement d'habitats fauniques, la création d'îlots au Lac Saint-Pierre. Ceci pourrait être réalisé à court terme à titre de projet pilote. En ce qui concerne les aménagements à caractère récréatif ou social, nous proposons le réaménagement des plages de la région de Québec. Ces projets devront faire l'objet d'un suivi environnemental. Les résultats de cette étude pourraient servir à démontrer le bien-fondé de l'utilisation de déblais de dragage pour reconstituer des habitats fauniques et créer ou améliorer des installations récréatives ou à caractère social.

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1 INTRODUCTION

With the steady growth in commercial shipping and pleasure cruising on the St. Lawrence River, particularly since the opening of the Seaway, extensive dredging operations have been necessary to maintain the navigational channel and existing harbours accessible to shipping, and to build new ports, marinas, and other marine facilities. Dredging operations can have a major impact on the environment, whether it be from the extraction, transport, or disposal of the dredged material at the containment sites or from its discharge into open water.

Nevertheless, numerous studies and projects over the last 20 or 30 years have shown that dredged material disposal can be embodied in an environmental development and enhancement policy where the dredged material is used for the restoration or creation of wildlife habitats or for recreational or social projects. In the United States, numerous projects have been conducted to assess the feasibility of using dredged material to create wetlands and artificial habitats. Several disposal sites for polluted and non-polluted dredged material have become successful wildlife habitats.

Closer to home, in the St. Lawrence corridor, there are many examples of dredged material being deposited in a way that has proved beneficial for birds and fish—though these successes have been more incidental than planned. Such is the case of, among others, Canard Island and Dickerson Island near Cornwall, Verte Island near Longueuil, Dufault Island and De La Broquerie Island not far from Boucherville, and the disposal sites at the Contrecoeur islands and Aux Sternes Island near Trois-Rivières.

All created with dredged material, the Beauport sand bar beaches, the islets of the La Prairie Basin, and the industrial sites near Beauharnois are other successful examples of development projects.

While well aware of the problems associated with the management of dredged material, St. Lawrence Centre officials are nevertheless eager to exploit the potential of such material for restoration and development projects, and therefore they wish to learn about the experiences of other countries to help them determine the best techniques to apply in the St. Lawrence River. They also need to know which are the best development sites in the St. Lawrence.

This study is thus a review of the literature on the use of dredged material for the restoration and creation of wildlife habitats and social and recreational facilities and an examination of potential development sites along the St. Lawrence.

2 REVIEW OF DEVELOPMENT EXPERIENCES WITH DREDGED MATERIAL: GENERAL CONSIDERATIONS

For this study we surveyed over 200 reports relating directly or indirectly to the use of dredged material for development projects. We should make it clear at the outset that we have some reservations about the apparent wealth of information. First, most of these documents concern projects carried out in the United States around 1978 as part of the Dredged Material Research Program. Second, the information is often inaccurate and project failures are rarely mentioned, giving the impression that all the techniques were successfully implemented.

It is important to note that chance played a large role in the creation of many developments. Completed projects were seldom followed up properly. Consequently, the validity of the techniques used is often difficult to determine. It is also noteworthy that most of the few follow-up studies we could find were conducted by the same organizations that carried out the original projects, raising doubts as to the objectivity of their findings. Finally, since much of the work was done in lentic environments, it cannot really be applied to the St. Lawrence River.

Accordingly, it is necessary to be dubious in evaluating the available information on foreign projects and to find out as much as possible about incidental development projects along the St. Lawrence. It is also essential to carry out pilot projects that will enable us to strengthen our ability in this area and demonstrate the validity of using dredged material to improve or create wildlife habitats or social and recreational facilities.

3 REVIEW OF DEVELOPMENT EXPERIENCES WITH DREDGED MATERIAL: DEVELOPMENT CRITERIA

3.1 Types of Development

From the existing literature, we were able to establish a relatively complete classification of the most common types of development. The various types are listed below:

- *Wildlife*:
  - Land and semi-aquatic habitats.
  - Aquatic habitats.
- *Other Types*:
  - Industrial and harbour uses.
  - Recreational and cultural uses.
  - Institutional uses.
  - Residential uses.
  - Waterway modifications.
  - Construction and fill uses.

Most projects often combine two or three different types of development. Furthermore, it is often the case that final use of the site differs from the original plans.

3.2 Chemical Quality of Dredged Material

3.2.1 Wildlife Habitat Development. At present there is an apparent lack of precise criteria for determining the acceptability of using contaminated dredged material for the development of wildlife habitats. Certain conclusions, however, may be drawn from the available literature.

3.2.1.1 ***Heavy Metals.*** Depending on the disposal method chosen, physicochemical changes can facilitate the mobility of certain contaminants and their absorption by plants growing on the site. Most dredged material can acidify, moderately or strongly, when exposed to air (particularly dredged material with sulphur or a low calcium carbonate content). This new environment facilitates the mobilization of heavy metals and their subsequent absorption by plants. Provided it remains submerged, dredged material only slightly or moderately contaminated by heavy metals can thus be used for wildlife habitat development.

3.2.1.2 ***Chlorinated Hydrocarbons.*** In intertidal regions, the development of wildlife habitats using dredged material heavily contaminated with chlorinated hydrocarbons (pesticides and PCBs) poses a threat to the environment. On land, provided a clean cap is used to cover contaminated dredged material and colonization by shallow-root species is encouraged, the risk of chlorinated hydrocarbon accumulation should be minimal. Some groups of contaminants (particularly organochlorine compounds with low molecular weight) can stabilize, deteriorate, or decompose when dredged material is oxidized.

3.2.2 Other Types of Development. The best disposal method for dredged material contaminated with heavy metals or organic pollutants is off-shore containment. Filled containment sites can be used for the development of industrial, recreational, and other facilities. Special measures are necessary, however, to ensure that the contaminants do not migrate beyond the containment site through lixiviation, bioaccumulation of flora and fauna, etc.

3.3 Physical Quality of Dredged Material

3.3.1 Wildlife Habitat Development. While virtually all types of uncontaminated dredged material can be used to develop wildlife habitats, some are more suitable than others. On certain substrates, fertilization is essential for rapid establishment of vegetation.

3.3.2 Other Types of Development. Institutional, residential, and industrial/-harbour developments are generally heavy, and the available space is densely utilized. These developments require substrate with a very high support strength. The most suitable materials used to accomplish this are silt and sand. Materials such as coarse-grained sand and gravel are generally used for embankments and hydraulic operations.

Fine-grain and even organic materials have been used successfully in numerous recreational development projects. Service buildings and similar heavy structures require the additional use of pilings or some other adequate construction technique.

3.4 Disposal Site Location

Regardless of the type of dredged material, a disposal site must combine optimal material stability with reasonable transport costs. We recommend that the dredged material be dumped in places with low wave-energy, such as shallow bays, which have weaker currents and a greater rate of sedimentation.

Sites subject to more severe erosion can also be developed, provided protective structures are erected. In this case, the substrate must have sufficient support strength to support the weight of these structures. This type of construction is feasible for large-scale projects only, due to the high cost of the protective structures.

3.4.1 Wildlife Habitat Development. Islands intended as bird habitats should be situated a reasonable distance from the riverbank in order to seclude them as much as possible from human disturbances and predators. This same principle applies to the location of the island in relation to surrounding islands, especially large and/or inhabited islands. Because both banks of the St. Lawrence River are densely populated, we suggest situating the new islands at least 200 m from the riverbank and at least 100 m from one another. We also recommend that they be situated at least 2 km from the Seaway to minimize any erosion caused by waves from passing ships.

3.4.2 Other Types of Development. Most other types of development are intended for public use, so easy access is essential. It is generally preferable to construct them as extensions of the riverbank rather than as islands, thereby avoiding the problems and costs associated with the construction of access roads, the supply of water and electricity, and the provision of various services.

3.5 Site Area

3.5.1 Wildlife Habitat Development. Ideally, islands built for wildlife should be no smaller than 0.5 ha and no larger than 1.5 ha. This optimal size takes into account such factors as construction costs, quantity of material required for construction, and possible erosion of material.

3.5.2 Other Types of Development. The type of area required depends on the development envisaged and may range from a simple headland for a scenic viewpoint to huge tracts of land for industrial/harbour complexes.

The area for swimming beaches should consist of 10 m^2 per person for the dry beach and 12 m^2 per person for the wet beach.

3.6 Site Configuration

3.6.1 Wildlife Habitat Development. A number of authors note that the formation of a bay within an island makes it more attractive to birds. A shallow area protected from currents and prevailing winds could be created by building crescent-shaped islands elongated in the direction of the current, like existing ones at several spots along the St. Lawrence River.

The island should be protected from wave and current action by a natural or artificial shoal, another island, or a rock breakwater. Smaller islands (less than 0.5 ha) should be circular in shape, whereas larger ones, since they are harder to build, should be rectangular. Large sand bars should be oblong.

3.6.2 Other Types of Development. Here, too, configuration can vary widely depending on the objectives. Aesthetically pleasing, natural-looking shapes are the most suitable for social development projects, while rectilinear, right-angled shapes are the best for commercial, industrial, and harbour facilities.

3.7 Site Elevation

3.7.1 Wildlife Habitat Development. One of the main factors determining plant cover is soil humidity, which depends on the groundwater level and the exposure to flooding.

Sites that are too low are subject to tidal flooding, which hampers the growth of certain plants. The elevation of a site is therefore an important factor to consider during the planning stage.

We suggest that grassland cover over 75 percent of the surface area of new sites. To achieve this, at least 75 percent of the island should be periodically flooded, a process which requires a very precise elevation. Table 1 gives suggested elevations for the sector of the St. Lawrence between Trois-Rivières and Lake Saint-François.

Table 1 Suggested Elevation for Islands Built with Dredged Material between Trois-Rivières and Lake Saint-François

Region	Elevation* (m)	Region	Elevation* (m)
Lake Saint-Louis	22.0	Sainte-Thérèse	7.9
La Prairie	11.1	Verchères	7.6
Boucherville	8.2	Contrecoeur	7.3
Varennes	8.1	Sorel	6.8

* Height corresponds to geodetic level.
Source: Bélanger et al., 1989.

We also suggest that a part of the island be slightly higher (by 1 or 2 m) to allow the establishment of a different type of vegetation. This type of plant cover can provide nesting sites for wildfowl (during flood levels) and other species of birds.

3.7.2 Other Types of Development. The preceding considerations also apply to other types of development projects. Additional criteria may be added, depending on the location and purpose of the development. In an urban environment, for instance, it may be necessary to slightly elevate the site in order to preserve a residential neighbourhood's view of a stretch of water. If underground structures such as parking or storage facilities are to be part of the site, then a low elevation may entail substantial waterproofing costs.

3.8 Site Slope

3.8.1 Wildlife Habitat Development. According to the literature, islands created as wildlife habitats should have a slope gradient ranging from 1:15 to 1:60. These low gradients apply to the part of the slope in contact with the water. Much steeper slopes are acceptable for the part not in contact with water.

3.8.2 Other Types of Development. The preceding considerations also apply to other types of development projects such as riverbank extensions and the creation of islands. They are particularly relevant to recreational sites, where the natural landscape features must be developed and where we try to encourage aquatic activities or nature appreciation. In urban areas, certain considerations (such as harmonization with the existing architecture) can necessitate the erection of protective walls. Likewise, specific functions, such as industrial or harbour uses, may require this type of construction.

Building a beach is a special case requiring particular attention. The standard generally used in Quebec is for the riverbank to have an average slope ranging between 2 and 8 percent with a maximum of 10 percent. The overall slope is divided up as follows:

- Submerged Beach: maximum of 8 percent
- Dry Beach: maximum of 5 percent
- Buffer Zone: maximum of 30 percent
- Backshore or Service Area: maximum of 5 percent

3.9 Confined Disposal Facilities

In the US and overseas, nearly all moderately contaminated dredged material is deposited in confined disposal facilities (CDFs) on land or along the riverbank. CDFs are specially designed to minimize the pollution of underground water and adjacent bodies of water. Once filled, these containment sites are developed for specific uses, many of them recreational.

CDFs are essentially primary and secondary sedimentation basins, and some are equipped with a weir or another type of discharge structure. During the settling and/or decanting process, all or at least part of the dredged material and the absorbed contaminants are retained by a closed dike.

3.9.1 Dikes. The containment dike must provide sufficient stability to prevent the loss of materials (and contaminants) through slippage, shearing, or subsidence, offer good resistance to adverse phenomena such as erosion, and be impervious enough to prevent any leakage.

The height of the dike depends on the storage volume requirement. Sizing is constrained, however, by technical and environmental considerations.

3.9.1.1 *Dike Stability.* The slope given to construction materials reinforces the stability of the dike and determines its maximum height. The slope is calculated according to several factors, including the characteristics of the foundations, the properties of the borrow material, and anticipated erosion.

3.9.1.2 *Dike Imperviousness.* Coarse soil provides better stability than cohesive soil, but it has a higher permeability coefficient, even after intensive compaction. In some cases (such as the containment of contaminated dredged material), an impervious layer may have to be added to the dike to prevent leakage of contaminants through the dike.

For upland containment, this impervious layer may consist of very fine materials with a very low permeability coefficient; open water or coastal containment usually makes use of a synthetic membrane.

3.9.2 Discharge Structures. These structures discharge the decant waters of dredged material, as well as runoff and drainage water. They are generally built on the outside dike and/or on cross sections of dikes separating adjacent containment areas. There are two main types:

- *The weir* : a channel in the upper part of the dike which allows surface water to run off.

- *The sluice*: a semicylindrical decantation tower made of wood or steel, equipped with a gate of riser planks. The water discharge rate from the basin is adjusted by adding or removing one or more planks.

4 REVIEW OF DEVELOPMENT EXPERIENCES WITH DREDGED MATERIAL: TECHNOLOGY USED

4.1 Unconfined Disposal Sites

4.1.1 Types of Dredges

4.1.1.1 ***Mechanical Dredge.*** As a general rule, the mechanical dredge should be used when the site is constructed with compact material. Sediment collected with this type of dredge undergoes little change. Thus, a mechanical dredge connected to a barge or scow to evacuate the dredged material should be used for building the foundations of islets and sand bars. A water depth of less than 2.7 m (the draft of a fully loaded barge) calls for the use of a hydraulic dredge equipped with a pipeline.

4.1.1.2 ***Conventional Hydraulic Dredge.*** The hydraulic dredge is generally used to dispose of dredged material in shallow waters (for example, for building the submerged part of islands or for beach nourishment). In the latter example, the dredged material is pumped through a pipeline and deposited directly on the riverbank or in shallow waters in the littoral zone.

4.1.2 **Modes of Transport.** Dredged material can be transported from the dredging site to the disposal site either by pipeline or by barge or scow. The transport system depends on such factors as the type of development, the biophysical and socio-economic features of the dredging site, riverbank and transport route, and the quantity of material to be dredged.

4.1.2.1 ***Pipeline.*** Generally speaking, the maximum pumping distance of a pipeline without a booster pump is 0.8 km and sometimes less, depending on the slope. Booster pumps are required in order to cover longer distances.

A pipeline is an economic form of transport, however, and its profitability increases with the volume dredged. In addition, it allows the disposal of material in shallow waters inaccessible by barge or scow. Still, a pipeline is inadvisable in the case of hilly terrain, urban development of the riverbank in some regions, and in particular low quantity of material to be dredged.

4.1.2.2 ***Barge and Scow.*** Large flat-bottomed barges and scows with bottom-dump doors are used for transporting dredged material removed with mechanical dredges to disposal sites. Most of them have a draft of 3 m and consequently will not work in water depths less than 3 m.

The operating cost of barges and scows over short distances is relatively low.

4.1.2.3 ***Barge and Pipeline.*** Dredged material can also be transported part of the way by barge and then pumped through a pipeline to the discharge site. Though not often used because of the relatively high cost, this technique allows the transport of dredged material over long distances and their disposal in areas inaccessible by barge.

4.2 Confined Disposal Sites

4.2.1 Dike Construction Methods. Dikes are generally built using uncontaminated granular material either from borrow sites on land or from dredging sites.

Conventional heavy equipment such as cranes, trucks, and bulldozers, or mechanical or hydraulic dredges, are used to handle, transport, and place material.

4.2.1.1 ***Conventional Equipment.*** Construction with conventional equipment must begin on land, where trucks unload material into the water. As soon as enough material accumulates, bulldozers spread and compact it, giving trucks greater leeway to work on and expand the dike.

4.2.1.2 ***Grab Dredge.*** This technique is the most common and certainly the most economical if good-quality borrow material (such as coarse sand or gravel) is available near the site and if the site's perimeter is not too large.

4.2.1.3 ***Hydraulic Dredge Connected to a Pipeline.*** This technique is generally used only for building the dike base when the containment site is located on the bank of a waterway. Once the base is built, conventional equipment can be used to finish the dike. Some contractors have apparently developed dike-construction techniques that require only hydraulic dredges equipped with diffusers.

4.2.2 Installation of Filtering Membrane. The exact location of the disposal site must first be indicated using buoys and pontoons; then the geotextile membrane can be assembled. The size of the assembled membrane floating on the water must be equal to the base of the dike to be erected and to the length of the dike's interior slope. A safety margin outside the base of the dike, as well as an extra width for anchoring the membrane on the crest of the dike after it has been folded over the interior slope, must be added.

Material is first dumped onto the part of the membrane to be situated outside the dike. With the membrane firmly held in place, construction of the dike can begin. The membrane is then folded over the interior slope of the dike and anchored at the crest. It thus prevents the escape of material accumulating behind the dike.

4.2.3 Deposition of Dredged Material in Confined Disposal Facilities. Generally, dredged material is placed in the diked storage area via a pipeline. Flocculants or coagulants can be added to assist sedimentation of very fine particles. Numerous products are available for this purpose.

4.2.4 Dredged Material Drainage. While a large amount of water drains off when the dredged material is deposited in the storage area, the dredged material will initially retain a semifluid consistency. The natural drainage of fine sediment is a long process (sometimes lasting several years) and the time limits for completing projects often demand special techniques to accelerate the process. The method most often used for dredged material is evaporative drying, which consists of ploughing furrows to increase the surface exposure of the slurry.

4.2.5 Capping with Clean Material. Once the drainage is completed (which takes about a year) the containment site can be capped with a layer of clean material or be developed into a recreational, social, or other facility. The thickness of the capping layer will depend on the type and contaminant concentration of the confined material.

4.3 Vegetation Cover

Vegetation can result from natural colonization or from direct planting. The advantage of natural colonization is its low cost. Direct planting, on the other hand, should accelerate surface stabilization and plant growth and allow greater control over plants growing on the site. It is not always easy, however, to locate, obtain, and prepare the desired plant material.

4.3.1 Natural Colonization. In some cases, vegetation has taken hold naturally after only a few months; while in others, as many as 30 or more years have been necessary for natural plant growth to occur.

4.3.2 Direct Planting. Direct planting can be done using cultivated or native plants. The latter have two major advantages over cultivated varieties. First, because of their slow metabolic rates, they better tolerate the low nutrient content of dredged material. Second, they are rustic (thus less sensitive to frost) and more tolerant of low temperatures than cultivated plants. The major drawback of using native plants is the inconvenience of having to secure a regular supply.

4.3.2.1 ***Preparation of the Substrate.*** Depending on the type of substrate, it may be necessary to use fertilizers to generate the growth of plants.

Fertilization should be done just before planting time. If a large quantity of fertilizer is necessary, the application can be done in two stages: before planting and once the plants have taken root. But fertilization has only short-term effectiveness and therefore may require repeated applications over several years.

Desiccation cracks can form in the dredged material if its surface crust is not exposed to tides or some other source of humidity. If this happens, then the ground should be ploughed or dug up several months before seeding or transplanting begins.

Marine substrates with a naturally neutral pH can become acidic when exposed to air; acidification can also affect the pH of dredged material, decreasing it to as low as 3.0. The pH neutralization time can range from three weeks to several months, depending on the type of material and the neutralizing agent used.

When the salt concentration of the substrate is too high and impedes plant growth (which is generally the case with marine sediment), the salt content has to be lowered to non-toxic levels before plant growth can begin. The duration of the process will depend on the initial salinity, the amount of precipitation, and the intrinsic permeability (i.e. the type of substrate). This process can take a year or even longer in some cases.

4.3.2.2 ***Selection of Plant Species.*** The project objective and plant availability are the main criteria in determining the species to be used. For instance, if the purpose of transplanting is to create a wildfowl habitat, then plants that can provide suitable cover for nesting should be selected. On the other hand, if the purpose is to stabilize a marsh, then fast-growing plants with well-developed root systems (such as grasses [*Graminae*], sedges [*Cyperaceae*], and marsh plants [*Typhaceae*]) should be chosen.

4.3.2.3 ***Seedlings versus Seeds.*** Seeds have documented advantages over seedlings: low cost and little handling. They are, however, susceptible to surface erosion and sensitive to the soil conditions of the seeding area. To limit possible losses, seeds should be used in rich soil only.

4.3.2.4 ***Seeding and Planting Techniques.*** Broadcast seeding is an acceptable technique for small areas. Mulching can provide vital protection for the seeds.

For larger areas, more even distribution of seeds can be achieved with agricultural equipment. Light machinery can generally be used as soon as the substrate can support a person's weight.

For hard-to-reach places, hydroseeding can be an effective technique—one which is facilitated by portable equipment.

4.3.2.5 ***Seedling Spacing.*** To obtain plant cover as quickly as possible, we suggest using mature plants with close spacing (less than one metre apart). This spacing rate is a reasonable compromise between rapid growth of plant cover and production costs. The same spacing rate also applies to sites subject to erosion.

4.4 Scheduling

4.4.1 **Dredging Work.** Dredging contractors must reconcile the time required for dredging with the period available prior to ice formation. Since the surveys to determine dredging requirements for the current year are generally conducted in spring or early summer, and taking into consideration the time necessary to issue calls for tender and to evaluate bids, contractors have only a few months in autumn to do the actual dredging.

From an environmental standpoint, this schedule is quite convenient because the work is performed after the wildfowl breeding season and the spawning season of most fish species. In addition, depositing dredged material in autumn allows the material to consolidate before the next plant growing season. From a technical standpoint, however, the short time available for dredging can impede the work because the operation of dredging equipment can be hindered by bad weather conditions often prevalent in autumn.

4.4.2 Planting Work. The best time for seeding is spring (until around June 15). Yet there is a good chance that spring floods will wash away seeded riverbanks. Sites that commonly experience seasonal fluctuations in water levels should therefore be seeded at the beginning of the summer in order to minimize loss.

Shrubs and bushes should preferably be planted in autumn.

4.5 Project Costs

Project costs depend on the following factors:

- Distance between the dredging site and the disposal site.
- Quantity of material dredged.
- Containment and protective structures required.
- Landscaping work (such as planting) required.
- Maintenance required.
- Supervision during construction.

In short, costs rise rapidly as project complexity increases.

5 REVIEW OF DEVELOPMENT EXPERIENCES WITH DREDGED MATERIAL: SOCIAL ACCEPTABILITY

5.1 Administrative Aspects

Many authors note that land-use planners are often reticent on the use of dredged material. We encountered the same reticence when we asked regional or local officials to identify projects that might be feasible in certain sectors of the St. Lawrence. This apprehension and reticence seems to have three major causes. The first is the source of the material; the second is a land-use planning problem; and the third is the general public's concern about the impact of the project. These causes deserve serious consideration because all three can lead to the delay or refusal of completely valid projects.

5.1.1 Source of Material. Due to the coverage the media have given to the toxicity of the St. Lawrence River sediments and to the notion of toxicity in general, land-use planners have become frightened over the whole issue. This fear leads either to a total refusal to even consider the advantages of using dredged material or to excessive requirements for demonstrating the material's security. In short, most parties involved seem to fear the possibility of being associated with a potential ecological disaster.

5.1.2 Land-Use Planning Problems. The complexity of land-use planning processes often seems to be used as a pretext for avoiding proper consideration of proposals to use dredged material made by agencies responsible for dredging operations. This problem is encountered in the United States, but it seems to be much more serious in Quebec, especially since the *Act respecting land-use planning and development* came into force. Under the Act, Regional County Municipalities (RCMs) are responsible for preparing and implementing a development plan. This involves a series of steps that include information and consultation meetings with the public, adjacent RCMs, and the Department of Municipal Affairs. When the development plan has been accepted, a planning program and by-laws ensuring compliance are adopted. Any major change to the original development plan thus entails going through at least part of this complex process once again and may involve new consultation sessions with the public and the agencies concerned.

It would therefore seem that any attempt to make use of dredged material (at least in the short term) should concentrate on projects already accepted and included in development plans. It may well be that the successful completion of such projects will facilitate the acceptance of future projects.

5.1.3 Public Apprehension. The literature shows that the general public is often just as reticent toward such projects. Opposition tends to be particularly strong when proposed projects are private rather than public or when they threaten to reduce views of the water.

5.2 Legal Aspects

In Quebec, all dredging operations and dredged material disposal projects must comply with either the federal Environmental Assessment and Review Process (EARP) or the provincial regulations under the *Quebec Environment Quality Act*. If a private project is subject to provincial regulations, and a federal decision-making body must intervene in the course of the project, then the proposal may have to comply with both review processes.

5.3 Environmental Impact

If well planned, the disposal of dredged material can go hand in hand with an environmental development and improvement policy—if the material is used in construction or restoration projects. The work required for these projects may, however, have an impact on the environment, in some cases direct and/or temporary, in others indirect and more or less permanent.

Whatever the type of development contemplated, it should be designed and situated so as to minimize its impact on the biophysical and human environment.

6 PROPOSALS FOR THE ST. LAWRENCE RIVER

6.1 Assessment of Proposals Made Previous to This Study

6.1.1 Proposals of Vigneault et al. (1978). A study conducted in Quebec in 1978 for the Study Committee on the St. Lawrence River by Vigneault et al. identified 14 development projects that could be carried out on the St. Lawrence River using dredged material. Table 2 outlines the 14 projects in question.

In most cases, the amount of dredged material available appears to be quite insufficient. Only the Louiseville (projects 9 and 10) and Trois-Rivières/-Bécancour (projects 11 and 12) sites seem to offer sufficient material for the projects proposed.

6.1.1.1 ***Louiseville.*** This region is known for its commercial and sport fishing in summer, autumn, and winter. Also, many wildfowl migrate to the region to nest and rear their young, and certain species of fish (such as carp and bullhead) spawn here in the spring. The proposed site would thus be a very rich wildlife habitat and should not be used for the disposal of dredged material.

6.1.1.2 ***Trois-Rivières/Bécancour.*** This sector offers some interesting possibilities for the development of wildlife habitats. Vast numbers of emergent and submerged water plants provide resting and feeding sites for wildfowl, but nesting sites seem to be scarce. The creation of islets suitable for nesting would thus be a worthwhile undertaking in this region.

6.1.2 Proposals of Bélanger et al. (1989). More recently, Bélanger et al. identified 11 potential sites for a pilot project to create an island made of dredged material in the National Wildlife Reserves at Verchères and Contrecoeur. These proposals were made because such islands had been successfully created there before and because the region has a large population of nesting ducks.

Table 2 Outline of Projects Proposed by the Study Committee on the St. Lawrence River (Vigneault et al., 1978)

Development Project	Type of Development	Amount of Material Required (m^3)	Description of Project	Cost of Moving Material per $1000 (1977)
Creation of a recreational area at Coteau-Landing, Saint-Zotique (Project 1)	Recreational	200 000	The old wharf would serve as the nucleus of a backfilling operation designed to increase the surface area that can be developed for community use.	2 400
Expansion of the campsite at Coteau-Landing, Saint-Zotique (Project 2)	Recreational	150 000	The campsite could be expanded by filling in the ditch separating it from Lalonde Island.	300
Protection of the De la Paix islands, Châteauguay (Project 3)	Protection	110 000	Building an embankment level with the islands and a sand bar on the shipping channel side would protect the De la Paix islands against erosion.	1 500
Creation of islets near the De la Paix islands, Châteauguay (Project 4)	Wildlife	420 000	Possibilities exist for increasing wildfowl habitats. Islets that are permanently emergent, even during floods, could be created.	110
Building of islets and sand bars opposite Valois Bay, Pointe-Claire (Project 5)	Wildlife and recreational	310 000	Building islets and sand bars opposite Valois Bay to create bird and fish habitats with the possibility of using them as recreational areas.	200
Development of De La Broquerie Island, Pointe-aux-Trembles (Project 6)	Wildlife	7 700 000	Dredged material could be used to develop wildfowl and fish habitats by creating a sheltered basin between De La Broquerie Island and the shipping channel and constructing a sand bar to protect against waves from passing ships.	1900
Development of the Bellegarde Island area, Repentigny (Project 7)	Wildlife	3 300 000	A bird and fish habitat would be created by building a shoal with some permanently emergent islets between Bellegarde Island and Hertel Island.	1 500
Development of the Aux Prunes Island and Aux Boeufs Island area, Verchères islands (Project 8)	Wildlife	310 000	Converting the channel between Bouchard Island and the Aux Prunes Island and Aux Boeufs Island into a basin to create a wildfowl and fish habitat and protecting this habitat from the channel with a string of dredged material heaps and sand bars.	1 500
Development of the De la Girodeau islands, Louiseville (Project 9)	Wildlife	170 000	This project involves creating a marshy basin protected by a string of permanently emergent islets. Canals between the islets will enable water and fish to circulate freely.	22 900

Table 2 (continued)

Development Project	Type of Development	Amount of Material Required (m^3)	Description of Project	Cost of Moving Material per $1000 (1977)
Development of the La Carpe sand bars, Louiseville (Project 10)	Wildlife	640 000	Construct a permanently emergent sand bar belt to create a marshy basin with a single outlet on the shipping channel side so as to improve the habitat for fish and birds.	1 560
Development of the Gentilly sand bars, Trois-Rivières (Project 11)	Wildlife	260 000	Build a string of islets emergent during high tide and spring floods to increase wildfowl habitat.	1 076
Development of the Saint-Pierre sand bars, Batiscan (Project 12)	Wildlife	380 000	Building a string of islets along the Saint-Pierre sand bars, emergent during high tide and spring floods, would increase the habitat available for fish and birds.	40
Development of the Sainte-Croix sand bar, Cap-Santé (Project 13)	Wildlife	1 600 000	Constructing a string of emergent islets to protect a large artificial sand bar would increase the habitat available for birds and fish.	40
Development of the Madame Island and Au Ruau Island area, (Project 14)	Wildlife	29 050 000	Building a submerged sand bar between the shipping channel and Madame Island and Au Ruau Island would improve the fish and bird habitat.	Un-determined

Nevertheless, the Verchères and Contrecoeur National Wildlife Reserves are more than 20 km off the major dredging sites (i.e. the Ports of Montréal and Tracy-Sorel). The material would therefore have to be transported over relatively long distances; consequently, the related costs could be very high.

Although these proposals do not seem feasible at present, they should be reconsidered if major dredging work is undertaken in the Contrecoeur and Verchères areas.

6.1.3 Proposals of Hamel, Beaulieu, and Associates (1989). Following an in-depth study, Hamel, Beaulieu, and Associates identified four sectors for the construction of artificial islets in Lake Saint-Pierre (see Map 1).

The first three sectors are located by the Bois-du-Boulé, near Baie-du-Febvre (upriver from the Longue Point), and between Point Yamachiche and Pointe-du-Lac, on the north bank of the river. The sites are in deep marshy areas where very little fishing is done. Building islets in these areas would help increase the habitat's diversity and richness.

The last site proposed is the Saint-François sand bars. Constructing a string of islets on a small area of the sand bar would diversify the wildlife habitats. The authors note that this development would promote the nesting of dabbling ducks and the spawning of certain fish species. A shoal which would protect the islets is an added advantage of the site.

All in all, these are very attractive sites for building islets because they offer good wildlife habitat potential. Furthermore, large quantities of dredged material are readily available. Moreover, the main parties involved in the development of Lake Saint-Pierre[1] appear to be in favour of the proposals made by the authors.

6.2 New Sites Proposed for Development Projects

6.2.1 Sector F: Port of Montréal. The 7000 m^3 of dredged material from the Port of Montréal could be transported by barge to Saint-Jean Island and Verte Island to create shoals that will eventually be colonized by vegetation. There is a noticeable lack of water plants for spawning and nesting in this area due to the steepness of the riverbanks.

Surveys should be conducted to determine the chemical quality of the sediment, as the most recent tests date from 1982.

6.2.2 Sector I: Du Nord Traverse and Saint-François Traverse (Orléans Island). The dredged material from maintenance work on the Du Nord Traverse and Saint-François Traverse could be used for a number of purposes. There is a noticeable lack

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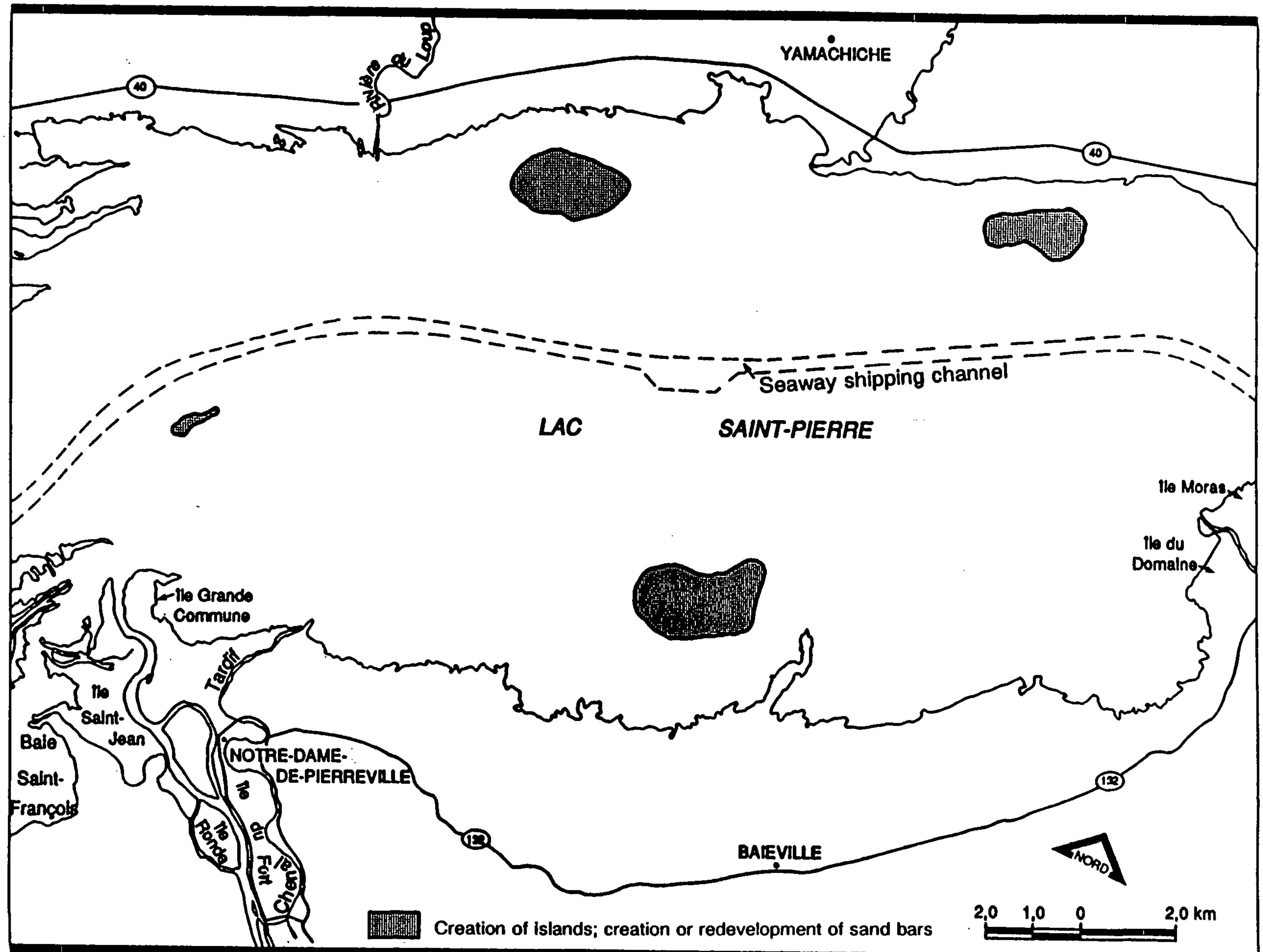
[1] Ministère du Loisir, de la Chasse et de la Pêche du Québec, Canadian Wildlife Service, Fisheries and Oceans, Société ornithologique du Centre du Québec, Corporation pour la mise en valéur du Lac Saint-Pierre, and Ducks Unlimited.



Source : Hamel, Beaulieu et Associés, 1989

Map 1 ***Recommended Development Areas in Lake Saint-Pierre***

of bulrush marshes in the Cap-Tourmente area, and the ever-increasing population of Greater Snow Geese is causing serious damage to existing marshes as well as to nearby crops. The dredged material could thus be used to build sand bars in this area. The dredged material could be deposited by pipeline near the existing marshes to facilitate natural colonization of the site by bulrushes. It seems preferable to allow for natural plant colonization. Direct planting is not advisable due to the presence of geese which would eat most of the seedlings.

Another development project which could be considered for the area is the creation of submerged sand bars near Madame Island and Au Ruau Island, as proposed by Vigneault et al. (1978). This project would have to be scaled down to suit the quantity of dredged material available.

Finally, sand from the Du Nord Traverse could be used to restore the beaches at Cap-Rouge, Sillery (Foulon beach), and Saint-Romuald. Although the dredging and deposit sites are quite far apart, the strong demand for beaches in the Québec City area may well warrant the additional cost of transporting the dredged material over long distances.

6.3 Conclusions

Constructing the wildlife habitats or recreational or social facilities we have proposed will require more in-depth, small-scale studies than those mentioned in this report. When it comes to wildlife habitat development, we are in favour of the proposals made by Hamel, Beaulieu, and Associates for building islets in Lake Saint-Pierre. A detailed study taking both environmental and technical constraints into consideration has been conducted of the area. This constitutes a distinct advantage over other projects, for which no such studies have been conducted; since that type of study is a necessary step in the process, the other projects could only be carried out in a long term. In addition, all the parties involved in the development of Lake Saint-Pierre seem to be in favour of the sites chosen for the creation of these islets. The proposal is therefore very realistic and could be undertaken in a short term as a pilot project for the development of wildlife habitats.

As for recreational or social development projects, we favour the restoration of the beaches in the Québec City area. Despite the distance separating these sites from the Du Nord Traverse, the quality and quantity of sediment which can be dredged there would be ideal for this type of development. Furthermore, there is already public desire to see this project go ahead. Close supervision should be exercised while the work is in progress to ensure that the technical specifications are met and to make any changes required because of unexpected constraints.

Finally, these pilot projects should be subjected to follow-up studies. When future projects are being considered, the findings of these studies could be used to demonstrate the validity of using dredged material to create wildlife habitats and build or improve recreational facilities.

7 RECOMMENDATIONS

In conducting this study we discovered that the elements of information pertinent to the creation of wildlife habitats in the St. Lawrence River are minimal and grossly flawed. We therefore recommend that future research and development work concentrate on the following areas with regard to technical questions:

- Most of the sectors which raise serious problems for the disposal of dredged material are located in the fluvial part of the St. Lawrence which is characterized by relatively fast-flowing water and by the dynamics of erosion rather than accumulation. Any attempt to develop a site by using dredged material will thus require protection or stabilization work in the short or mid term. It is therefore recommended that special attention be paid to the development, improvement, and application of effective protection methods and structures which do not conflict or interfere with the anticipated use by birds (submerged dikes, shoals, use of hydrodynamic profiles, etc.).
- The development of dredged material deposit strategies and techniques which account for and take advantage of the specific conditions which characterize the various sectors of the St. Lawrence (spring floods, tides, direction of current flow and site hydraulics, shipping channel and ship-generated waves, etc.).

As for wildlife habitats as such, research and development should focus on the following topics:

- Study and identification of the best types of plants according to their availability (plumules, seeds, propagules) and their ecological requirements (pedological and edaphic conditions, resistance to direct sunlight, to wave action, to dehydration, rate of growth, of reproduction, etc.).
- Study of the means of correcting and enriching the pedological conditions of dredged material.
- Study and strategic development of the placement and maintenance of plant cover (use and optimization of plant succession processes, study of planting and propagation methods, study of the uses of the environment, and development of methods to maintain ideal plant cover and prevent destruction of the habitat by wildlife).

- Study of the genuine toxicity risks (direct acute toxicity, indirect and chronic toxicity, bioaccumulation) associated with the use of highly contaminated dredged material (threats to the resource directly affected, threats to the aquatic environment, threats to human health, etc.).

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