Halifax Harbour Task Force

Final Report

Prepared for

The Honourable John Leefe

Minister of Environment

Submitted by

Robert O. Fournier

Task Force Chairman

August 1990

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Acknowledgements

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The following individuals and organizations provided direct support to the Task Force:

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Halifax Harbour Task Force

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The Honourable John Leefe
Minister of the Environment

Dear Minister:

As Chairman of the Halifax Harbour Task Force I enclose our Final Report. It is a succinct summary of our often extensive discussions, and I feel that it captures the complex nature of the problem which confronts any serious deliberations regarding the future of Halifax Harbour. Also included are 18 recommendations which represent the essence of our advice to you.

The Halifax Harbour Task Force has seen itself as representing the community at large. There is no doubt that each of us came to the table with some preconceived notions or representing some particular community bias. In the end, however our advice has been an attempt to serve the entire community through recommendations dealing with the long term sustainable utilization of the Harbour.

The amount of time required by the Task Force to carry out its duties has been judged by some to be extraordinary. In our opinion it reflects two things: the entire group was made up of unpaid volunteers who accommodated these additional responsibilities around existing commitments; and it gives perhaps some inkling to the casual observer as to the variety and complexity of the issues involved. A final decision on these matters is not simply a scientific assessment, but rather an attempt to overlay the science on society. This in turn requires some treatment of previously unsuspected issues.

Finally, I wish to emphasize that the Province has been extremely well served by the individuals who agreed to serve on this Task Force. They have been vigorous proponents of intelligent and thoughtful ways of dealing with difficult problems, while at the same time arguing forcefully for the preservation of an important piece of Nova Scotia. It has been my pleasure to have been part of this process.

Sincerely,

Robert O. Fournier

Robert O. Fournier
Chairman, Halifax Harbour Task Force

1.0 The Halifax Harbour Task Force

1.1 Why the Task Force Was Formed

Halifax and Dartmouth have been using Halifax Harbour as a repository for raw sewage for nearly 250 years. The first sewer pipes were installed in the 1850s. They discharged sewage and stormwater runoff directly into the Harbour at the closest convenient point. Today over 40 outfalls line the Halifax and Dartmouth waterfronts.

In the 1960s the NS Department of Environment refused to permit the construction of any new outfalls discharging raw sewage. As a result, the Mill Cove and Eastern Passage treatment plants were built to accommodate new development in Halifax County. But this still left 80 percent of Metro's sewage untreated.

For over twenty years sewage treatment for Halifax Harbour has been studied, debated and set aside. A study carried out by the Metropolitan Area Planning Commission (MAPC) in 1977 concluded that a single regional plant, providing primary treatment, should be located at Sandwich Point just to the north of Herring Cove. But no action was taken, mainly because federal funding for municipal sewer and water projects had disappeared.

Ten years later a second MAPC study concluded that this was still the appropriate choice. But this time the study led to Federal-Provincial negotiations and a subsequent agreement by the federal government to provide $73.4 million towards the estimated cost of the project.

This decision was greeted with dismay by the residents of Herring Cove who had already been involved in a protracted disagreement with the City of Halifax over problems with the existing outfall at Watleys Cove and storm overflows coming down the McIntosh Run. In response, MAPC requested that an environmental impact study be carried out to look at the effect of the proposed project on the Herring Cove fishery. The Minister of Environment gave this task to the Environmental Control Council in the spring of 1988.

The Environmental Control Council's report, published in February 1989, produced more questions. Three major gaps were targeted: the need for a better understanding of the Harbour as a marine environment, the lack of clear objectives for future Harbour use, and the need for public participation in the decision making process.

The Province's response was to commission a new physical oceanographic study of the outer Harbour, and to ask Dr Robert Fournier to form a Task Force to review the proposed regional sewage treatment project, focusing particularly on the marine environment and Harbour use objectives, and to report directly to the Minister of Environment. All the members were volunteers and the Task Force met regularly between April 1989 and June 1990

Box 1: Task Force Members

Robert Fournier, Chairman, is Associate Vice-President (Research) at Dalhousie University, and an oceanographer by training.

Raymond Côté teaches in the environmental studies and marine affairs programs at Dalhousie University and has a specific interest in toxic chemicals and marine environmental protection strategies.

Gordon Fader is a marine geologist with the Geological Survey of Canada at the Bedford Institute of Oceanography (BIO), studying the history and distribution of sediments off the East Coast.

Donald Gordon is Chief of the Habitat Ecology Division with the Department of Fisheries and Oceans at BIO. A marine ecologist, he has studied diverse environmental issues in coastal waters, and has been a longstanding member of the Dartmouth Lakes Advisory Board. Don Gordon also acted as liaison with the City of Dartmouth.

Jill Grant teaches environmental planning at the Nova Scotia College of Art and Design. Her research focuses on public participation and urban planning.

Paul Klaamas is Head of Municipal Wastes, Food and Technology Transfer, with Environment Canada. He reviews plans for wastewater treatment facilities and is involved in the transfer of technology in the wastewater treatment field.

Brian Nicholls is Head of the Marine Assessment and Liaison Division with the Department of Fisheries and Oceans at BIO, and also chairs the federal Science Advisory Committee on Halifax Inlet Sewage Disposal. Brian Nicholls also acted as liaison with the Town of Bedford.

Peter Pelham chairs the Herring Cove Ratepayers Association, and is a long-term resident of the Cove. He is a cameraman with CBC, a keen environmentalist, and very active in outdoor recreation.

Brian Petrie is a physical oceanographer with the Department of Fisheries and Oceans at BIO. He has studied the mean, wind-driven and tidal circulation in coastal embayments and on the Continental Shelf.

Stanley Purdy is a resident of Eastern Passage and has been a commercial fisherman for over forty years. He is the Secretary-Treasurer of the Eastern Shore Fishermen's Association.

Alan Ruffman joined the Task Force in January, 1990, as an alternate for Peter Pelham who was unable to attend all meetings for health reasons. Alan is a marine geophysicist, specializing in mapping ocean floors. He has been actively following the progress of the Harbour clean up since 1970.

Donald Waller is the Director of the Centre for Water Resources Studies at the Technical University of Nova Scotia (TUNS). His experience includes determining waste water loadings and planning sewage systems. Don Waller also acted as liaison with the City of Halifax.

Frank Potter, an environmental engineer and Assistant Director, Waste Management Branch, at the NS Department of Environment, acted as liaison between the Department and the Task Force.

Lesley Griffiths, an environmental planner with Griffiths-Muecke Associates, provided secretariat services to the Task Force.

1.2 The Issues

The Task Force focused its attention primarily on the following issues identified by the Environmental Control Council:

Environmental Quality Objectives

It is difficult to make decisions about outfall locations and treatment levels without proper goals. What vision do we have for the future of Halifax Harbour and what level of environmental quality must we first reach and then maintain? (The ECC Report talked about "water quality objectives" — the Task Force uses the term "environmental quality objectives" to include sediments and biota as well).

Knowledge About the Harbour

A recurring theme in previous studies was the lack of information about the physical, chemical and biological environment of the Harbour. Which way do the currents move? Do various layers of water move in different directions? Where do sediments accumulate and how thick are they? Where will sediments from the new regional system be deposited?

What Should be Included in a Regional Approach to Sewage Management

The regional plant proposed in the MAPC report would treat sewage from Halifax, Dartmouth and a small area of Halifax County. But the main growth in Metro is mainly occurring in the areas served by the Mill Cove and Eastern Passage plants. Can these plants be expanded and should they be? Should a regional system be planned to include these high-growth areas?

Innovative Sewage Collection and Treatment Technologies

Are alternative collection or treatment technologies available which can be used now or in the future? What impact might future technological change have on decisions made today?

Multi-Plant or Single Plant Approach

The MAPC report considered both single and multi-plant options but selected a single regional plant scenario. Many people who spoke at the ECC meetings favoured multiple plants for reasons related to the environment, politics or cost. What are the merits of each approach? How many outfalls are required?

Treatment Options

Earlier studies suggested primary treatment for an outer Harbour outfall and secondary treatment for the inner Harbour. The 1987 MAPC Report considered only preliminary and primary treatment and eventually recommended primary. What quality of effluent does each level of treatment deliver, and what impact would it have on water and sediment quality in the Harbour? What is required to reach environmental quality objectives? What form of disinfection should be used?

Control and Treatment of Toxic Contaminants

High concentrations of toxics in either water or sediment could harm marine life or humans, either through direct exposure or through accumulation in the food chain. What proportion should be prevented from entering the sewer system versus the amount that should be removed by treatment? What residual will be left?

Selecting an Outfall Location

Which comes first — plant or outfall site selection? The Task Force took the approach that outfall location takes precedence, based on Harbour use and environmental quality objectives. Following that, a range of potential plant sites within reasonable distance could be identified. What criteria are to be used in selection of outfall locations?

Containment or Disposal

Even with good control of toxics both at source and in a treatment plant, a certain level of contaminants will remain in the effluent. Should these be dispersed over a wide area to reduce concentrations, or should they be contained in a known area so that they can be readily monitored and controlled?

The Impact of Sewage Treatment on Contaminants in Existing Sediments

A concern exists that increased oxygen in the surface layer of Harbour sediments might liberate trace metals presently contained therein. How quickly might improved treatment bring this about? What will be the impact on water and sediment quality and on the animals living in the Harbour? Should this issue influence decisions about treatment level or outfall locations?

Location of Treatment Facilities

What are sewage treatment plants really like? Can they be reasonable neighbours or must they be kept as far away from residential areas as possible? What criteria should be used to identify and evaluate potential sites?

Costs

To what degree should costs be considered in decisions about siting outfalls and treatment plants and treatment levels?

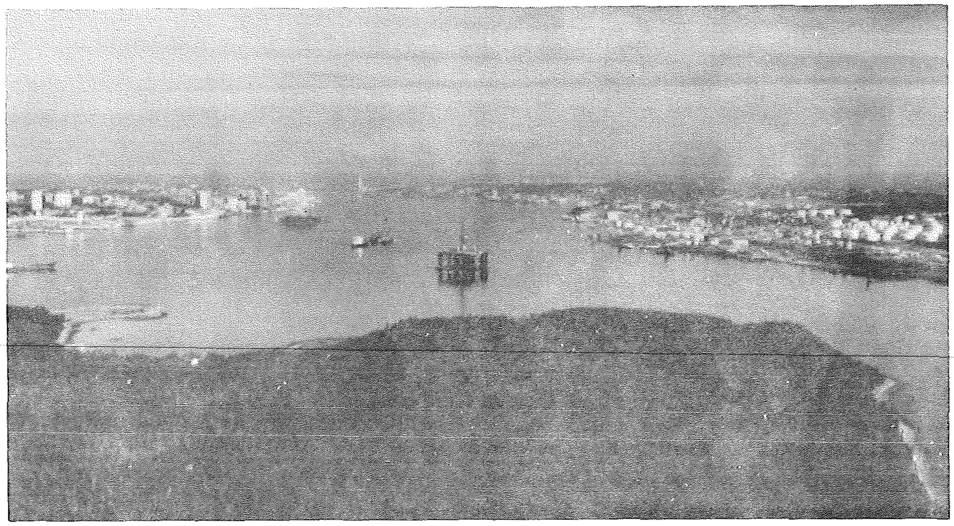


Photo 1: The Harbour Viewed From McNabs Island

Storm Overflows

Most sewers in Halifax and Dartmouth carry both sewage and stormwater runoff from streets and parking lots. Only sewers in recently developed areas are separate. When a sewage treatment system uses combined sewers, the capacity of the system will be exceeded sometimes during rainstorms. A mixture of stormwater and raw sewage will then be released directly into the Harbour through combined sewer overflows. What impact will this have on water quality and Harbour uses? Where should these overflows be located? What options exist to minimize their impact?

Public Participation in the Decision Making Process

The Halifax Harbour sewage treatment project has proceeded by fits and starts, with few opportunities for the public to participate in the process. The first formal opportunity for public involvement came only after a project had been defined and a site proposed. What role should the public play, and what information do they need?

Sewage Treatment and Harbour Management

Treating Metro's sewage will make an important contribution to the Harbour clean up but many other concerns remain. Do we need a cooperative approach toward planning and management for Halifax Harbour?

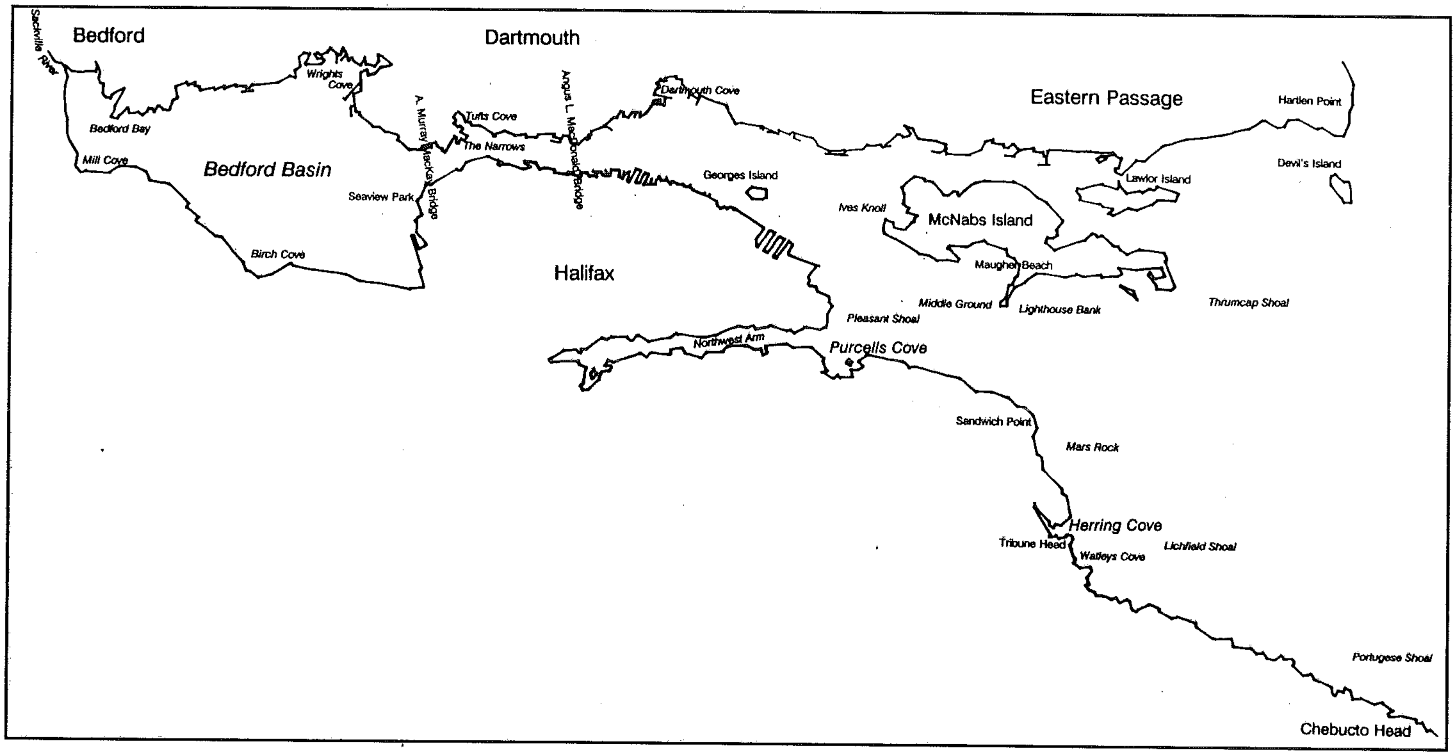


Figure 1: Halifax Harbour

1.3 Terms of Reference

The Task Force set the following Terms of Reference which were subsequently accepted by the Minister of Environment:

The Task Force will

Recommend Harbour use objectives related to environmental quality.

Examine existing engineering and scientific information.

Identify important information gaps and recommend studies needed to fill them.

Recommend, where appropriate, outfall siting criteria, treatment levels or other strategies.

Achieve the above goals with public participation.

> ***Box 2:* Selected Highlights**
>
> February 1989
> *Premier asks Robert Fournier to form Task Force*
>
> April 21
> *First meeting of the Task Force*
>
> July
> *Newsletter #1 distributed*
>
> July 24
> *Open Meeting at the Public Archives in Halifax*
>
> September 22
> *Boat tour of Halifax Harbour outfalls*
>
> October 20
> *Tour of Eastern Passage and Mill Cove treatment plants*
>
> November 9
> *Task Force members make presentations at BIO Workshop on the Halifax Inlet*
>
> November 14-15
> *Visit to sewage treatment plants in Boston and Providence*
>
> November
> *Newsletter #2 distributed*
>
> December 5
> *Workshop on Harbour Use and Water Quality Objectives in Dartmouth*
>
> February
> *Newsletter #3 distributed*
>
> February 20-27
> *Community Meetings in Eastern Passage, Bedford, Herring Cove, Dartmouth and Halifax*
>
> March - June
> *Analysis of information, development of recommendations, and report preparation*
>
> June 25
> *Final meeting*

1.4 Approach

As well as reviewing existing studies and reports, the work of the Task Force included a considerable amount of original research carried out by Task Force members and their colleagues at BIO.

Specifically, Brian Petrie analyzed both archived data plus data gathered during the 1989 ASA field study, developed models of the mean circulation, and applied them to determine the distribution of trace metals, suspended particulate material and nutrients in the Harbour. He also developed other models to determine the distribution of fecal coliform in effluent plumes.

Gordon Fader organized and led an extensive survey of the entire sea floor of Halifax Harbour. This involved acoustic profiling below the sediment surface, underwater photography, sediment analysis and overall evaluation of processes which have contributed to the present makeup of Halifax Harbour. The sedimentary and circulatory approaches are highly complimentary.

Task Force members also provided advice to ASA Consulting Ltd on their field study and modelling.

Public Participation

The Environmental Control Council Report identified an important need for greater public participation on the Harbour issues. Specifically, they suggested opportunities for both the general public and special interest groups to receive more information and to have more input. While unable to run a full-scale public participation program, the Task Force did respond to this need in the following ways:

Newsletters

Three newsletters were written and distributed to about 800 people. A fourth is a summary of this report. The mailing list was compiled from other selected lists, names gathered at public meetings, and people who responded to newspaper advertisements.

Briefs and Letters

In total, over 30 briefs and letters were sent to the Task Force by individuals and organizations (Appendix G). These included a petition signed by over 1400 people.

Task Force Open Meeting

An Open Meeting was held on July 24, 1989, in Halifax to permit people to meet Task Force members, comment on the proposed terms of reference and highlight issues they wanted the Task Force to address. This meeting was attended by over 130 people.

Harbour Use and Water Quality Objectives Workshop

Over 80 people attended this workshop held on December 5, 1989 in Dartmouth, at which various use and water quality scenarios were discussed.

Harbour User Meetings

A Task Force subcommittee met with commercial Harbour users, including Department of National Defense and the Port Advisory Committee. Discussions were also held with representatives of diving groups and windsurfers.

Community Meetings

Five community meetings were held at different locations around the Harbour and were attended by about 250 Metro residents. Five general outfall location scenarios were presented and discussed in small working groups. Participants were encouraged to fill out feedback forms and many did.

Observers

All Task Force meetings were open to observers. Members of the Ecology Action Centre's Harbour Committee attended nearly every meeting.

1.5 This Report

This report has been organized in five parts.

Part I, The Background, provides the context for the work of the Task Force, why it was formed, and the current status of sewage management in the Metro area.

Part II, The Harbour Today, briefly describes the natural marine ecosystem, the physical oceanography, the geological setting, and a summary of Harbour uses. It then reviews the present state of the Harbour environment.

Part III, Setting Objectives, is the pivotal part of the report. It sets out the principles used by the Task Force to make decisions, and the environmental quality guidelines against which predicted impacts were measured.

Part IV, The Regional Sewage Treatment System, explains the recommendations made by the Task Force on outfall location, treatment levels and plant siting.

Part V, Integrated Harbour Management, deals with broader Harbour management issues.

2.0 The Planning Context

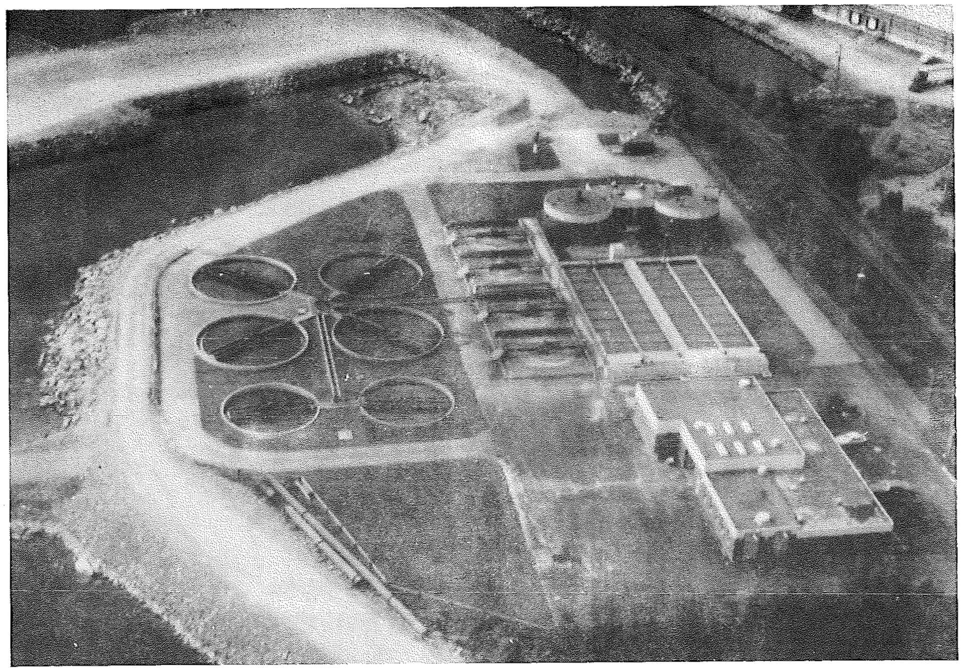


Photo 2: Mill Cove Sewage Treatment Plant

2.1 The Existing Sewage Collection System

Until the 1970s most of the sewers were combined, carrying both sanitary sewage (wastewater from domestic and commercial sources) and stormwater runoff. This situation is no different from that found in most older cities. It has been estimated that approximately half of Canada's population are served by combined sewers.

As development progressed outside the two cities the County of Halifax adopted a policy requiring the construction of separate sewers. One set of pipes was to carry stormwater to a local watercourse or to the Harbour, and one set to carry sanitary sewage to one of the County's sewage treatment plants. All Metro municipalities now require new development to use separate sewers.

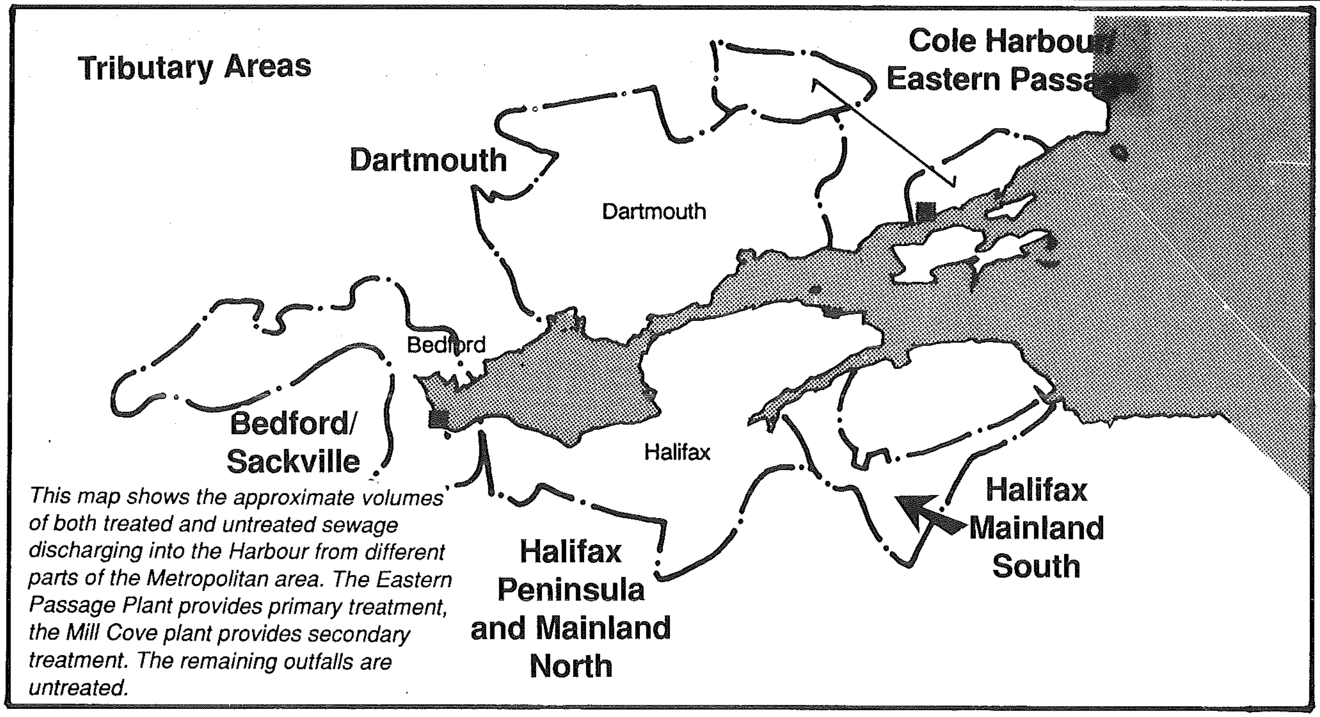
Figure 2 shows the approximate sewage loading from different areas of Metro. At this time no-one has precise information about how much sewage is discharged into the Harbour. Flows through the two existing treatment plants are gauged constantly, but the treated outflows only account for about 20 percent of the Metro total. Halifax Harbour Cleanup Inc., the body charged with the responsibility of designing and building the regional sewage treatment system, is now in the process of designing a study to provide more information on both the amount of sewage being discharged and its composition.

2.2 Existing Sewage Treatment Facilities

Mill Cove

The plant at Mill Cove was built by Halifax County in 1969 and provides secondary treatment. It serves approximately 30-35,000 people living in Sackville and the Town of Bedford. It was originally built to treat 11,250 m^3/d (2.5 Imgd), but by 1982 the capacity had to be doubled. Because the serviced area is developing rapidly the plant will soon require expansion again, and Bedford and the County are now studying the available options including the possible diversion into a regional system.

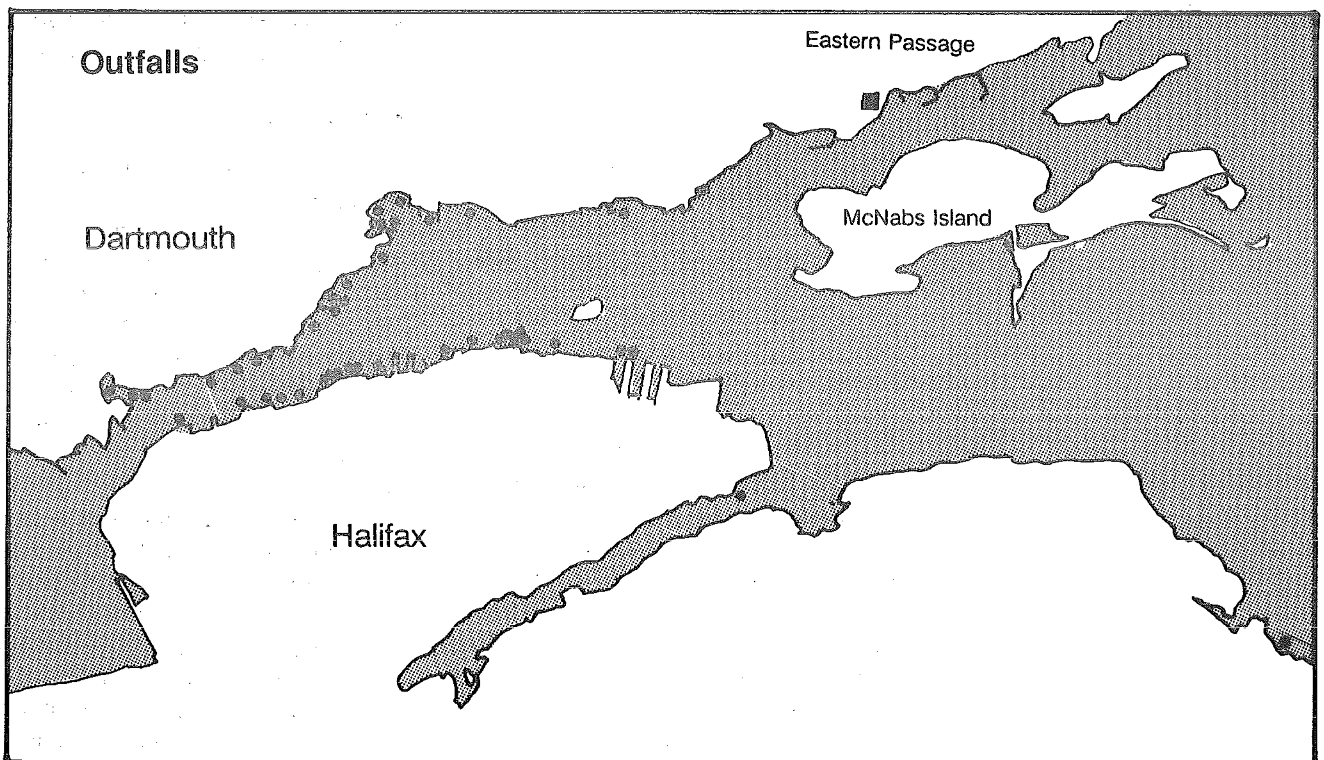
A prominent concern often heard about this facility deals with raw sewage which bypasses the plant and pumping stations during heavy storms. This occurs about 24 times a year at the plant but the pumping station overflows are not recorded. Overflows are screened and disinfected at the plant, but not at the pumping stations.



This map shows the approximate volumes of both treated and untreated sewage discharging into the Harbour from different parts of the Metropolitan area. The Eastern Passage Plant provides primary treatment, the Mill Cove plant provides secondary treatment. The remaining outfalls are untreated.

Average Dry Weather Flows

Halifax Peninsula and Mainland North	127,000 m^3/day	**Untreated Sewage**
Dartmouth	48,400 m^3/day	**Untreated Sewage**
Halifax Mainland South	9,000 m^3/day	**Untreated Sewage**
Cole Harbour/Eastern Passage	13,000 m^3/day	**Primary Effluent**
Bedford/Sackville	19,500 m^3/day	**Secondary Effluent**



● Separate or Combined Sewer Outfall
■ Sewage Treatment Plant

Figure 2: Existing Sewage Flows Into Halifax Harbour

Recent fieldwork by the Department of Energy, Mines and Resources to collect seismic and sidescan sonar data of the Harbour floor showed that large sludge banks have not accumulated around the outfalls at either Mill Cove or Eastern Passage. This indicates that in both cases there is enough energy in the local circulation to disperse most of the sediments.

Flows are bypassed at the plant during heavy rainstorms about 24 times a year, but the flows are screened and partially disinfected. Again, overflows from pumping stations receive no treatment and their frequency is not recorded.

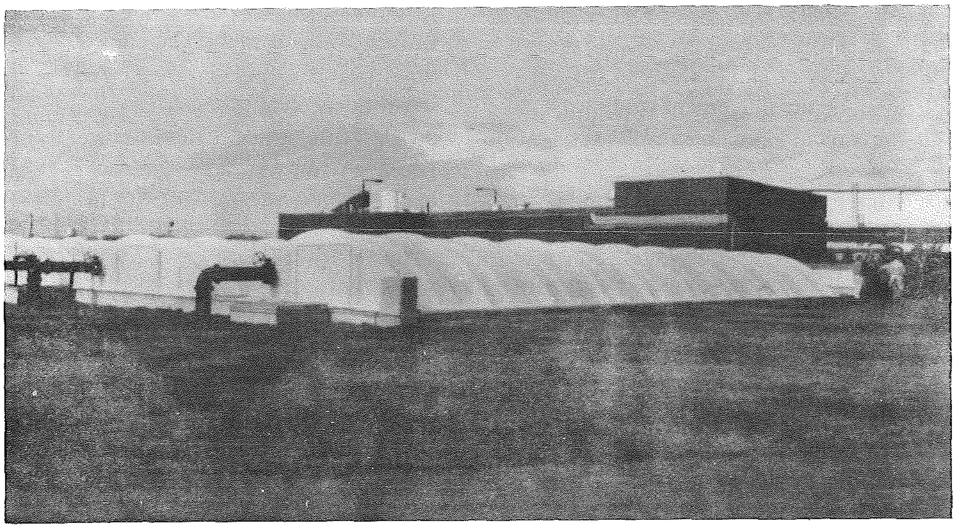


Photo 3: Eastern Passage Sewage Treatment Plant

Eastern Passage

The Eastern Passage plant serves about 25,000 people living in the Eastern Passage/Cole Harbour/Westphal area. It was built by the County of Halifax in 1974 to provide secondary treatment for 8640 m^3/d (1.9 Imgd), but like Mill Cove its capacity was soon exceeded. Because of overloading, the plant was plagued with odour problems from 1978 onwards.

Based on results from the water quality model developed for the MAPC Report, the County was given permission to expand the plant to handle 17,300 m^3/d (3.8 Imgd) and change the level of treatment to primary (with the stipulation that the plant would be upgraded to secondary again if necessary).

The expansion was completed in 1988. The work included covering all open tanks, installing air pollution controls, and changing the sludge digestion process. This greatly reduced odour problems, but complaints recurred temporarily until problems with the digester roof and the waste gas flow stack were solved.

2.3 The MAPC Report

The Halifax Inlet Water Quality Study completed in 1987 by MAPC is the most recent in a long list of reports on sewage treatment (see Box 3, *Previous Studies*). The consultants were asked to:

Study the current impact of sewage disposal on the Harbour

Develop a water quality model to assess the effect of various sewage management options

Recommend how the existing 40 or more outfalls could be consolidated into 6 major groupings

Determine what level of improvement would be achieved by
(a) altering the outfalls
(b) screening the effluent or
(c) providing primary treatment at these 6 locations

Compare these local improvements to the original proposal made in 1977 to build a single regional plant providing primary treatment at Sandwich Point.

The 1987 MAPC Study concluded that:

The main problems caused by sewage in the Harbour were the unsightly "floatables" and the concentrations of fecal coliform, and that these would only get worse with time.

Only primary treatment (out of the three options studied) would reduce the loading of coliform bacteria.

Both multi-plant and single plant options, with primary treatment, would reduce bacteria levels sufficiently to allow swimming throughout most of the Harbour, but that combined sewer overflows and stormwater run-off would continue to cause problems.

A single primary treatment plant at Sandwich Point would improve water quality most because the flushing rate is probably better towards the mouth of the Harbour and consequently the sewage effluent would disperse more quickly.

The capital costs of a multi-plant approach would be cheaper than a single plant, but operating and maintenance costs over the life of the plants would be higher.

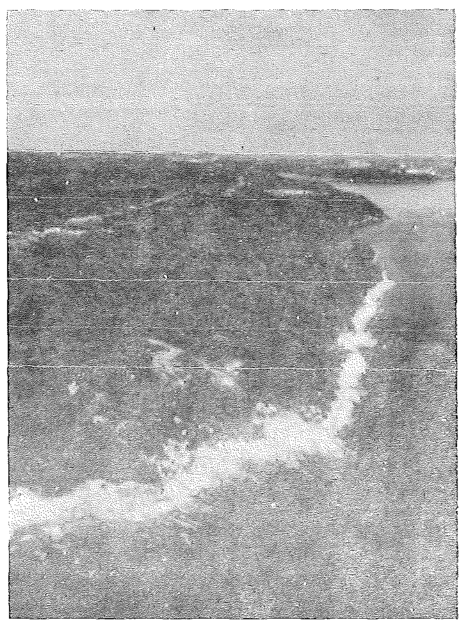


Photo 4: Sandwich Point

Box 3: Previous Studies

1966 County of Halifax
Servicing study for the Bedford-Sackville Area, recommended secondary treatment plant at Mill Cove. Updated in 1969 to include new development in Sackville. (These collection and treatment facilities were completed in 1971).

1969 City of Dartmouth
Pollution control study recommended five secondary treatment plants: three to discharge to lakes, two to the Harbour (Dartmouth Cove and Tuft's Cove).

1970 City of Dartmouth, County of Halifax
Two studies recommended use of watershed boundaries instead of political boundaries. Four treatment plants proposed (Tufts Cove, Dartmouth Cove, Marion Heights and Cow Bay) to serve both Dartmouth and adjacent County areas.

1970 City of Halifax
Study recommended improved design standards, upgraded collection system in annexed areas (these recommendations were both carried out), an interceptor tunnel along the Northwest Arm to prevent stormwater overflows, and the construction of a secondary treatment plant at Purcells Cove.

1971 County of Halifax
Study recommended system of gravity and pressure sewers to direct all sewage from Cole Harbour and Eastern Passage to a secondary treatment plant at Eastern Passage. (These collection and treatment facilities were completed in 1974).

1971 Metropolitan Area Planning Committee
Study concluded that a single regional plant would be the most cost effective. Recommended that the assimilative capacity of the Harbour be studied.

1977 Metropolitan Area Planning Commission (MAPC)
Recommended single regional primary treatment plant at Sandwich Point. The Eastern Passage and Mill Cove plants would continue to operate, but the assimilative capacity of Bedford Basin should be studied to determine the future of Mill Cove.

1978 County of Halifax
A sludge management study was conducted to evaluate different options for sludge generated at the County plants. (A sludge lagoon was eventually constructed at the AeroTech Park in 1989).

1979 County of Halifax
Study looked at future of Eastern Passage and Mill Cove plants. Did not recommend participating in regional system unless environmental studies indicated that tertiary treatment was needed at Mill Cove. (These studies were not carried out, but Mill Cove was expanded as a secondary treatment plant in 1982).

1981 NS Department of Municipal Affairs
Study of infrastructure requirements as part of the Regional Development Plan Review. Recommended comprehensive environmental study of the Harbour in order to develop appropriate pollution control policies for the region.

1981 City of Halifax
Study recommended improvements to eliminate uncontrolled raw sewage overflows into the McIntosh Run. (These were completed in 1989).

1985 County of Halifax
Study recommended expansion of the Eastern Passage plant as a secondary facility to accommodate growth to the year 2001. After that, an additional plant would be required.

1986 MAPC
Numerical model developed to assess present conditions and predict future water quality if sewage treatment not provided. This was Phase 2 of a three phase study.

1986 County of Halifax
Study using the water quality model to evaluate impacts of expanding Eastern Passage plant. Concluded that impacts would be minor whether secondary or primary effluent discharged. (The Eastern Passage plant was subsequently expanded as a primary facility in 1988).

1986 City of Halifax
Study of environmental problems caused by sewage discharges to McIntosh Run and Herring Cove. Recommended improvements to the outfall in Watleys Cove, and the construction of a primary treatment plant if shown to be necessary by a continued monitoring program.

1986 NS Department of Environment
Study of existing water quality conditions.

1987 MAPC
Phase 3 report evaluated different sewage treatment scenarios for the region.

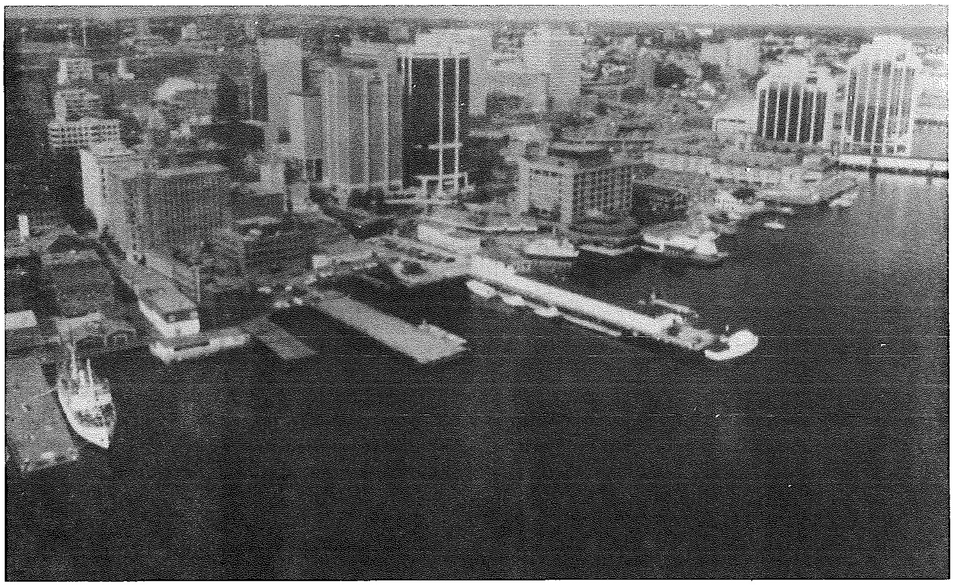


Photo 5: Downtown Halifax

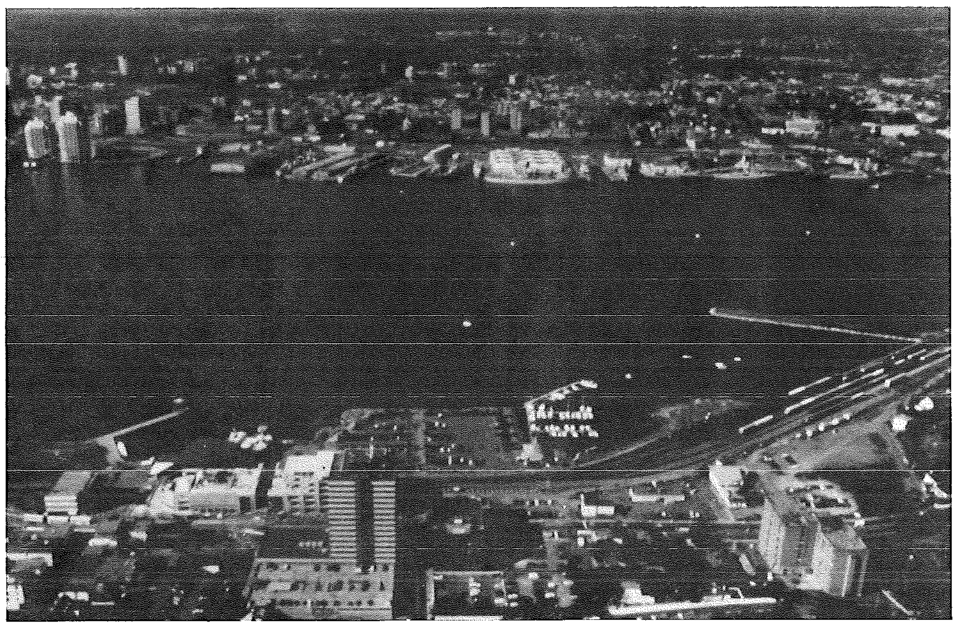


Photo 6: Downtown Dartmouth

2.4 The Federal-Provincial Agreement

In 1988, the Governments of Canada and Nova Scotia signed a subsidiary agreement which was a turning point for the regional sewage treatment project. The Agreement applied to a number of projects, but most of the assistance was earmarked for sewage treatment.

The central purpose of the Agreement is "to support further economic expansion in a manner compatible with the protection of the environment". The preamble to the Agreement states that the provision of municipal sewer services is fundamentally a provincial-municipal responsibility, but makes an exception in the case of Halifax Harbour on three grounds:

> The urgent concern of the current state of the regional infrastructure
>
> The amount of the region's wastewater which is currently generated by federal or federally supported facilities
>
> The opportunity to apply oil-from-sludge technology.

In the Agreement the Federal Government promised $73.4 million towards the estimated total cost of the regional sewage treatment project.

Two other key points in the Federal-Provincial Agreement were:

> That both parties agree to employ oil-from-sludge technology developed by Environment Canada's Wastewater Technology Centre in Burlington
>
> That there be an assessment of the feasibility of private sector involvement in the building and management of the sewage treatment facilities.

In 1989 a Memorandum of Agreement was signed by the Province, the City of Halifax, the City of Dartmouth and the County of Halifax, making a commitment to regional sewage management. The federal and provincial governments would split 75 percent of the estimated cost, while the three municipalities would share the remaining 25 percent on the basis of property tax assessment. The final cost sharing formula was as follows:

Federal Government	$ 73.4 million
Provincial Government	$ 73.4
Municipalities	$ 48.9
	$195.7

The municipal portion of the total cost would be split as follows:

City of Halifax	66.6%
City of Dartmouth	32.8%
County of Halifax	0.6%

The Memorandum also stipulated that the municipal share of any cost overruns would be limited to 25 percent. (The Federal Government made no commitment to cost-share overruns).

The Province and the municipalities agreed to establish Halifax Harbour Cleanup Inc. to oversee the design and construction of the regional sewage treatment system. The Corporation was formed in June, 1989, and has begun work on a number of projects including a flow gauging and sampling program, geotechnical studies, surveying and mapping, and the development of a geotechnical information system.

The organization chart in Figure 3 shows how the Federal-Provincial Agreement is managed.

2.5 REGULATION OF SEWAGE DISCHARGES

Jurisdiction

The Federal Fisheries Act and the Canadian Environmental Protection Act (CEPA) apply to municipal sewer discharges. The Fisheries Act prohibits the discharge of substances deleterious to fish except where approved by regulations, while CEPA may be applied to the control of some toxic substances discharged from local sources. Environmental quality objectives developed under CEPA may influence the level of treatment applied to municipal wastes. Finally, the ocean dumping provisions of CEPA would be used to control the disposal of sewage sludge in the ocean if this were ever to be contemplated. It is quite clear, as a result of recent Supreme Court decisions, that the federal government has the jurisdiction and authority to exercise control over sources of marine pollution.

Unfortunately the situation is not that simple because traditionally legal control has been exercised over the activities of municipalities by the provinces. In Nova Scotia, this has been achieved through such legislation as the Towns Act and the Planning Act. Environmental legislation such as the Environmental Protection Act and the Water Act can also be brought to bear, at least above the tidal high water mark.

Responsibilities

The responsibility for the prevention and control of water pollution at the provincial level is shared by the Nova Scotia Department of Environment (NSDoE) and the Nova Scotia Department of Health and Fitness. Before a municipality, company or individual proceeds to construct a wastewater treatment system, a Joint Certificate of Approval must be obtained from both departments. This permits the proponent to proceed with construction. It can contain certain stipulations about the size of the facility, the type of treatment, and the effluent quality but a separate operating permit is not required. If a plant contravenes these stipulations, the Department must issue a Ministerial Order, and, if subsequently necessary, lay charges.

The Department is currently in the process of reviewing its manual which contains guidelines for wastewater treatment design and operations.

The Federal Department of Environment has the mandate to clean up and control pollution from all land-based installations covered under federal statutes. In most cases the NS Department of Environment reviews and approves projects, and the federal role remains an audit function. Exceptions occur under the following circumstances:

The final effluent from the treatment plant is discharged to an interprovincial or international water body.

The discharge poses a potential threat to a fisheries or shellfish resource.

No active provincial programs exist.

The discharges pose a potential health threat.

The discharge occurs within an area bounded by federal property or from an installation owned or operated by the federal government.

Environmental Impact Assessment

In addition to legislation pertaining directly (or indirectly) to discharges into Halifax Harbour, both the federal and provincial governments have adopted environmental impact assessment requirements. These requirements are preventive in nature and are designed to ensure that ecological and socio-economic implications of programs and projects are adequately considered before irrevocable decisions are taken. The Halifax Harbour sewage treatment project will be subject to some form of environmental impact assessment over and above that already undertaken by this Task Force and other studies.

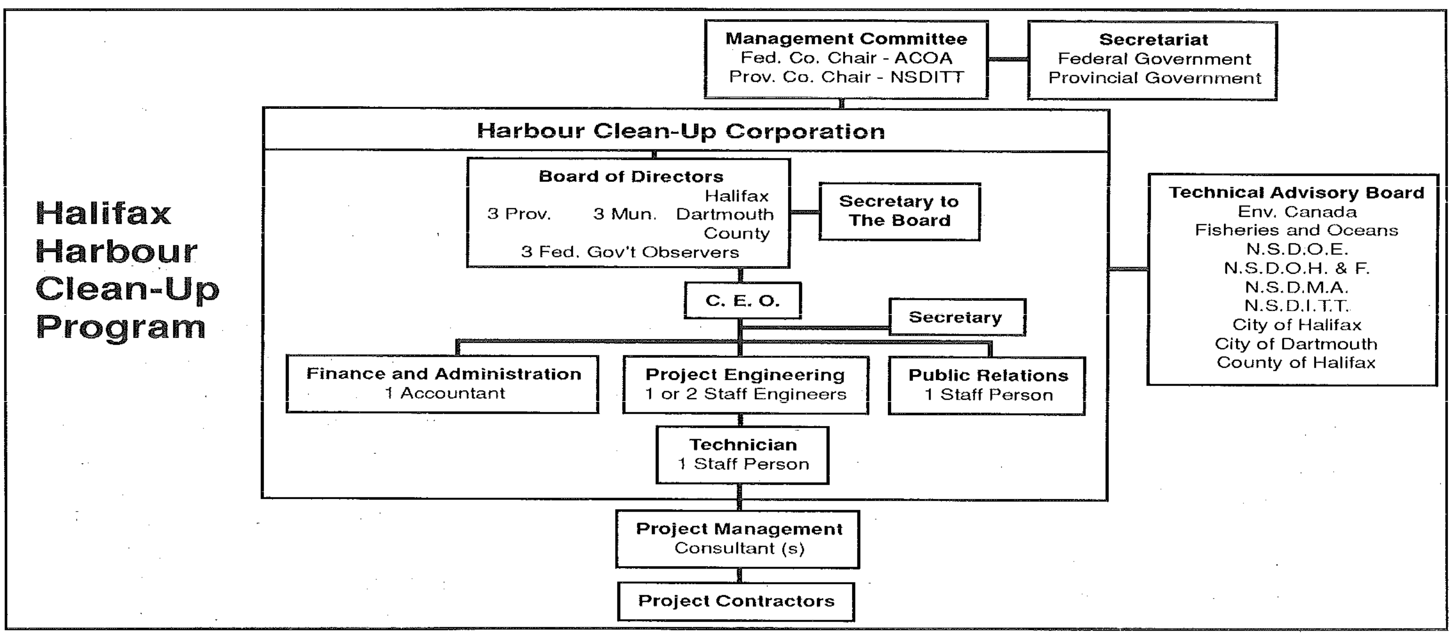


Figure 3: Organization Chart

3.0 Sewage and Stormwater Management Alternatives

3.1 Sewage: Sources and Characteristics

Sewage is the flow of used water and wastes from a community. The characteristics of sewage will vary from location to location depending upon such factors as the population, industries served, land uses, groundwater levels, and degree of separation between storm water and sanitary wastes.

Usually about 400 litres of sewage are generated per capita per day in Canadian cities. Great variations in flow rate are often observed throughout a day, as well as from season to season. In larger communities sewage flow can vary from 20 percent of the average in the middle of the night to 200 percent at times of peak water use (early morning for example).

Sewage is usually gray in colour and has a musty odour. It is 99.9% water, with only 0.1% solids. About one third of the solids are suspended and the rest are dissolved. Wastes are composed of organic components (such as carbohydrates, proteins, fats, greases, oils, pesticides), inorganic compounds (heavy metals, nitrogen, phosphorus, toxic compounds) and various gases.

According to sampling carried out by Environment Canada and compared to the characteristics of sewage from other urban areas, sewage in the Metro area can be classified as weak. Biochemical oxygen demand (BOD) averages about 110 mg/L, suspended solids about 100 mg/L, and oil and grease about 50 mg/L.

3.2 Stormwater and Combined Sewage

Stormwater runoff is precipitation that travels across land surfaces before entering receiving waters. Make-up of stormwater reflects the composition of precipitation and the surfaces with which it has come in contact. Suspended solids concentrations tend to be high, especially where new development is occurring and the soil is exposed. BOD values are often low, bacteria are high from contact with animal droppings, and nutrient concentrations can also be significant due to artificial fertilizers. Sometimes sanitary sewers are illegally connected to storm sewers which will increase contamination.

Combined sewage in dry weather is principally sanitary sewage plus some inflow into pipes from groundwater. Since the pipes are sized to carry high flows in wet weather, they may allow solids to settle out in dry periods. With the return of wet conditions composition will be affected by those solids deposited earlier and later scoured out.

Typical concentrations in urban storm runoff and combined sewage, compared with sanitary sewage, are indicated in Table 1. The diagram in Figure 4 shows the difference between combined and separate systems.

	Suspended Solids	BOD	Fecal Coliform per 100 mL
Urban Storm Runoff	170 mg/L	14 mg/L	1×10^4
Combined Sewer	190 mg/L	40 mg/L	5×10^5
Sanitary Sewage	225 mg/L	165 mg/L	3×10^6

Table 1: Concentrations of Typical Contaminants in Urban Storm Runoff, Combined Sewage and Sanitary Sewage

3.3 Sewage Treatment

Source Controls

The three Rs - Reduce, Reuse and Recycle - are usually addressed in connection with solid waste management, but they apply equally well to sewage management, and particularly to the problem of persistent toxics. These contaminants are often attached to the smallest particles in the sewage and are therefore difficult and expensive to remove. Secondary treatment involves biological processes which are particularly vulnerable to disruption by high concentrations of toxic material in the waste stream.

Sewage treatment will remove some of the toxics; just how much depends on the particular chemical involved and the level of treatment. This is why ranges as wide as 0-40% are typically cited for the removal of heavy metals by primary treatment. The range cited for secondary treatment is around 15-65%. But it is important to understand that neither primary nor secondary treatment come with any guarantees respecting metal removal. Depending on the composition of the raw sewage, it is quite possible that a primary and a secondary plant could achieve very similar rates of removal for certain critical chemicals.

Reliably high levels of removal (85-95%) are only achieved with tertiary treatment. But this has two major drawbacks. The first is cost. The second is that the toxics removed from the effluent through treatment do not disappear, but are concentrated in the sludge. As sludge becomes more contaminated, options for recycling or disposal become more limited. This problem is intensified by the fact that higher levels of treatment produce substantially more sludge.

The answer to this problem is to ensure that toxics do not get into the raw sewage in the first place by establishing and enforcing strict source controls.

Source controls can be generally applied but are especially important with many commercial and industrial establishments and some institutions. A variety of pretreatment and treatment systems are available to reduce the volume and toxicity of discharges into municipal sewers. Pretreatment or waste minimization can be enforced by

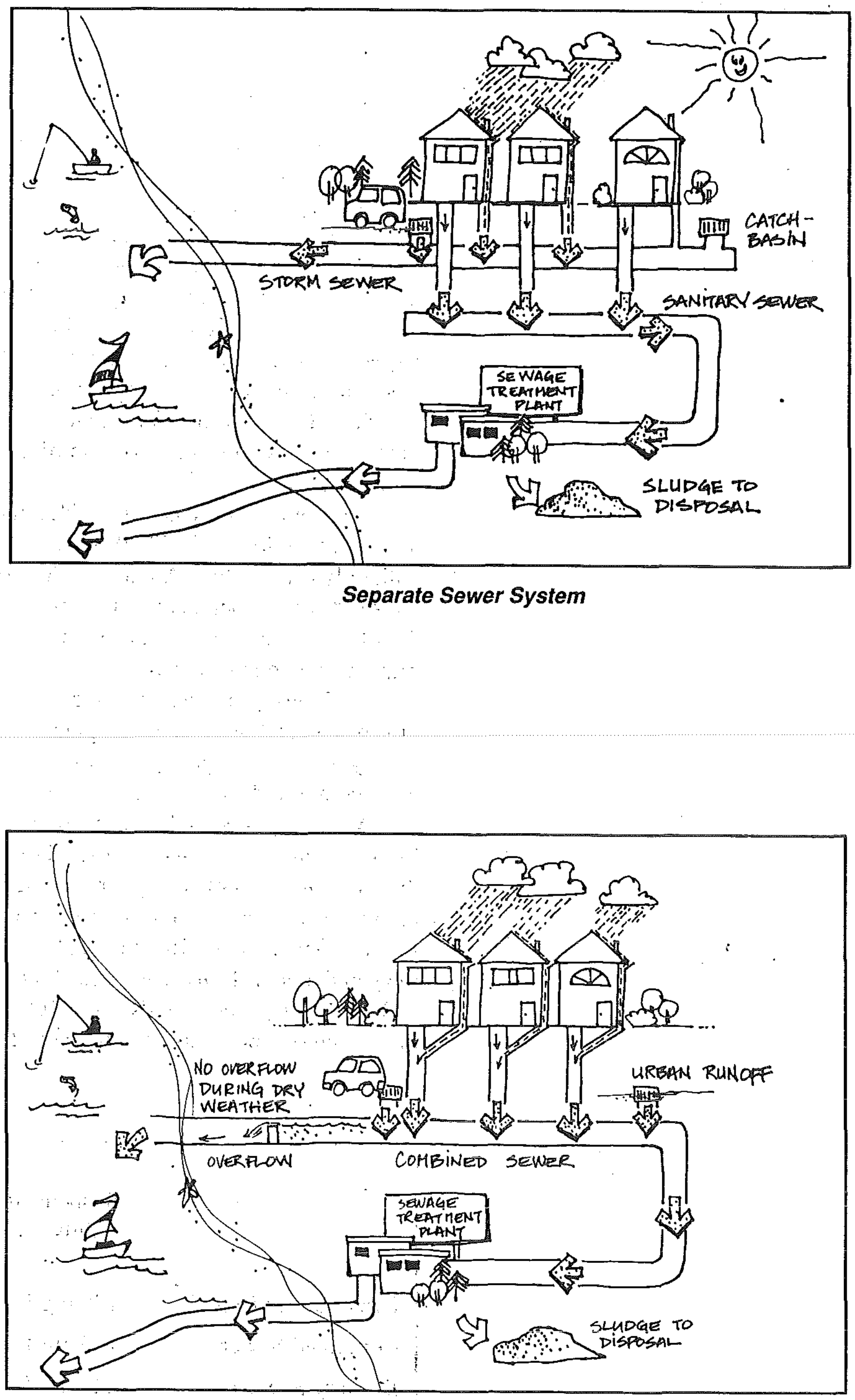


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Figure 4: Combined and Separate Storm Sewers

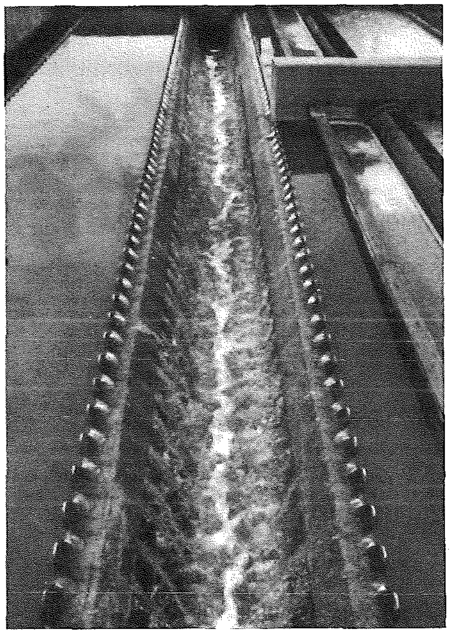


Photo 7: Discharge from primary clarifier

regulations such as sewer use by-laws as well as user fees and administrative fines. Measures can include reducing the volume and hazard of the waste, recovering chemicals used in the manufacturing process, re-using dilution water or process solutions and recycling some waste products. Treatment of the remaining effluent may also be required before it is discharged into the sewer system. These requirements can be imposed on a case by case basis or uniformly across all similar industries or wastes. In addition, recovery of chemicals is often shown to be of economic benefit to the industry in question.

Source controls can also be applied to domestic waste sources. A large number of products containing toxic chemicals are flushed down sinks and toilets when they are no longer needed. Approaches to controlling domestic wastes can include household hazardous waste collection facilities and public education about reducing or safely disposing of wastes.

Water conservation is also a form of source control. Measures include using low flow shower heads, low flush toilets or composting toilets, or simply turning the tap off while washing or brushing teeth. Pressurized low flush toilets, for example, use about 7 litres of water per flush compared to 22-27 litres used by conventional toilets. In theory, by using less water, we could reduce or conserve the hydraulic capacity needed in the regional system. However, it is possible that the hydraulic impact would not be all that significant because of groundwater infiltration into the collection system. Water conservation also does not lower the total organic loading: volumes would go down but BOD concentrations would go up.

Primary Treatment

Primary sewage treatment consists of two main processes: preliminary treatment and primary sedimentation. Primary treatment removes about 90-95% of the settleable and floating solids which cause most of the aesthetic impacts. It also removes about 40-60% of the suspended solids. This in turn removes about 25-

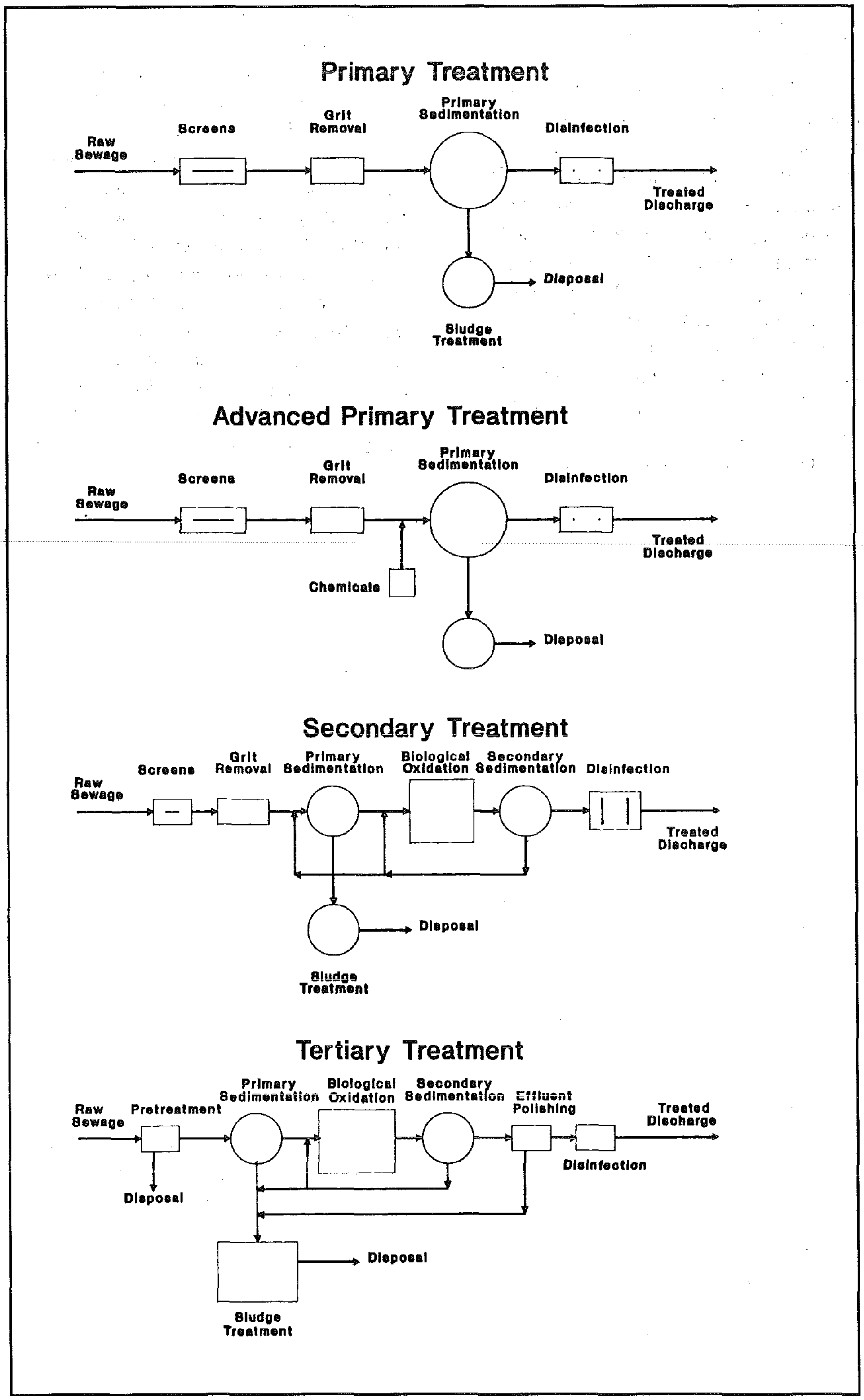


Figure 5: Sewage Treatment Processes

35% of the biochemical oxygen demand and about 35% of the fecal coliform bacteria.

Preliminary treatment removes or reduces solids such as sand and gravel, pieces of wood, cloth, paper, plastic and fecal matter. It also removes excessive amounts of oil and grease. The processes involved include coarse and fine screening devices, grinders and cutters, grit chambers, and pre-aeration chambers.

Primary sedimentation removes organic and inorganic settleable and floating solids by reducing the velocity of the flow so that a major portion of solids will have sufficient time to settle out. Normally, primary sedimentation tanks are designed to provide for a detention time of approximately 1.5 to 2.5 hours based on the average dry weather rate of flow. Primary sedimentation produces about 3000 litres of sludge (about 120 kg on a dry weight basis) per million litres of sewage processed.

Heavy metals and nutrients associated with the settled solids are removed in the primary sludge, but many of these substances remain in the liquid stream and pass through the primary treatment stage. The removal efficiency for heavy metals can range anywhere from 0 to 40% depending on the metals involved. The range for nutrient removal will be 0 to 20%.

Figure 5 shows schematically the process sequence for primary, advanced primary, secondary and tertiary treatment.

Advanced Primary Treatment

Advanced primary treatment consists of primary treatment plus the addition of chemicals to improve the recovery of finer particles. By adding chemicals it is possible to increase the removal of suspended solids from 60 to 85% and of biochemical oxygen demand from 40 to 70%. Heavy metal removal efficiencies also improve as do nutrient removal efficiencies.

The main drawback to this level of treatment is that it generates larger quantities of sludge. Advanced primary treatment produces slightly less than twice the amount of sludge generated by regular primary treatment on a dry weight basis.

Secondary Treatment

Secondary treatment involves aerobic biological oxidation and secondary sedimentation following primary treatment. Secondary treatment removes soluble and particulate organic matter by microbial decomposition. Secondary treatment will remove approximately 85-95% of the biochemical oxygen demand and approximately 85-95% of the suspended solids.

Secondary processes commonly used are activated sludge, rotating biological contactors and trickling filters. Waste stabilization ponds and aerated lagoons are also considered as secondary treatment systems since they depend on microbial decomposition to degrade organic matter in the sewage, but these methods require more land and are not generally considered where land availability is a problem. Because secondary treatment uses biological rather than mechanical processes, there is greater potential for operating problems.

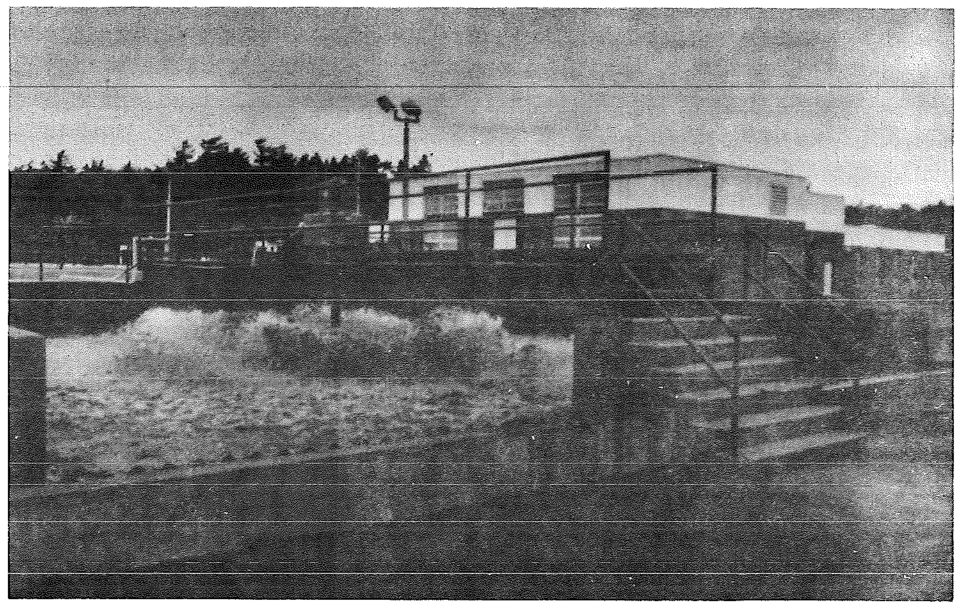


Photo 8: Aeration Tank, Secondary Treatment

Secondary treatment generates about twice as much sludge (about 240 kg on a dry weight basis) as primary treatment. On average heavy metal removal efficiencies in the 15-65% range can be expected, and nutrient removal efficiencies of approximately 10-30%.

Tertiary Treatment

Tertiary treatment is an advanced type of treatment or "polishing" stage following secondary treatment. A number of different processes for different purposes can come under the heading of tertiary treatment. Phosphorus, heavy metals, and colloidal solids can be removed using chemical precipitation. Nitrogen can be removed through nitrification-denitrification; suspended solids can be filtered; and activated carbon adsorption can remove dissolved organics, and inorganic compounds such as heavy metals. At the end of tertiary treatment, approximately 80-95% of the nutrients and heavy metals can be removed.

Disinfection

Sewage disinfection is carried out to prevent waterborne transmission of disease. It is applied just before the effluent is released in order to kill most of the remaining organisms. There are many disinfection alternatives available but those most commonly used include chlorination, ozonation, and ultraviolet radiation. When deciding how to disinfect sewage effluent, factors to be considered include effectiveness, reliability, cost, complexity, flexibility, safety, site specific constraints, and potential adverse effects.

Chlorination is the most common method of disinfection used at sewage treatment facilities. The effectiveness of the chlorination process depends on factors such as suspended solids, temperature, pH, alkalinity, chemical oxygen demand and nitrogen containing compounds. Chlorine is a strong oxidizing agent with a high solubility in water.

Free available chlorine is seldom found in treated effluents because the applied chlorine dosage is below the "breakpoint" level between free chlorine and ammonia. Thus, only combined available chlorine is usually detected. However, if complete chlorine residual removal is required before the disinfected effluent is discharged to the receiving waters dechlorination of the effluent can be achieved by use of compounds such as sulfur dioxide and activated carbon.

Chlorine can be supplied in a gaseous, solid or liquid form. In the gaseous form, chlorine is handled in steel containers of 68 kg cylinders up to 82 tonne railroad cars. In Nova Scotia, the most common sizes used are the 68 kg cylinder and the 0.91 tonne container.

Hypochlorination involves the use of solid or liquid hypochlorite compounds and is typically used at smaller treatment plants because of cost. Larger plants also sometimes use sodium hypochlorite, in spite of the higher unit costs, in order to minimize the risks of transporting liquid chlorine through populated urban areas.

Because ozone is an unstable gas it needs to be generated on site from air or oxygen. It is a very effective disinfectant, but its residual is short-lived and therefore difficult to measure. An ozonation system is usually more complex to operate and maintain than a chlorination system. At present there are no ozonation systems at sewage treatment facilities in Atlantic Canada. There are ozonation systems in use at water treatment facilities, but the water is also chlorinated to provide a measurable residual to indicate instantly that disinfection is occurring.

Ultraviolet radiation is a physical disinfecting process as compared to the chemical processes of chlorination and ozonation. The equipment, consisting mainly of ultraviolet lamps, is simple to operate and maintain. However, the fouling of the lamps requires regular maintenance to ensure optimum efficiency. High levels of suspended solids, colour, or soluble organics in the effluent can reduce disinfection efficiency. Improvements in lamp and system designs, improved reliability, lower costs, and simplicity of operation are helping to make ultraviolet radiation more popular as a disinfection method.

Dilution and Dispersal

The final step in the whole treatment process is dilution and dispersal in the receiving waters. Even with an effective disinfection system, effluent will still contain fairly high concentrations of fecal coliform bacteria and other pathogens, and levels in the immediate area of the outfall usually exceed water quality standards for swimming. These bacteria will die after several hours in seawater and so the goal is to design and locate the outfall diffuser in such a way that any surviving bacteria are quickly dispersed to an acceptable level before coming into contact with any sensitive areas. This also applies to other contaminants in the effluent.

New Treatment Technologies

Newer treatment technologies include those using plants and other living organisms to extract and use contaminants from the sewage, either in man-made marsh systems or in tanks covered by solar greenhouses. Direct land application of sewage is practised in some areas.

Some of these systems are achieving effluent equivalent to tertiary standards, and at much lower costs. They are particularly effective in removing and using nutrients. The marsh systems require large areas of land, however. In Arcata, California, for example, 40 hectares (100 acres) is needed to treat the sewage from 15,000 people. Even if such a system would work well in Nova Scotia's colder winters, this means that about 800 hectares (2,000 acres) would be needed to serve Halifax and Dartmouth. The solar tank systems require much less space, but have so far only been used in small pilot projects.

3.4 Sludge Management

Sewage treatment splits the waste stream into three parts: the liquid effluent, screenings (the large solids screened out in the early stages), and sludge. Often, public attention is focused on effluent and its ultimate fate. However, the problems of handling and disposing of sludge and screenings is increasingly affecting major decisions about design and location of treatment systems. One dilemma is that as effluent quality improves through treatment, the sludge problem gets worse because both the volumes and the contamination levels increase. A sustainable development approach to sewage treatment demands that sludge be considered as a resource, but options for using the sludge as compost or soil conditioner may be limited by the presence of heavy metals and other toxics.

Different treatment processes produce different kinds of sludge which need further treatment to make them useable. The processes used will depend on the characteristics of the sludge. Their purpose is to condition, thicken, stabilize and finally dewater the sludge. At this point the sludge is more easily handled.

Sludge management options include land application, co-disposal with municipal solid wastes, composting, incineration and using the sludge to generate oil. Screenings are usually landfilled or incinerated.

Oil From Sludge

A new sludge treatment option, "oil from sludge" technology, currently under development by Environment Canada at the Wastewater Technology Centre in Burlington, offers an alternative approach to sludge management.

The sludge is preconditioned by mechanically removing water to yield a sludge with approximately 35% solids and then dried to 95% solids. The dried sludge is then heated, without oxygen, to a temperature of 350 to 450 C, producing gases and solids with the metals in the sludge acting as catalysts. The gases are condensed and converted into oil while the solids form the char. The char produced in the process provides the energy to dry and heat the sludge to the required temperature for the conversion process, while the oil would be surplus for use elsewhere.

Data on the process comes from the pilot plant at Burlington, and from a second pilot plant in Perth, Australia. Average oil yields have ranged from less than 20% (on a dry sludge solids basis) for anaerobically digested sludges, to about 45% for raw sludges. The oil produced generally meets the specifications for a #4 fuel oil. A joint research program with the federal Department of Energy, Mines and Resources is currently evaluating alternative uses of the oil. The process produces about 150 to 300 litres of oil and approximately 0.5 tonne of char per tonne of dry sludge processed.

A significant advantage of this technology is that the residual material (in this case ash) needing disposal is only about 20 to 30% of the original dried sludge volume. The process operates at low enough temperatures to ensure that the metals remain in the char but at the same time the temperatures are high enough to ensure that all pathogens and viruses are destroyed. The combustion process converts the metals to non-leachable oxides or silicates, which do not pose environmental problems. Existing air pollution abatement technologies would be able to reduce all emissions to meet clean air standards.

Energy is routinely recovered from sludge in conventional sludge management processes in the form of methane which can then be used to provide space and process heat for the treatment plant. In the case of oil from sludge the main difference is that the energy can easily be stored. In the summer months the methane produced in conventional plants usually exceeds heating requirements and has to be flared off.

Oil from sludge technology can be used with all levels of treatment. In order to be cost effective 20-25 tonnes of dry sludge per day would be required. Current data indicate that raw sludge generates more oil than digested sludge.

3.5 Costs

About halfway through its deliberations, the Task Force commissioned a very general costing exercise. The purpose was not to put exact costs to precise scenarios, but rather to enable the Task Force and the public to understand in a general sense the kinds of economic trade-offs which may have to be taken into consideration. These trade-offs can include different levels of treatment, multi-plant options versus single plant options, and different locations for treatment facilities and outfalls.

The Task Force was cautious about relying on the costs predicted through this exercise. The costs provided in the MAPC Phase 3 Report, which had developed more precise scenarios, were only considered accurate within plus or minus 30 percent. More exact costs cannot be estimated until after the design stage of the final project. Nor did the Task Force forget that a broader understanding of costs and benefits must take more into account than just the direct costs of constructing and operating facilities.

As a first step, the Task Force divided the Harbour and its approaches into six basic subdivisions, referred to as "boxes" (Box A to Box F). These are shown in Figure 6.

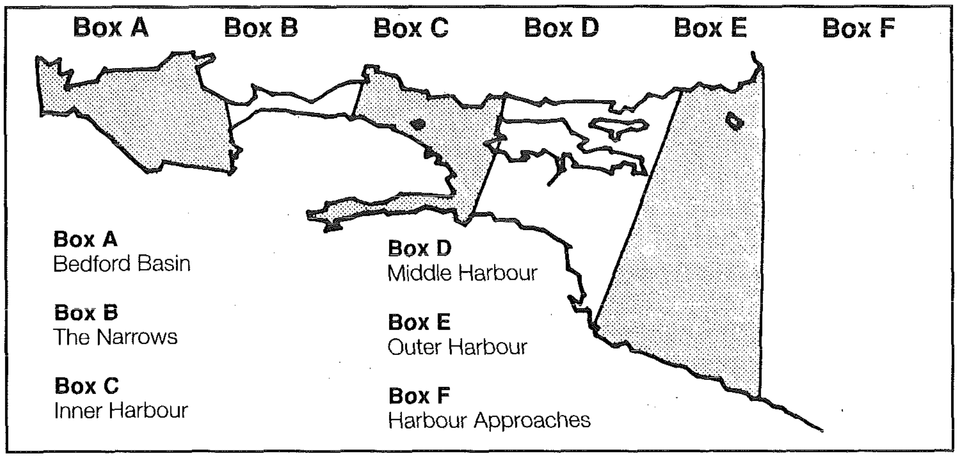


Figure 6: Harbour Subdivisions

Harbour Subdivisions used by Task Force to assess potential impact of locating outfalls in different parts of the Harbour.

A range of possible outfall locations and treatment scenarios was then developed and costed. Because of the general nature of the exercise, exact outfall locations were not specified (for cost purposes only, it was assumed that the outfall would be in the middle of the relevant box). As this work was carried out before potential treatment plant locations were identified, certain assumptions had to be made about land availability. For this reason, only a multi-plant option was costed for the scenario discharging into Boxes B and C because it was assumed that land availability would preclude the construction of a single regional plant in this area.

Figure 7 shows the comparative capital, operating and lifecycle costs for alternative collection and treatment options. Box 4 explains the basic assumptions used in estimating these costs.

***Box 4:* Assumptions Used in the Comparative Cost Estimates Shown in Figure 7**

Option 1:5-plant scenario discharging most of the sewage into Box B

Option 2:2-plant scenario discharging toBox C

Option 3:1-plant scenario discharging to Box D

Option 4:1-plant scenario discharging to Box E

Option 5:1-plant scenario discharging to Box F

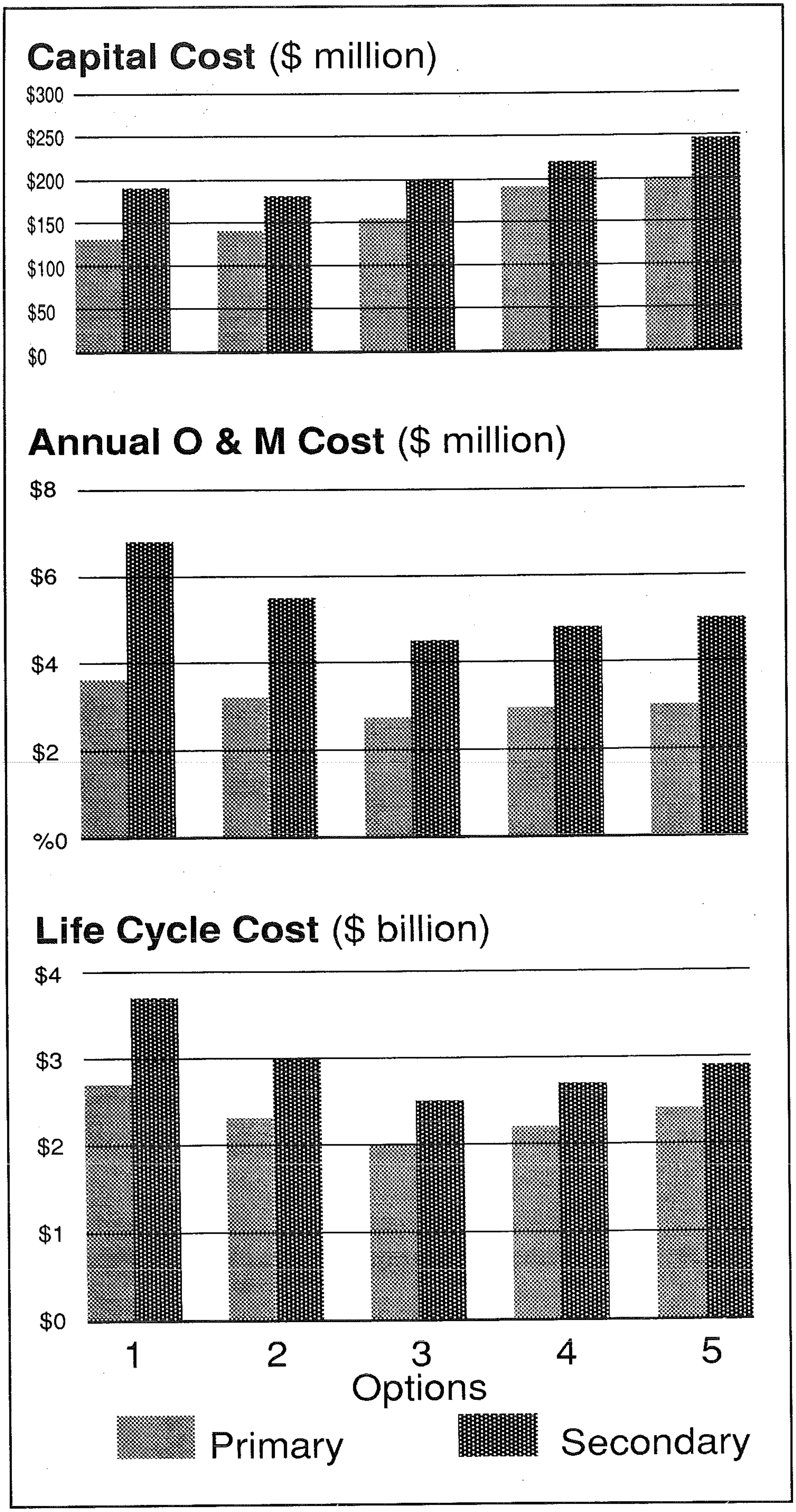


Figure 7: Comparative Capital, Operation and Maintenance, and Life Cycle Costs for Different Options

Costs are to the first quarter of 1987.

Capital costs include an allowance of 20% for engineering and contingencies.

Construction costs are based on historical prices for similar work.

Operation and maintenance costs for treatment systems include labour, power, chemicals, materials supply, and sludge disposal costs.

Operation and maintenance costs for pipework and tunnels are 0.25 % of construction costs.

Land purchase costs are based on assessed values. Land costs also include reclamation, clearing and grubbing, and site grading.

Annual costs based on;
- 10% interest rate
- 20 year amortization
- first year costs not including inflation
- municipal share only (25% of capital cost)

Life cycle costs based on;
- 60 year period
- interest rate 10%
- inflation rate 5%
- capital expenditure of 25% of initial capital cost required after 20 years and 40 years to allow for expansion and equipment replacement
- operation and maintenance costs increased by 25% at 20 years and 40 years.

Infrastructure Requirements

A trunk sewer will be required to intercept flows from the forty or more outfalls along the Halifax and Dartmouth waterfronts. The interceptor system will probably be constructed using conventional large diameter piping, or a combination of piping and tunnels. The specific construction technique chosen will depend on factors such as hydraulic capacity, vertical alignment and geotechnical conditions. The interceptor system will take the sewage to one or more sewage treatment plants. Pumping stations may be required at strategic locations along the interceptor system, and also to lift sewage into the plant or plants. Treated effluent will be discharged through one or more submerged outfalls, using diffusers to maximize the initial effluent dilution.

Design Considerations

Underground pipework and tunnels generally have a useful service life of over 100 years. These systems are not easy to expand once built, especially in extensively developed urban areas. Therefore interceptors are commonly designed to accommodate flows well into the future, taking into consideration the future complete development of the drainage area served.

Treatment plants and pumping stations are modular in design and may be readily expanded, provided there is sufficient land, to accommodate future load increases. Common design horizons for these components are 15 to 20 years, after which expansion and upgrading are required. The structural elements of pumping station and plants have a useful service life of 50 to 100 years, but the equipment and machinery usually only last 20 years after which they must be replaced or refurbished.

Treatment Technology

The degree of treatment required and the type of treatment process used will significantly affect the cost of the project. The cost of treatment increases with the level of treatment provided. For example, the capital cost of a secondary treatment plant is typically 1.5 to 2.0 times the cost of a primary treatment plant, and the operation and maintenance costs are about 1.75 to 2.25 times higher. The cost increase for the whole project would not be as great because the cost of treatment plants only represents a portion of the total project cost. Secondary treatment would increase the capital costs of the *total* project by 20 to 30 percent, and the operation and maintenance costs of the project by 60 to 70 percent.

The choice of specific processes or technologies will also affect costs. For example, use of thermal processes such as oil from sludge technology will be more costly than sludge disposal options involving stabilization and direct application on land. In situations where land for treatment facilities is restricted, treatment plants are sometimes constructed using technologies such as the deep-shaft process or by stacking plant components. Where it is difficult to provide sufficient buffering from residential areas, tanks may have to be covered to minimize risks of odours. In some cases, the entire plant is buried for aesthetic reasons. All of these construction features add costs.

Number and Location of Plants

The Metro area could be serviced by a single regional plant or by a number of plants. The costing exercise looked at several general scenarios: both single and multi-plant options discharging into The Narrows or the Inner Harbour, and single plant options discharging progressively further out of the Harbour.

The interceptor system required to convey sewage to a single regional plant will be considerably more expensive than the requirements for a multi-plant option. However, multi-plant options are much more plant and equipment intensive.

The initial capital cost of most of the single and multi-plant options was comparable, but the plant and equipment costs for the multi-plant options was much higher. Because of this, the annual operation and maintenance costs are also significantly higher. The long term costs of a multi-plant approach will therefore be considerably higher than a single plant approach. The current funding formulas only apply to initial capital costs, so these higher operating costs will be borne entirely by the municipalities.

The actual location of a treatment plant and outfall will also affect project costs. If plants are located near the waterfront, interceptor systems and outfalls will be comparatively short. If the plants are moved inland, interceptor and outfall lengths will increase and costs will increase accordingly. As plants or outfalls are moved farther out of the Harbour, the costs will also increase. In general, for a given level of treatment, there is little cost difference between options discharging effluent into The Narrows, the Inner Harbour, or the Middle Harbour. However, costs increase considerably for options which discharge into the Outer Harbour or the Harbour Approaches. For example, an option discharging into the Harbour Approaches could increase total project costs by 50 percent or more because of additional tunneling and piping.

Combined Sewer Overflows

It is not economically feasible to treat the total volume of peak wet weather flows from combined sewer systems. Normal practice involves intercepting a reasonable multiple of dry weather flow for treatment. Excess flows are discharged directly to the receiving waters as combined sewer overflows (CSOs). As the volume of flow designated for treatment increases, the magnitude of the CSOs decreases. However, the hydraulic capacity of the interceptor sewer and treatment plant must also be increased, which increases costs.

Various techniques have been used to mitigate the impacts of CSOs. Outfalls carrying CSOs may be extended to deeper water and designed with more effective diffuser systems to increase initial dilution and dispersion. Screening is sometimes used to remove coarse material and floatables before discharge. More sophisticated devices such as swirl concentrators may be used to increase the removal of solids. Sometimes part or all of the storm overflow is retained in temporary storage, and then pumped back to the interceptor system for treatment after the storm subsides.

Implementing these mitigative measures will increase the capital cost of the project. Annual operation and maintenance costs will also increase. For example, if CSOs are screened, municipalities will have to deal with the problem and costs of collecting and disposing of the screenings.

Mill Cove and Eastern Passage Plants

The future of the Mill Cove and Eastern Passage treatment plants must be considered in a regional context. Technically, these facilities could be expanded and upgraded at their present locations as loads increase in the future. It may however be more cost effective to integrate the serviced areas into the proposed regional system. This could add approximately 20-25% to the cost of the total project.

Other factors may determine the future of these facilities. Insufficient land may be available at the Mill Cove site to accommodate plant expansion, and at Eastern Passage County planning policy does not permit expansion at the present location. However, integration into a regional system may only be possible if a single regional plant is constructed to serve the metro region. Integration is less likely if Halifax and Dartmouth each construct their own plant(s). Significant costs will be incurred in the future to service the Bedford-Sackville and Cole Harbour-Eastern Passage areas. If these areas are to be integrated into the regional system, the costs of the interceptor systems and treatment facilities will increase considerably.

II
The Harbour Today

4.0 Halifax Harbour: A Biophysical Description

4.1 Circulation

Halifax Harbour is an estuary, created by the ancient geological processes of erosion by ice and water. The Harbour is actually the remnant of an old valley formed by an early Sackville River that was eventually drowned by rising sea level. Thousands of years ago, when sea level was lower, the river extended several tens of kilometres further seaward beyond its present position at the head of Bedford Basin. This ancient river valley, last modified by powerful glaciers, can still be detected in the form of a deep channel along the western side of the Outer Harbour floor. Figure 8 shows depths of water in the Harbour.

The circulation of water in estuaries is characterized by a two-layered flow; incoming waters which are saltier, and therefore heavier, enter along the bottom while the outgoing flow is at or near the surface. This movement is driven by river discharge and by freshwater flowing in from the surrounding land.

Freshwater

The major source of freshwater is the Sackville River which has an average annual inflow of 5.3 m^3/s, but varies from a high of 9 m^3/s in March and April to a low of about 2 m^3/s in the July to September period. Additional freshwater is contributed by numerous streams and sewers, and amounts to 2.2 times the average discharge of the Sackville River, and is distributed around the periphery of the Harbour.

The flow of sewage into the Harbour is fairly constant throughout the year and is about equivalent to the summertime flow of the Sackville River (about 2 m^3/s).

Currents

Because the freshwater flowing into the Harbour is lighter than ocean water it stays near the surface. The surface and bottom waters remain as separate layers because they have different densities, but mixing takes place at the interface. The

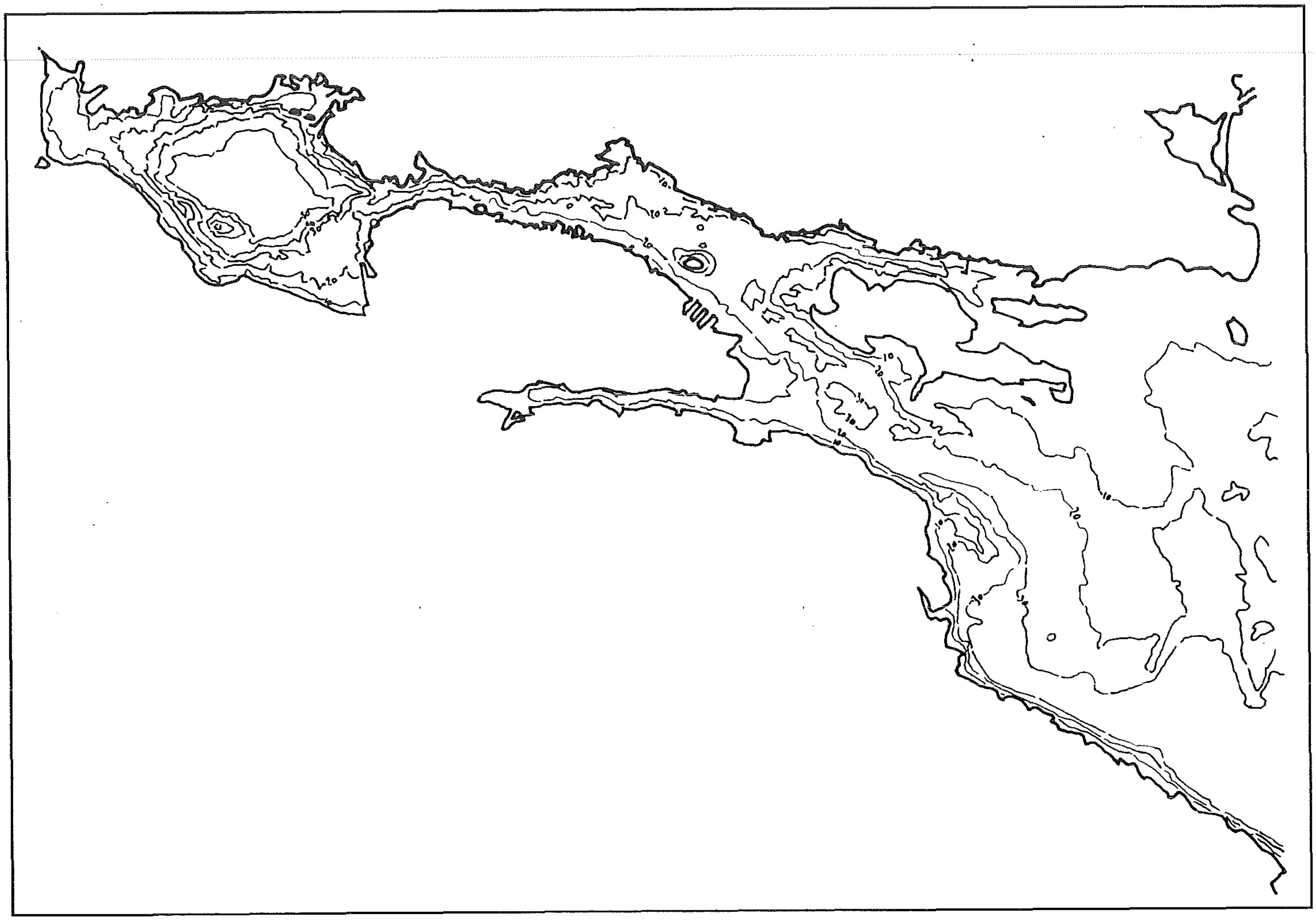


Figure 8: Bathymetry of the Harbour. Contour intervals are 10 metres.

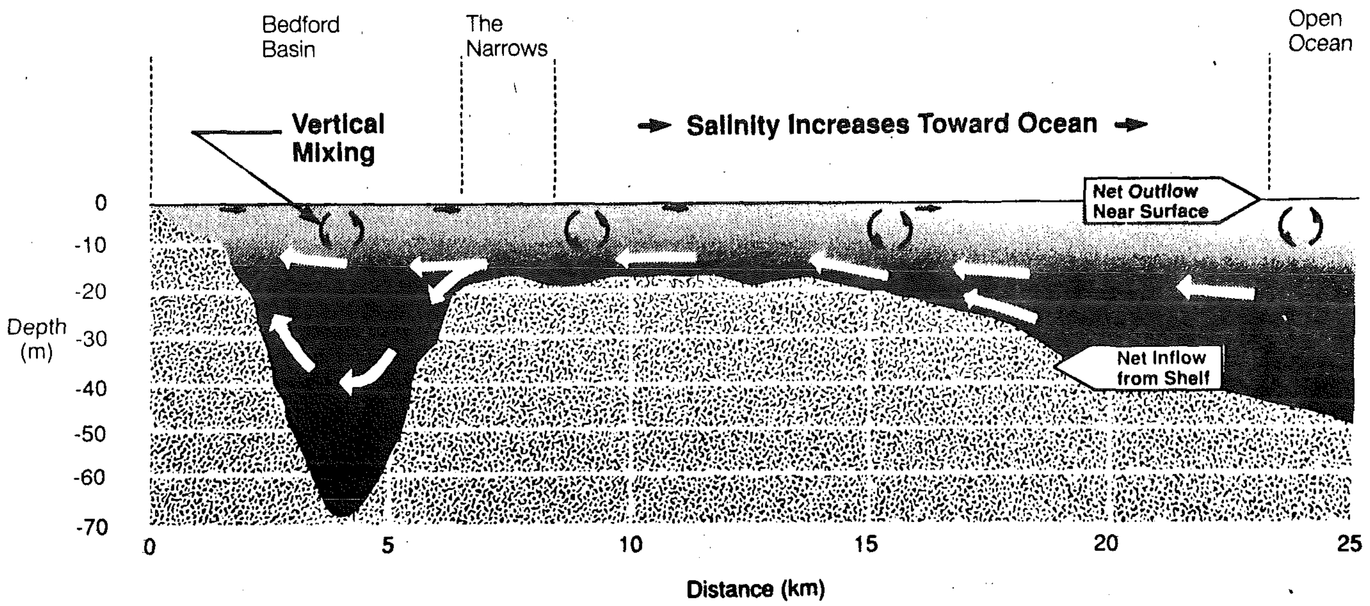


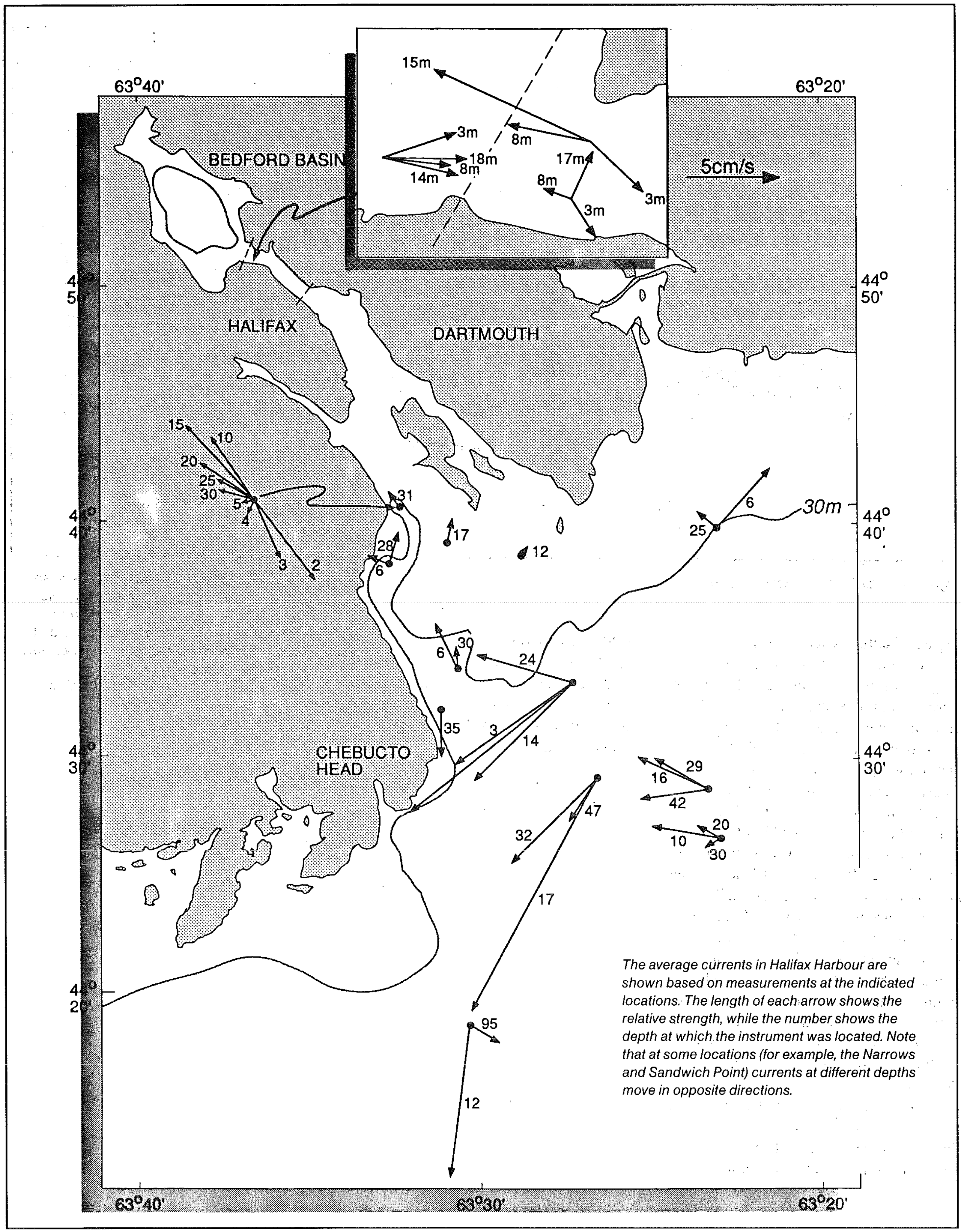
Figure 9: Circulation in Halifax Harbour

The circulation is typically that of an estuary. Denser, therefore heavier, water flows into the Harbour along the bottom, eventually mixing upward and then moving outward at the surface. The outer flow is lighter because of the addition of freshwater from the Sackville River, runoff and sewage inflow.

degree of saltiness serves as a marker which can be used to measure the progress of the freshwater as it leaves the Harbour. Figure 9 shows a simplified view of circulation in the Harbour.

Calculations based on salinity distribution plus actual current measurements show that the strongest average currents occur in The Narrows, ranging between 0.06-0.22 km/hour with the highest values observed in the bottom layer (Figure 10). The next highest values are observed off Sandwich Point. The weakest currents are found in Bedford Basin. In the Outer Harbour, average currents are stronger with a general flow to the southwest. Calculations based on salinity distribution indicate that the most vigorous vertical mixing between the two opposing layers occurs in The Narrows, the Inner Harbour and the Sandwich Point area.

Measurements averaged over several months give the erroneous impression that the circulation in the Harbour is constant and predictable. Currents do in fact change rapidly in both velocity and direction due to variations in wind or tidal effects. In The Narrows, for example, tidal flow exceeds 0.9 km/hour, 4-20 times the observed average velocities. In addition, meteorological events can temporarily alter the "typical" estuarine circulation in which water moves inward near the bottom and outward near the surface.



The average currents in Halifax Harbour are shown based on measurements at the indicated locations. The length of each arrow shows the relative strength, while the number shows the depth at which the instrument was located. Note that at some locations (for example, the Narrows and Sandwich Point) currents at different depths move in opposite directions.

Figure 10: Average Currents in Halifax Harbour

4.2 Sediments

Like all estuaries, Bedford Basin and the Inner Harbour act as a trap for sediments which erode off the surrounding land. When Halifax was founded in 1749 major changes took place which affected the seabed. Land was cleared, crops were cultivated, shoreline infilling began, and people started using the Harbour as a repository for their domestic and industrial wastes.

The sediments on the bottom of the Harbour vary in thickness from a few centimetres to over 20 m, and the composition ranges from gravel and sand to silt or clay (Figures 11a and 11b). The distribution of the different types of sediment mirrors circulation patterns, because the smallest clay-sized particles will only settle where the currents are relatively weak. Where currents are stronger, the seabed is covered with sand and gravel. Areas of exposed bedrock indicate that the currents are strong enough to prevent any sediment accumulation.

The fine-grained sediments of silt and clay adsorb minor trace elements and contain more organic matter than coarser sand and gravel. The organically rich sediments also contain higher concentrations of most metals.

In general, from south to north, the fine-grained sediments only occur on the sea floor inside a line between Sandwich Point and Maugher Beach on McNabs Island. Further out, there is too much movement in the water to allow the finer particles to remain on the bottom. In the Inner Harbour the mud is not evenly distributed and there are large areas of sand, gravel and bedrock, such as Ives Knoll, The Narrows and some nearshore areas. Where it has been measured north of McNabs Island the thickness of the mud varies substantially, ranging up to 12 m (Figure 12).

It is possible to learn how sediments are transported in the Harbour by studying where the different particle sizes are presently distributed. Other useful information includes bedforms in sand and fine-grained gravel, scour features around seabed obstructions and the distribution of sewage banks and anchor marks. From these observations it appears that sediments generally move in a northerly direction, towards the head of the Harbour, that is, in the same direction as the near bottom circulation.

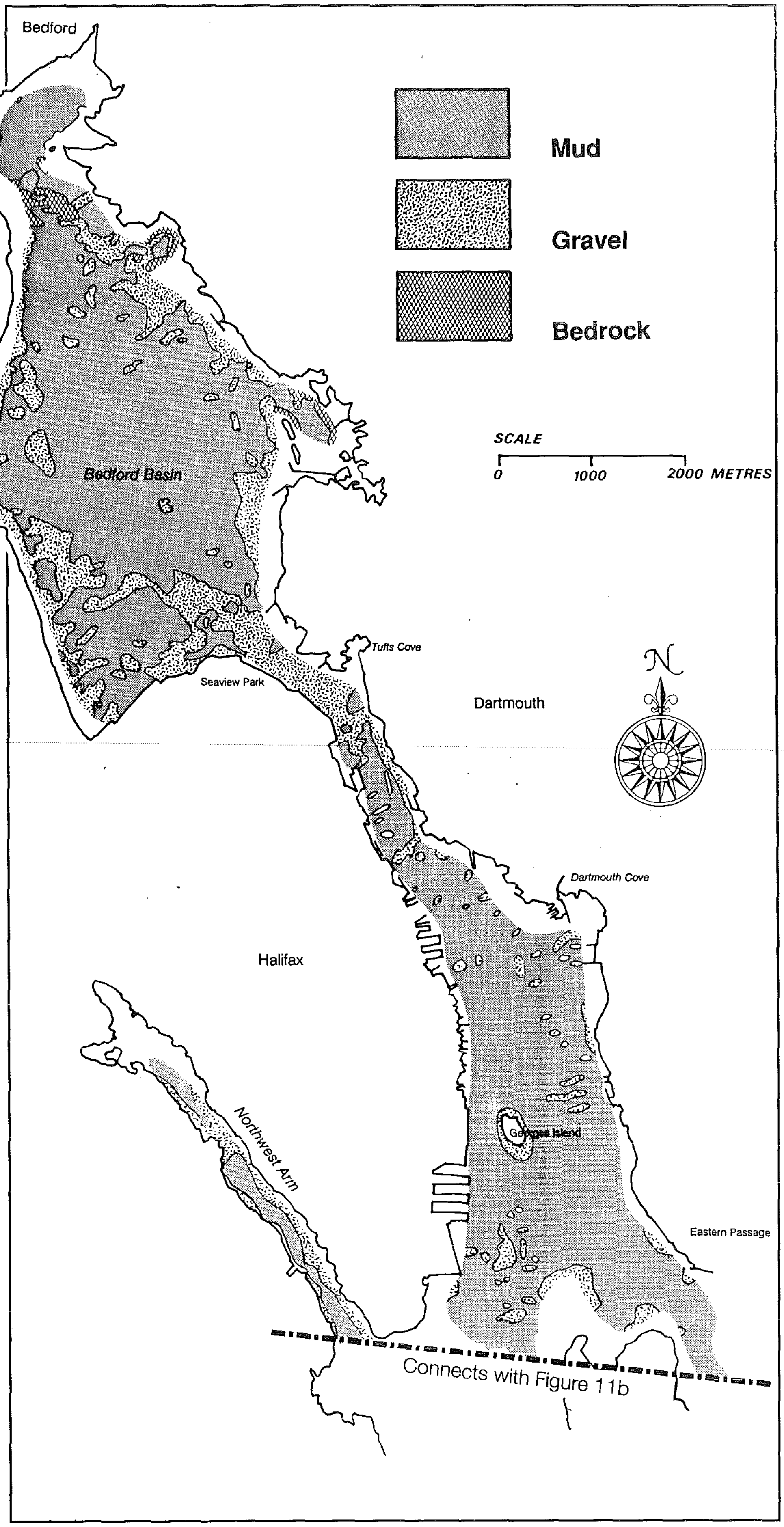


Figure 11a: Distribution of Sediment Types–Inner Harbour, Halifax Harbour

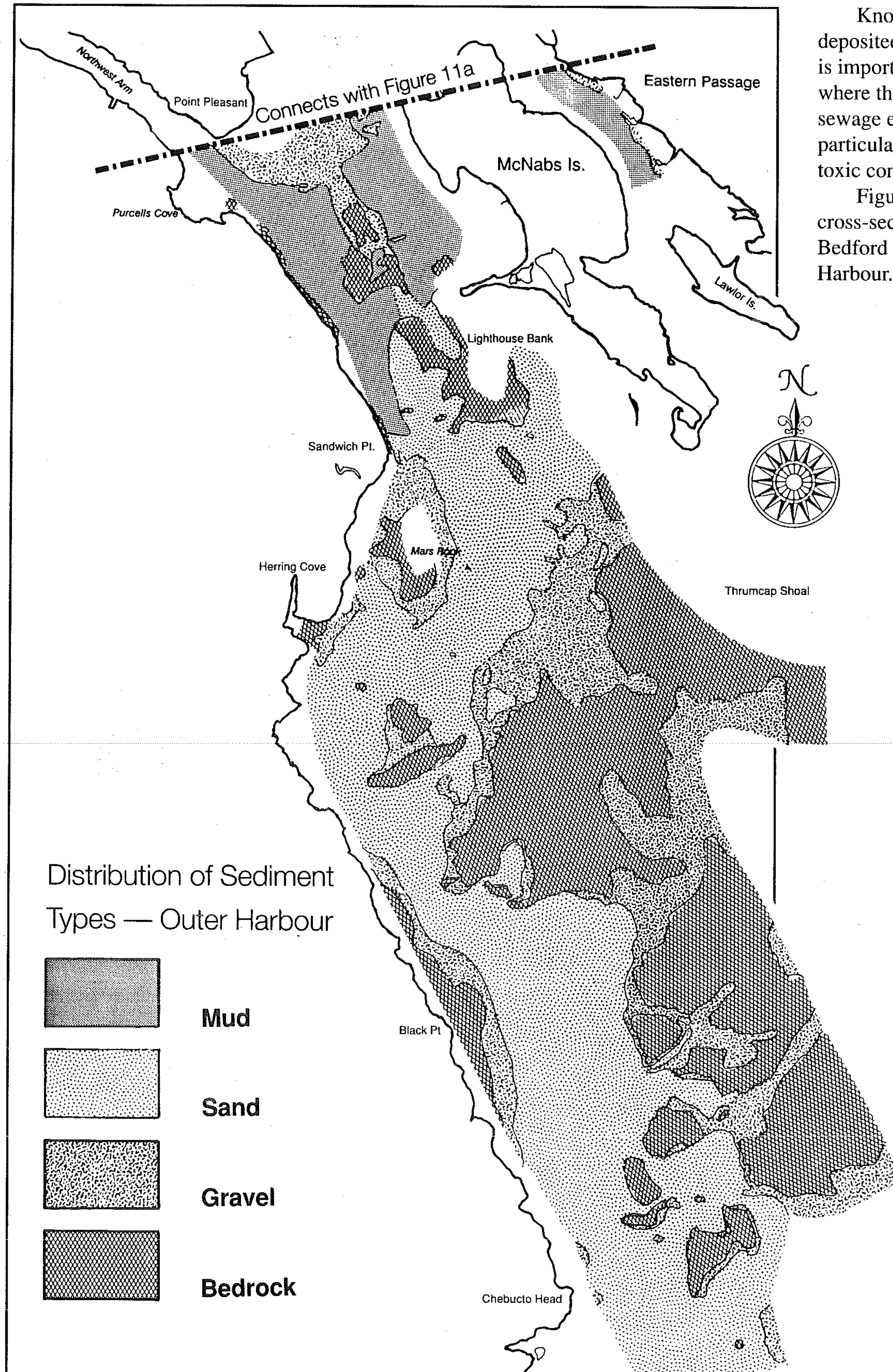


Figure 11b: Distribution of Sediment Types–Outer Harbour, Halifax Harbour

Knowing where sediments are deposited and resuspended in the Harbour is important because it helps to predict where the sediments in the treated sewage effluent will probably end up, and particularly what the fate of the residual toxic contaminants might be.

Figure 13 shows the seafloor in cross-section along a line running from Bedford Basin to the mouth of the Harbour.

This map shows the thickness of mud deposited during the Holocene period (the last 10,000 years of Earth"s history).

Thickness in Metres

0-2

2-4

4-6

6-8

Greater than 8

Areas of Acoustic Masking

SCALE METRES

1000 500 0 1000

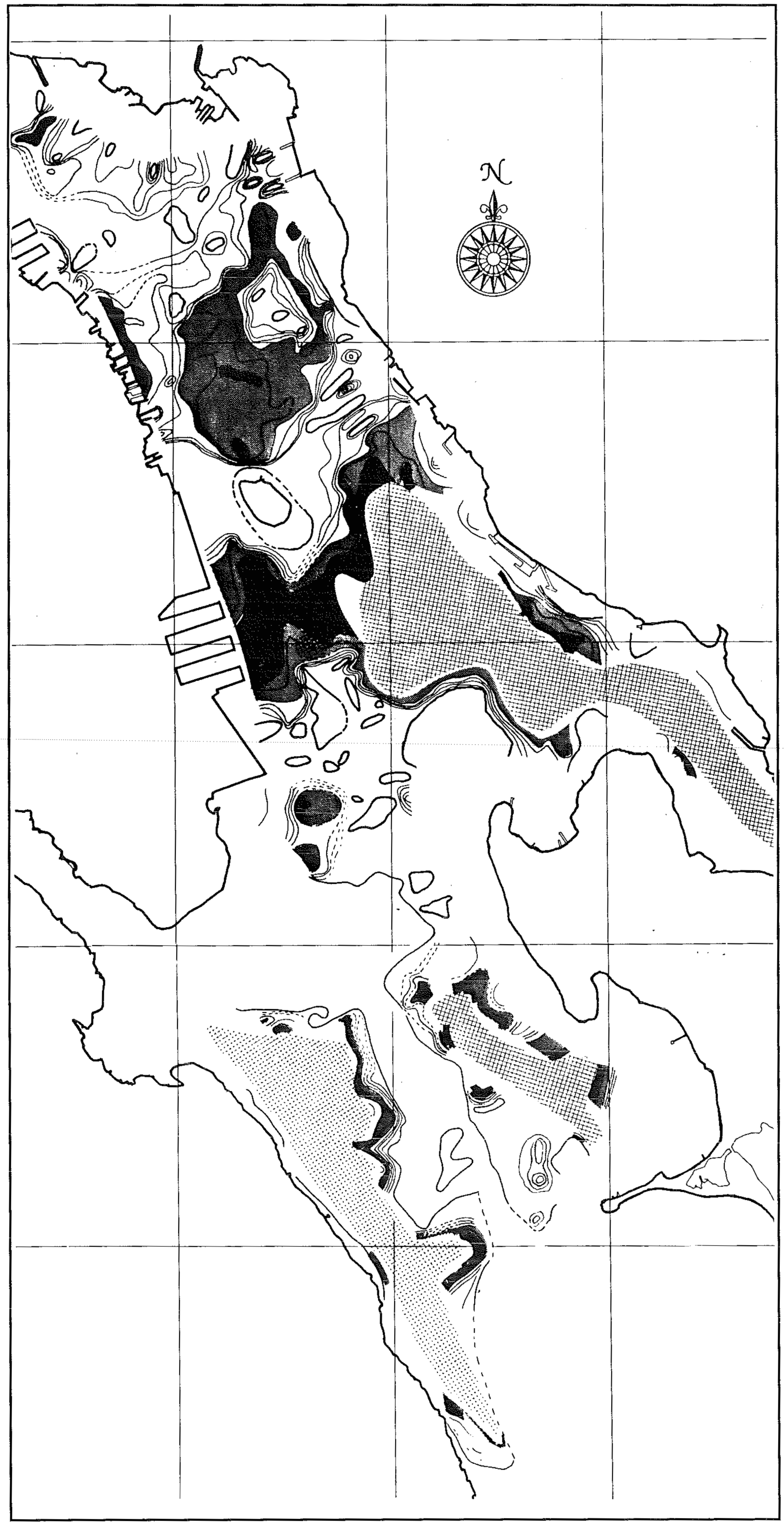
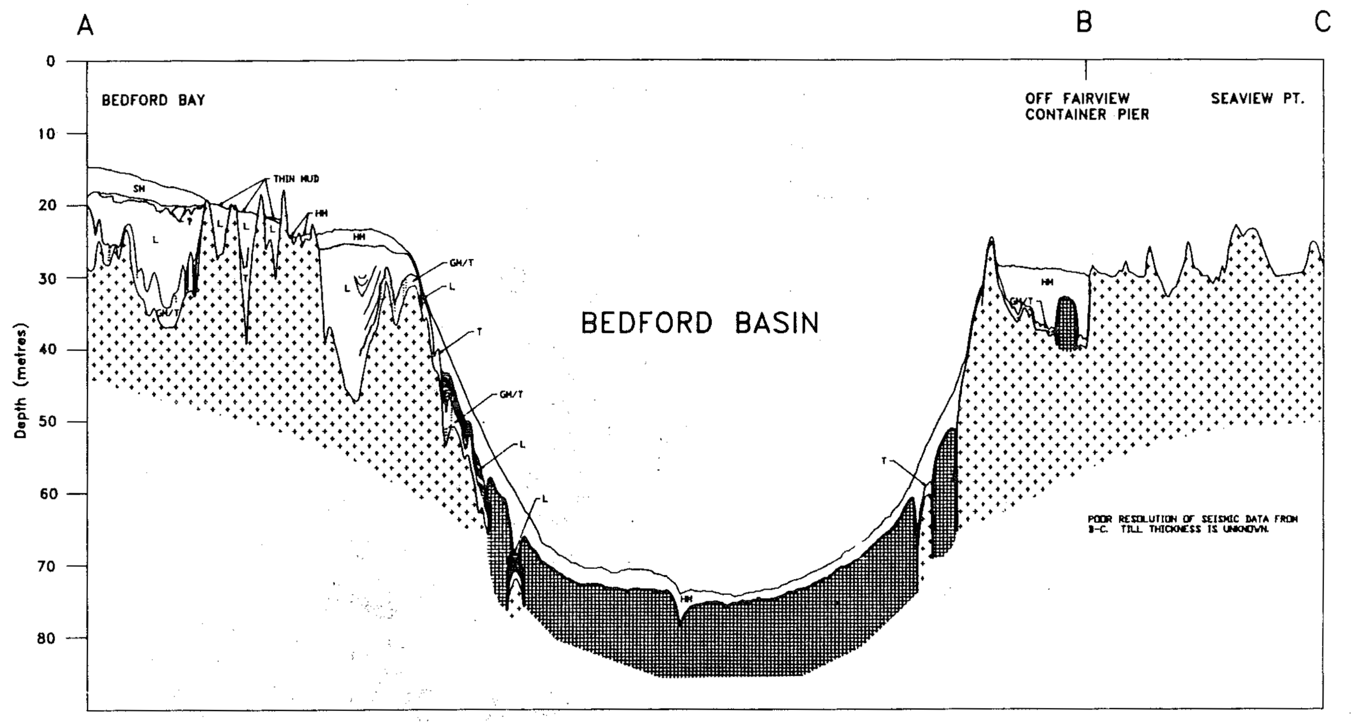
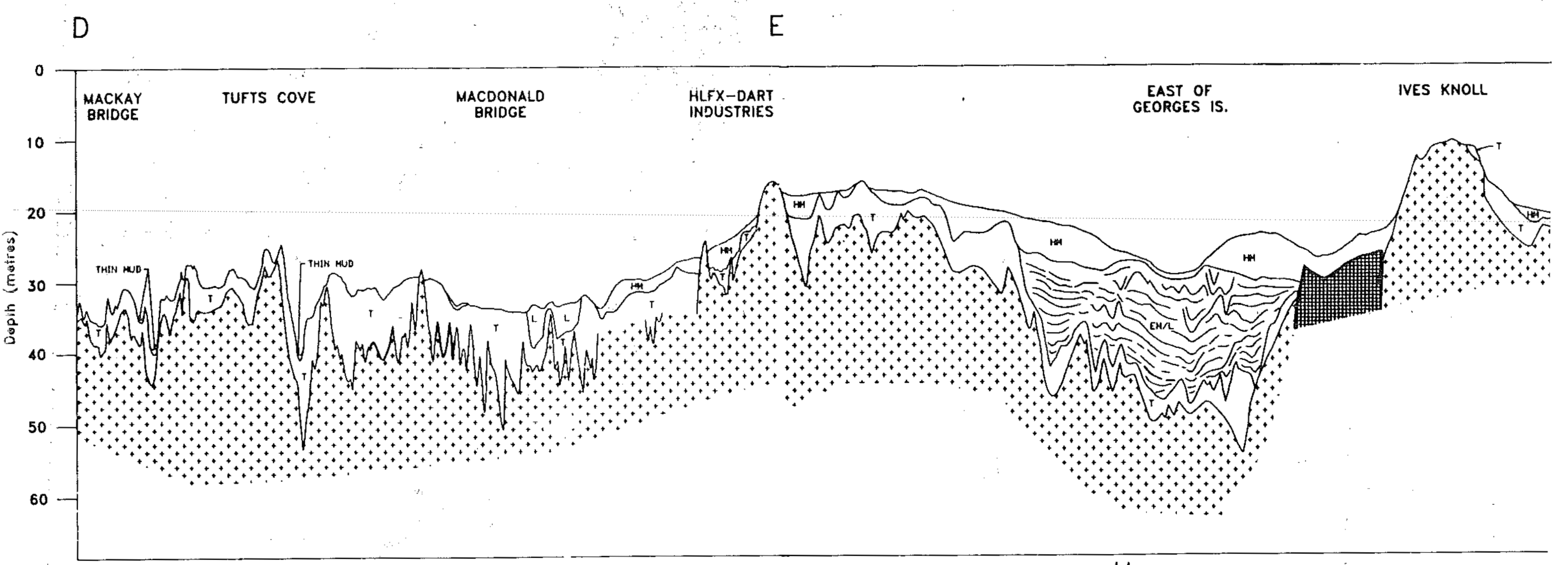


Figure 12: Holocene Mud in the Inner Harbour, Halifax Harbour





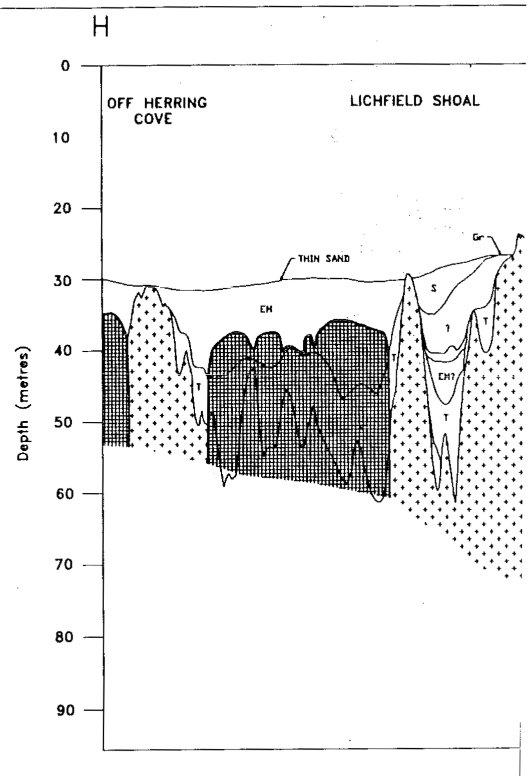
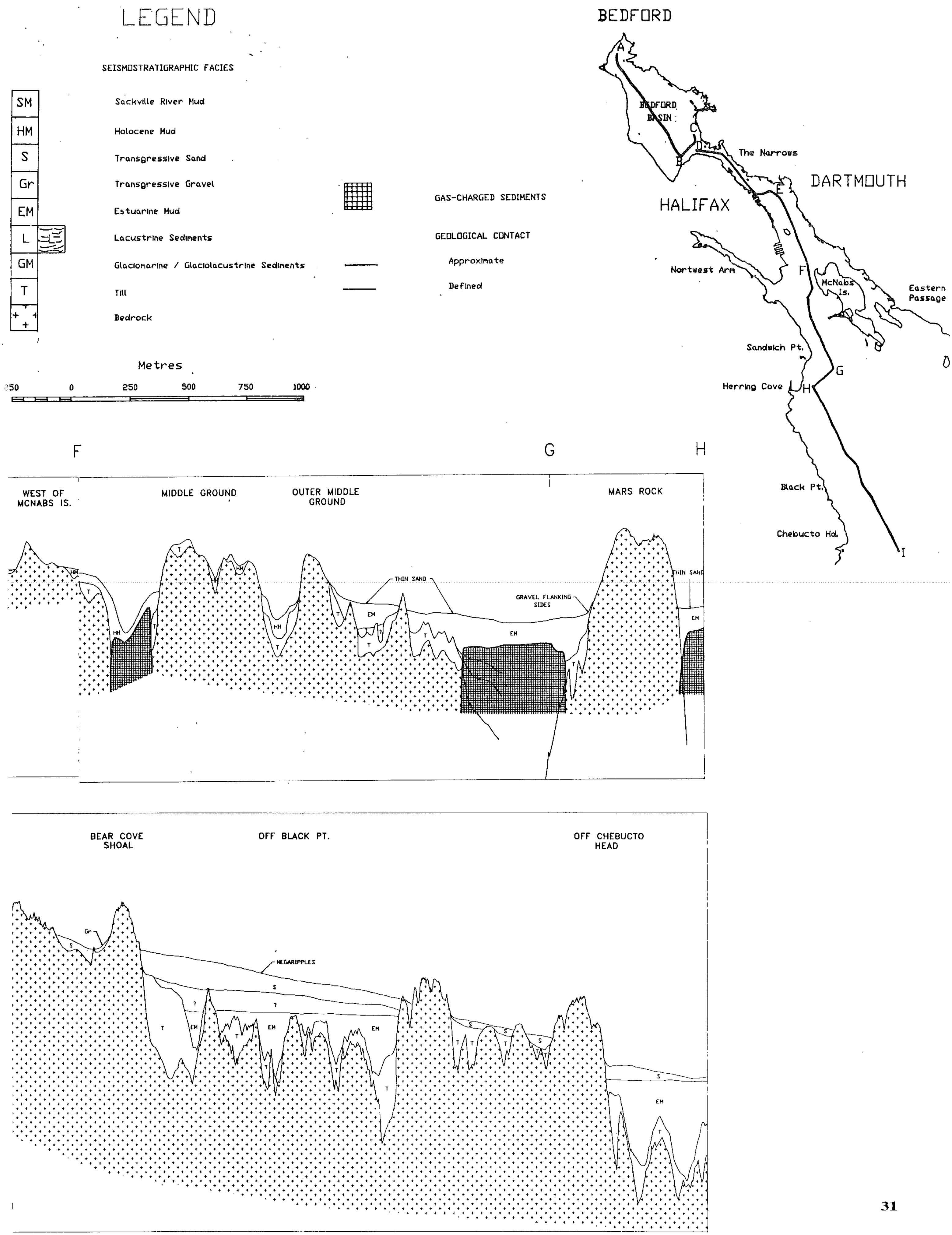


Figure 13: Longitudinal Section of the Halifax Harbour Floor and Subsurface Geology.
A longitudinal section along a line running from Bedford Bay through the Harbour (with the exception of The Narrows) to Chebucto Head.


LEGEND
SEISMOSTRATIGRAPHIC FACIES
SM Sackville River Mud
HM Holocene Mud
S Transgressive Sand
Gr Transgressive Gravel
EM Estuarine Mud
L Lacustrine Sediments
GM Glaciomarine / Glaciolacustrine Sediments
T Till
Bedrock
GAS-CHARGED SEDIMENTS
GEOLOGICAL CONTACT
Approximate
Defined
Metres
250 0 250 500 750 1000
BEDFORD
BEDFORD BASIN
The Narrows
DARTMOUTH
HALIFAX
Northwest Arm
McNabs Is.
Eastern Passage
Sandwich Pt.
Herring Cove
Black Pt.
Chebucto Hd.
A B C D E F G H I
F G H
WEST OF MCNABS IS.
MIDDLE GROUND
OUTER MIDDLE GROUND
MARS ROCK
THIN SAND
GRAVEL FLANKING SIDES
EM HM T
BEAR COVE SHOAL
OFF BLACK PT.
OFF CHEBUCTO HEAD
MEGARIPPLES
Gr S EM T ?

4.3 Harbour Subdivisions

Bedford Basin (Box A)

Bedford Basin, at the head of the Harbour, is approximately 6 km long, 4 km wide, and has an area of 17 square km. The Basin's deepest point is 71 m, and it is separated from the remainder of the Harbour by a narrow, shallow opening, 20 m deep and 300-400 m wide, located at The Narrows.

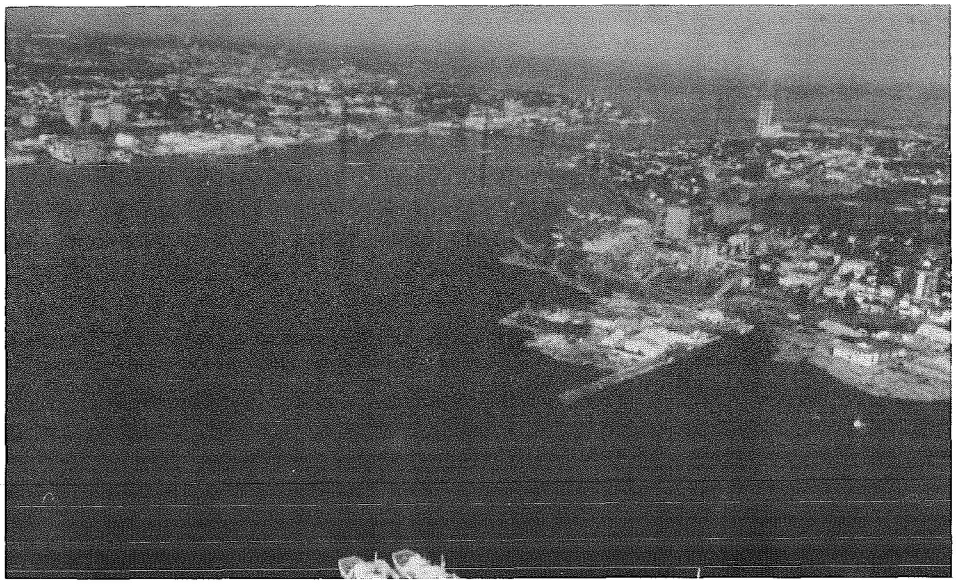


Photo 9: Bedford Basin

The main source of freshwater into the Harbour, the Sackville River, enters at the northern-most point of the Basin, in Bedford Bay. The weakest currents in the Harbour are found in the Basin where stagnation occurs in the deeper waters due to poor mixing and infrequent flushing.

Much of the floor of Bedford Basin is covered with sediment which contains between 60-80% mud. The highest concentrations of mud are found in the deepest locations. Sand and gravel occur in the shallower places along the shores, to depths of approximately 10 m. In the nearshore area there are many large boulders and occasional bedrock outcrops. Two conspicuous boulder ridges ring Bedford Basin at a depth of 23 m. They were probably developed during a period of lower sealevel when the Basin was a lake and seasonal freezing resulted in their concentration. Scattered across the floor of Bedford Basin are many generations of anchor marks plus patches and mounds of coarse debris, probably dredge spoils dumped by barges.

The Narrows (Box B)

The Narrows, essentially the area between the two bridges, is about 500 m wide and 3 km long, with an average depth of about 20 m. Near the Angus L. Macdonald Bridge it quickly widens to 1500 m. As the water forces its way through The Narrows the currents increase. Tidal currents are on average about 1 km/hour compared to 0.05 km/hour in the Basin, or 0.3 km/hour in the Inner Harbour. Sediments are much coarser, consisting mostly of gravel (Photo 10). Boulders and bedrock outcrops are common. South of the MacKay Bridge, off the Duffus Street sewage outfall, a zone of fine-grained sediment covers the harder gravel seabed in a depression extending across the Harbour. Some of this sediment probably comes from the outfall itself. Tufts Cove contains soft, fine-grained sediment which continues part way out into the main channel of The Narrows where it eventually ends.

Photo 10: Seafloor in The Narrows. Hard bottom of sand, pebbles, cobbles and boulders. Numerous broken and whole shells.

Inner Harbour (Box C)

The Inner Harbour begins south of The Narrows, where the Harbour widens, and extends southward to the northern end of McNabs Island. In this area there are large sediment patches which contain more than 80% mud (Photo 11). The northernmost patch, just north of Georges Island and extending over to Dartmouth Cove, is at least 7 m thick. However, the largest body of sediment is found to the south east of Georges Island and extends over to Eastern Passage. It is over 9 m thick and is charged with methane gas. Similar deposits in varying thickness continue south to the vicinity of Sandwich Point.

On the western side of the Inner Harbour, at the entrance to the Northwest Arm, another area of gas-charged mud occurs which is also over 8 m thick. These two thick, gas-charged sediment deposits in Box C are separated from each other by a bedrock ridge which extends south from the Point Pleasant area; effectively separating these two

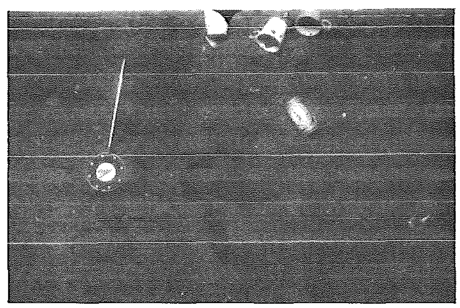


Photo 11: Seafloor in the Inner Harbour adjacent to the naval dockyard. Clayey silt with a few pebbles and cobbles. Numerous worm tubes project from the seafloor and sea urchins and starfish can be seen. Debris is scattered across the bottom.

areas into separate sedimentary basins. Geochemical analysis of the sediments from both areas suggest that material does not cross the shoal bedrock area and is probably deposited locally in each of the basins.

Areas of coarse sandy and gravelly sediments occur on Ives Knoll north of McNabs Island and continue across the Harbour to the south end container pier. The shoal areas known as Point Pleasant Shoal and Middle Ground consists principally of gravel with outcropping bedrock.

Northwest Arm

The Northwest Arm is the western component of the Inner Harbour and is approximately 5 km long, and several hundred metres wide, varying between 10-15 m in depth. It originates on the western side of the Inner Harbour opposite McNabs Island with its entrance separated from the eastern area of the Inner Harbour by Point Pleasant Shoal. The circulation in the Arm is generally weak, with tidal currents estimated at about 0.04 km/hour.

Within the Northwest Arm, there are two separate areas of thick gas-filled mud on either side of an area of coarse sediment adjacent to Fleming Park. The coarse sediments extend out from both shores extending across the Arm. Localized stronger currents generated here in the narrowest part of the channel may prevent fine-grained silts and clays from settling out.

Middle Harbour (Box D)

Main Channel

This portion of the Harbour is transitional between the Outer and Inner Harbours in terms of sediment distribution, water depth and bedforms. The Inner Harbour mud ends on the western side of Box D in an area adjacent to Sandwich Point. On the eastern side mud does not continue seaward past Maugher Beach. The southern half of Box D is dominated by a seabed similar to the remainder of the Outer Harbour and the inner Scotian Shelf. It consists principally of sand, gravel and bedrock.

The deep channel of the ancestral Sackville River is represented by the 30 m contour which begins adjacent to Sandwich Point and continues seaward around Mars Rock and off the entrance to Herring Cove. The first bedforms to occur in sand upon leaving the Harbour are bounded by the 30 m contour off Sandwich Point. They may result from a combination of bottom shoaling and the presence of associated currents. The bedforms indicate the presence of strong currents near the seabed.

Middle Ground, Lighthouse Bank and Mars Rock are all shallow areas composed principally of outcropping bedrock and gravel with boulders. The western side is dominated by sand and silty sand, but no bedforms were found adjacent to the entrance to Herring Cove. It appears that Lichfield Shoal, to the south, acts as a barrier to incoming currents, in effect, sheltering the seabed. The oceanographic measurements in this area confirmed this interpretation together with observations from the fishing community. In the nearshore areas adjacent to bedrock outcrop, ripples occur in gravel formed in response to surface waves.

Eastern Passage

Eastern Passage is a narrow channel several hundred metres wide between McNabs Island and the eastern shore of the Harbour. It is about 20 m deep and heavily silted near Lawlor Island. The sediments in the Passage consist of thick gas-filled muds similar to those found in the Northwest Arm. Coarse sediment only occurs in the shallow nearshore areas.

Outer Harbour (Box E)

The seabed of the Outer Harbour is a seaward continuation of conditions in the southern half of Box D, but with the presence of even more dynamic characteristics. There are no fine-grained muddy sediments. The surface is covered with megaripples, undulations in sand formed by currents moving at speeds of approximately 1.8 km/hour. These bedforms occur south of Lichfield Shoal and continue on the western side of the Outer Harbour to Chebucto Head (Photo 12).

The deep channel of the ancient Sackville River, which ranges to over 40 m in depth in this area, continues out of the Harbour confined to the western side.

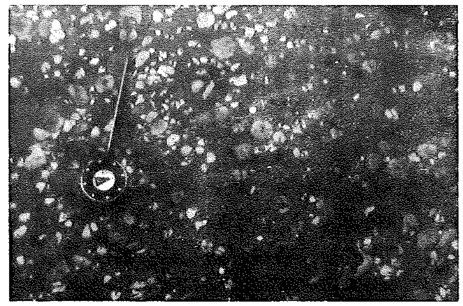


Photo 12: Sandy seafloor in the western deep channel area in the Outer Harbour. The bottom consists of medium to fine-grained sand with numerous broken and whole shells. Megaripples caused by strong currents occur across the seabed, and this photograph is from a trough between megaripples where shells and pebbles collect.

Its formation was probably controlled by the granite bluffs which dominate the shoreline from Herring Cove to Chebucto Head. The floor of the channel is covered with thin sand overlying muddy estuarine and glacial sediments in the subsurface.

The eastern side of the Outer Harbour largely consists of outcropping bedrock with gravel (Photo 13). The bedrock is often covered with Lithothamnium, a pink coralline algae, and kelp. From study of bottom photographs across many of the gravel cobble areas, it appears that up to 20% of the cobbles have recently been turned over and redistributed locally. This indicates that waves are affecting the seabed in water depths up to 20 m. A few isolated patches of sand occur on the

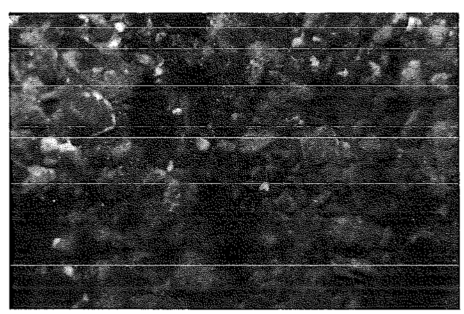


Photo 13: Gravel seafloor in the Outer Harbour. Sub-rounded pebbles, cobbles and boulders with minor amounts of sand and organic growth. Many of the rock surfaces are covered with a pink coralline algal growth. Some of them appear to have been recently turned over, indicating that wave energy affects the seabed in water depths over 20m in the Outer Harbour.

eastern side of Box E to the west of Devils Island. Most of the eastern area, southeast of McNabs Island is shallow with depths ranging between 10-20 m and shoals are common.

Harbour Approaches (Box F)

The seabed of Box F consists of sand, gravel and bedrock, similar to conditions on much of the inner Scotian Shelf. The channel of the ancient Sackville River continues seaward for at least 30 km with depths over 60 m. Bedforms are less frequent in this area as the currents are weaker and not as confined as in the Harbour. Ripples in gravel are also rare because the water is much deeper and wave energy does not reach the seabed.

4.4 Harbour Ecosystem

Considering that it has received human and industrial wastes for almost 250 years, Halifax Harbour remains a remarkably healthy and diverse ecosystem with relatively few signs of serious degradation. The floor of Bedford Basin, however, shows a low diversity of species, probably attributable to periodically low oxygen levels in the poorly flushed deep waters. Small areas in the immediate vicinity of some of the larger sewage outfalls show evidence of deteriorated environments (for example, sludge banks, low oxygen levels and mats of bacteria), but experience in other harbours shows that quality returns quickly after treatment programs begin.

Microbes

Naturally occurring microorganisms in water and sediments play an important role in degrading organic wastes. They are an essential part of nature's own "treatment system". Concentrations of microorganisms in Halifax Harbour are elevated because of the addition of bacteria associated with untreated sewage, in particular coliform bacteria which are abundant in human fecal matter.

Seaweeds

Seaweeds are abundant throughout the Harbour wherever they can attach themselves to a suitable hard surface such as rocks, piers, concrete walls, debris, wrecks and pilings. Many of the species common to the rocky shores of eastern Canada are present. No specific studies have been conducted to determine whether water quality is having any impact on their growth rate. Seaweeds are generally less abundant in Bedford Basin, in part because of fewer hard surfaces and perhaps because of siltation after heavy rains. Stands of seaweed are found along the shoreline of the most heavily used parts of the Harbour such as the ferry docks.

Phytoplankton

Phytoplankton are microscopic plants that normally live dispersed in the water. The factors affecting the growth of these organisms have been thoroughly studied in Bedford Basin. They are controlled primarily by light, nutrient concentrations and mixing, and at certain seasons by predation from animals. In Bedford Basin, plant growth occurs primarily in the upper 15 m, with the highest rates in the upper 5 m. The quantity of phytoplankton is high throughout the year.

Phytoplankton production in Bedford Basin is estimated to be about 15 % higher than that measured in nearby St. Margaret's Bay. This level is comparable to production in the Gulf of Maine but substantially lower than that measured on Georges Bank. Nutrient enrichment from sewage has not greatly enhanced production in Halifax Harbour because of the negative effect of higher turbidity and therefore lower efficiency in using available light. Turbidity can vary due to a variety of inputs including natural runoff, increased plant production and sewage.

Occasionally the growth of phytoplankton in an area undergoes a sudden spurt. This is called a phytoplankton "bloom" and, depending on species composition, it can be toxic to marine life. During 1989 there were six such events in the Harbour with different species. These blooms may be a sign that too many nutrients are entering the Harbour from sewage and other sources. Another hypothesis is that they are caused by the release of ballast water from ships arriving in the Harbour, especially since some of the species are new to the area. There is no clear evidence to support either view.

Bottom-Dwelling Organisms

In the coarse sediments at the mouth of Halifax Harbour, the most common bottom or benthic organisms are sea urchins, snails, mussels, bryozoans, starfish, clams and crabs. There is no sign of habitat deterioration, not even near the sewer outfall at Tribune Head. Little information is available on benthic organisms in the central Harbour and Northwest Arm. The most common organisms in Bedford Basin are segmented worms which live in the muddy sediments. The average accumulated weight of these animals is very similar to that observed in St. Margaret's Bay. In contrast to St. Margaret's Bay, however, the number of species in parts of Bedford Basin is much lower, presumably reflecting the periodic natural depletion of oxygen in deep water. Sea anemones are common, attached to debris, wrecks and boulders in the Inner and Outer Harbours.

Shellfish and Lobster

Mussels and clams are abundant in several parts of the Harbour, but there are no fisheries because of high fecal coliform levels caused by raw sewage. There is, however, a significant lobster fishery. The heaviest fishing takes place in the outer part of the Harbour around and seaward of McNabs Island.

Vertebrate Fish

All commercial finfish fisheries are located in the outer part of the Harbour around and seaward of McNabs Island. Species fished include cod, herring, haddock and mackerel. Some minor hand-lining takes place in late summer where The Narrows enters Bedford Basin. There are minor gaspereau and salmon runs in the Sackville River and efforts are underway to improve them. Recreational fishing for pollock, flatfish and other species takes place from numerous piers and boats.

Marine Mammals

Many species of marine mammals frequent Halifax Harbour for at least part of the year. The most common large whale is the fin. Whales can often be seen during the winter off Chebucto Head, with over 30-40 being sighted in exceptional years. Other large whales periodically visiting the Outer Harbour include the humpback, right and sei. Smaller whales include the minke and pilot. Occasional beluga have also been reported. Common and white-sided dolphins as well as harbour porpoise are regular visitors in the summer and fall. Harbour seals are commonly seen all the way into Bedford Basin, especially in the winter. Grey seals are also present but more difficult to see.

Marine mammals are attracted into the Harbour by the abundance of prey which include small planktonic crustaceans, flounder, mackerel, young herring and squid. Most marine mammals appear to become conditioned to Harbour activities and are appreciated by a majority of the Metro population. They can, however, be a nuisance to local fishermen.

Birds

The Harbour supports a diverse assemblage of resident and migratory birds. Common gulls such as the herring and blackback are present year round. Summer visitors include the common tern which nests on several islands. Cormorants, ducks, grebes, and loons are regularly seen. The last decade has seen a remarkable recovery in the local osprey population and numerous nesting sites are located in the more remote regions around the Harbour, especially on McNabs Island. Sitings of bald eagles are also regular in the winter. Onshore storms can blow in stray migrants or oceanic birds.

Other Animals

Other large marine animals which occasionally visit the Harbour include leatherback turtles, sunfish and basking sharks.

5.0 Harbour Uses

Halifax Harbour is a busy, multi-use waterway (Figure 14) and from time to time conflicts between uses occur. These can be over space (container ships and windsurfers vying for the same part of the Harbour) or over water quality (a sewer pipe discharging into the Harbour while a research laboratory tries to draw in clean seawater for its research aquaria).

There is some potential for future space conflicts between sewage treatment and other Harbour uses since the pipes and diffuser will require use of the seabed, but the main concern is how the sewage effluent will affect water and sediment quality, and how in turn this might influence other Harbour uses.

Shipping

Halifax Harbour is a major shipping port with approximately 2,000 ship movements annually to and from the Fairview Cove container pier, the National Gypsum pier, the two refineries, the Autoport, the Halterm container pier, and other Port Corporation facilities

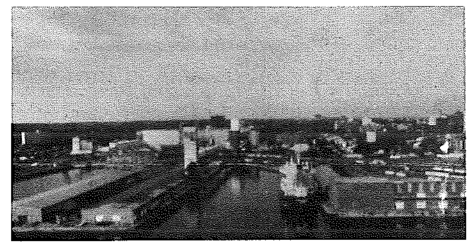


Photo 14: Pier A, Halifax Port Corporation

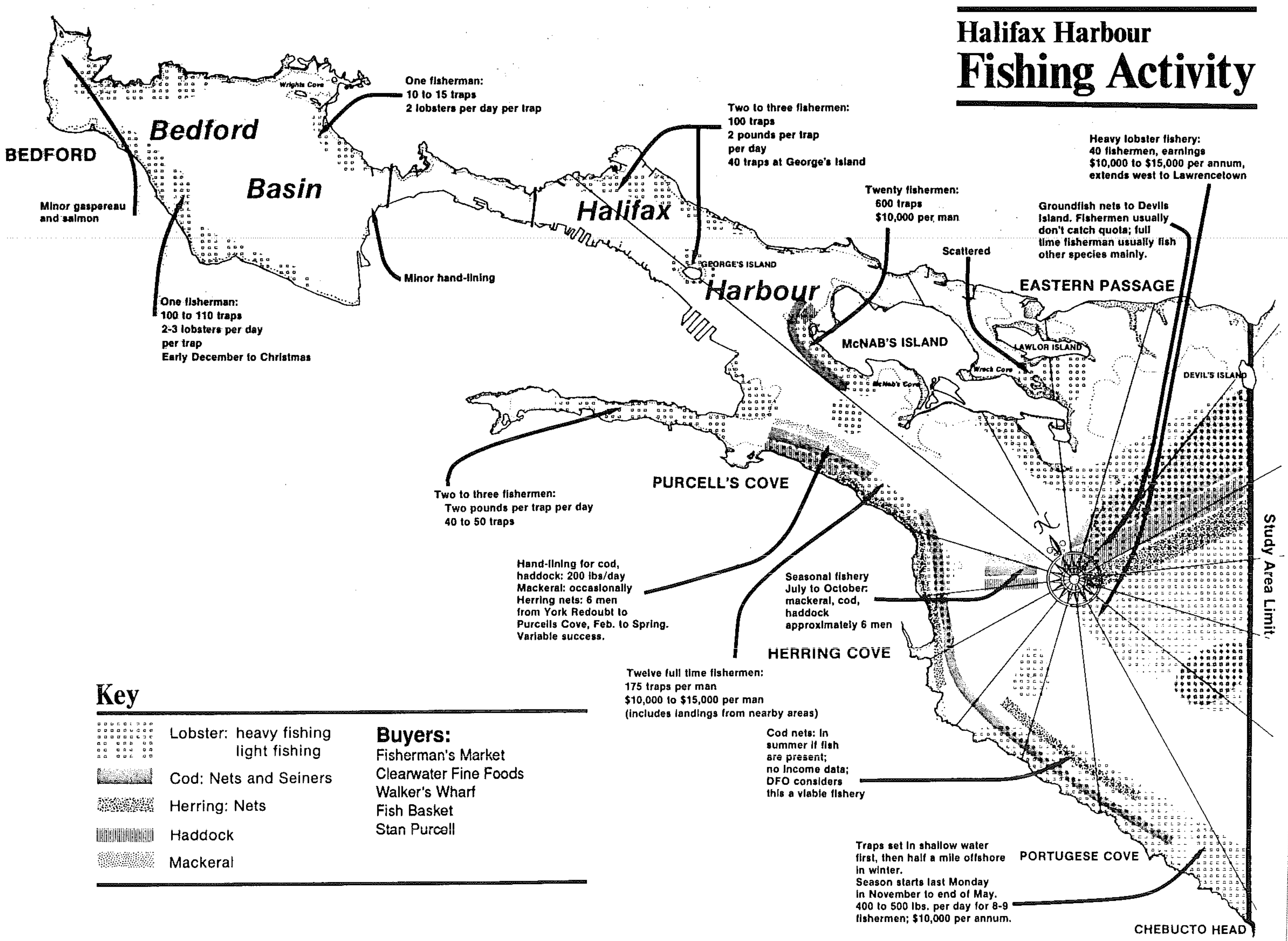


Figure 14: Harbour Use

along the waterfront. Shipping makes no particular demands on water quality.

The Military

Halifax is the Department of National Defence's major naval facility on the east coast. In the past, ship repair and related activities contaminated local sediments which led to restrictions being placed on sediments dredged from these areas. As long as the wastes from the bases are treated, the remaining conflicts are spatial because some areas of the inlet have been declared off-limits. Most military uses do not require a high standard of water quality, but outfalls should be located away from sounding ranges and other underwater facilities.

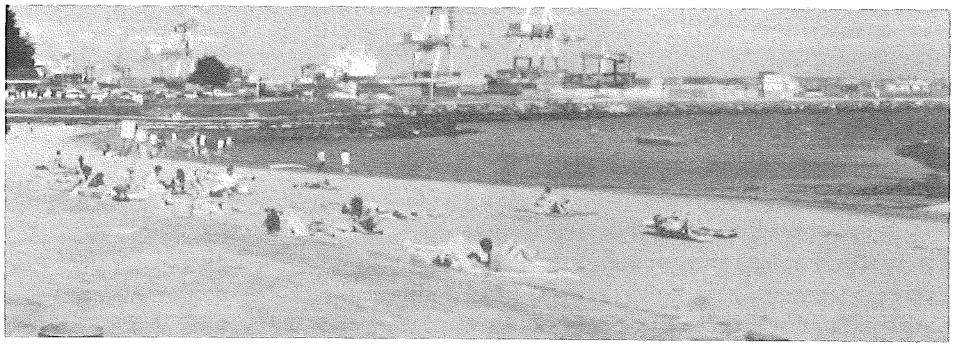
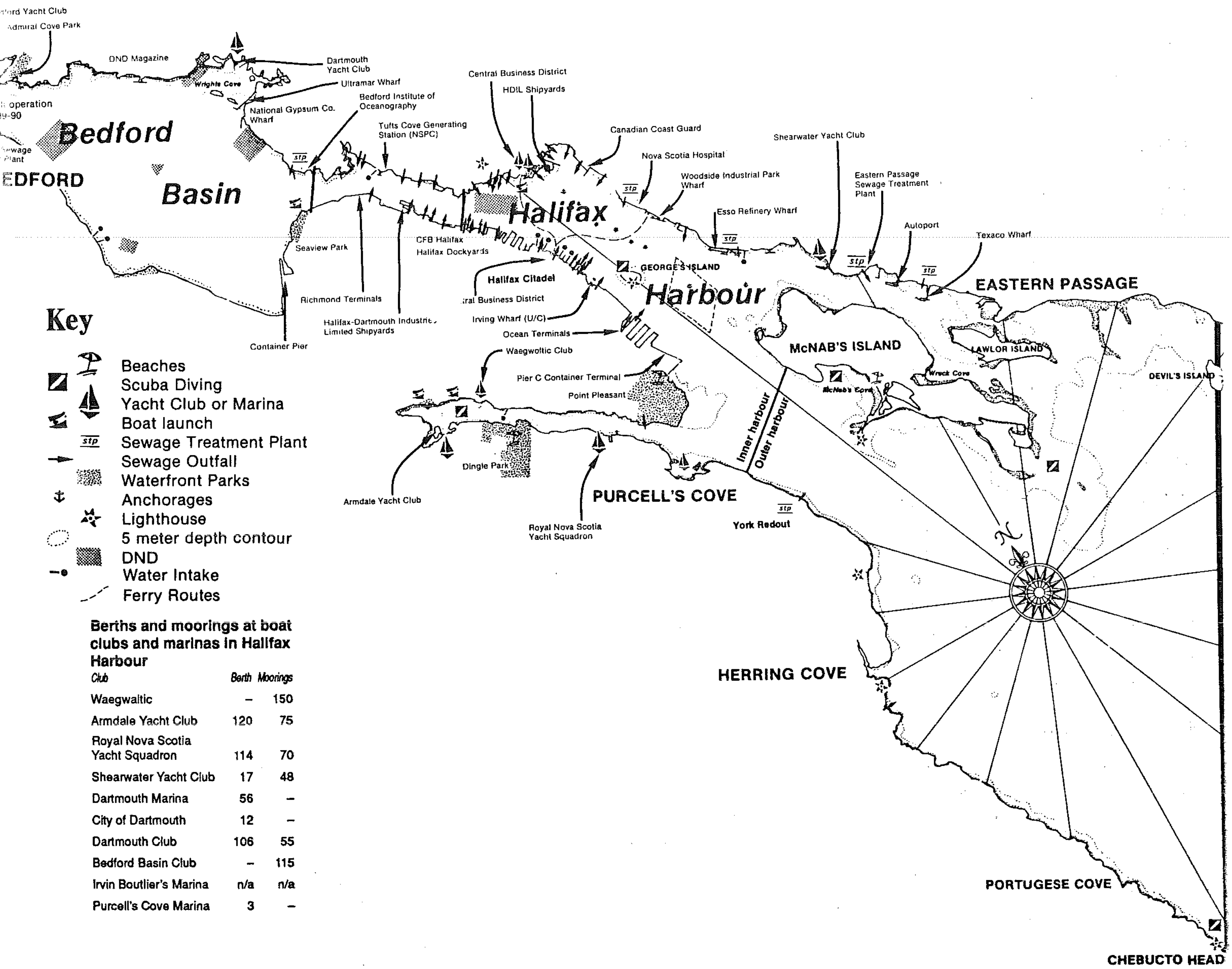


Photo 15: Black Rock Beach, Point Pleasant Park

Recreation and Tourism

At least ten yacht clubs and marinas service the boaters with more than a thousand berths. In addition, there are several public boat launches. The aesthetic quality of the Harbour has long been an issue for sailors, rowers and canoeists. Some windsurfing occurs in the Harbour although competitions have been stopped due to concern over the risk of infection from contamination by



Berths and moorings at boat clubs and marinas in Halifax Harbour

Club	Berth	Moorings
Waegwaltic	–	150
Armdale Yacht Club	120	75
Royal Nova Scotia Yacht Squadron	114	70
Shearwater Yacht Club	17	48
Dartmouth Marina	56	–
City of Dartmouth	12	–
Dartmouth Club	106	55
Bedford Basin Club	–	115
Irvin Boutlier's Marina	n/a	n/a
Purcell's Cove Marina	3	–

bacteria and viruses.

Thousands of metro residents enjoy swimming and sunbathing on the few beaches around the Harbour during the summer and early fall. The principal beaches and swimming areas are Black Rock, Fleming Park, and Maugher Beach. There is also some use of the beach at Eastern Passage and the Bedford Lions Park.

Scuba diving has become an increasingly important recreational and commercial activity especially around McNabs Island, George's Island, the Northwest Arm and along the shore between York Redoubt and Chebucto Head where the waters are very clear and wrecks are abundant.

Other recreational and tourism related activities include boat tours, harbourside walks, visits to McNabs Island, and whale watching. The present poor quality of the water is often said to interfere with tourists' enjoyment.

Fishing

The Harbour supports several seasonal commercial fisheries for lobster, herring, haddock, mackerel and cod. More than five thousand lobster pots are set in the inlet each year by fishermen from Herring Cove, Eastern Passage and elsewhere. Up to 100 people are involved full or part time in these fisheries. Recreational fishing is also an important use of the Harbour.

Research

Halifax Harbour is used extensively by research institutions which include the Bedford Institute of Oceanography, the Defence Research Establishment Atlantic, Halifax Fisheries Research Laboratory, the Atlantic Research Laboratory (NRC), Dalhousie University and some private firms.

Cooling Water

A number of industrial and institutional facilities take water from the Harbour for cooling and other purposes. The Tufts Cove generating station and the Imperial Oil refinery use many millions of litres of Harbour water daily and return it at a slightly higher temperature.

Public Transportation

The Harbour is also used for public transportation via the Dartmouth ferries. Aesthetic considerations (floating objects discharged through sewer outfalls) would be the main water quality concern.

Infilling and Dredging

In a number of locations the Harbour has been filled to permit commercial, industrial and recreational uses of the shoreline. Some degradation of nearby waters will occur unless precautions are taken with regard to the material used for infilling and the construction activity itself. An example of precautions to prevent dispersion of silt were those used by the Bedford Waterfront Development Corporation.

Dredging is another activity which can influence water and sediment quality and biota. Dredging is done to deepen the main channel as well as berths adjacent to piers. In such cases the spoils are often, but not always, dumped in deeper parts of the Harbour.

Marine Life Support System

Finally the Harbour is a life support system for an extensive marine food web which includes plankton, molluscs, crustaceans, birds, seals, porpoises and whales. All aspects of water and sediment quality affect this "use" of the Harbour.

6.0 Environmental Quality in the Harbour Today

6.1 Environmental Quality Concerns

Concerns about environmental quality in the Harbour can be grouped into four categories:

Acute Risk to Public Health

People can quickly become ill (with gastroenteritis and other infections) from swimming in waters or eating shellfish contaminated by pathogens from sewage.

Acute Risk to Aquatic Life

Pollution can cause immediate fish kills due to low dissolved oxygen or the presence of acute toxins.

Chronic Risk to Public Health

Over a much longer period diseases in humans may be linked to eating heavily contaminated seafood regularly or by swimming frequently in a contaminated area.

Chronic Risk to Aquatic Life

Long exposure to toxic contaminants can cause cancers and other diseases in marine life, as well as contributing to changes in species composition.

In certain locations in the Harbour, bacterial and possibly viral concentrations are sometimes high enough to cause health problems for swimmers and scuba divers. The Harbour has been closed to harvesting of shellfish for many years. None of the many other contaminants in wastewater appear to cause acute human health problems.

Limited research has been conducted on marine animals and communities in Halifax Harbour to assess chronic, sublethal effects. For example, fish collected from industrial harbours in the United States, Europe and elsewhere in Canada have been found with a variety of tumours. Some tumours are normal in every population but when present in unusual numbers, they indicate that all is not well. The ecological significance of these symptoms is not well understood. Tumours on fish in Halifax Harbour have not been reported, but more study is warranted.

Changes in bottom dwelling organisms have been found in other harbours. Sometimes the destructiveness of such changes only becomes apparent after a reduction is observed in species diversity.

Unfortunately there is no organized data base on the quality and diversity of the biota of Halifax Harbour. If this information were available, it might be used to assist in measuring trends in the health of the ecosystem. This would help to determine how effective sewage treatment was, and whether more remedial action was required.

6.2 Sources and Types of Pollutants Entering Halifax Harbour

Sources

In Halifax Harbour there are a number of different sources of contamination. They include a wide variety of organic and inorganic chemicals, biological materials and debris. Since European settlement, human inputs have either been (a) transported out of the Harbour and dispersed into the open ocean, (b) deposited with the sediments, (c) broken down by natural processes into non-harmful compounds or elements, (d) transformed into other potentially harmful chemicals, or (e) absorbed and accumulated by living organisms. All of these processes continue to this day.

Inputs are normally classified as *point* and *non-point*. Sewers discharging domestic or industrial wastes are examples of point sources, while atmospheric inputs and urban run-off are examples of non-point sources.

Sources of contamination include:

Domestic Sewage

This includes not only human waste but also a wide assortment of commercial chemicals used in homes, hotels and institutions as well as metals dissolved from piping.

Commercial and Small Industrial Facilities

These facilities which also release wastes directly into the sewage system include automobile dealerships, battery repairs, autobody shops, car washes, carpet cleaners, chemical toilet rentals, electroplaters, furniture strippers, painters, jewellery makers, analytical laboratories, dry cleaners, laundromats, printers and photographers.

Institutions

In the Metro area institutional users include government research laboratories, universities, community colleges, schools, military bases and hospitals.

Large Industries

These include the refineries, the Autoport, Halifax-Dartmouth Industries Ltd, and the Nova Scotia Power Corporation at Tufts Cove.

Non-Point Sources

Non-point sources include river discharges and run-off from streets and other paved areas following rain and snowfall. The distinction between point and non-point sources becomes blurred when runoff is channelled into storm or combined sewers.

Sediments

Sediments from the Harbour floor which have accumulated contaminants through the years can also contribute to environmental deterioration. They are resuspended in the water column by propeller activity, anchoring, dredging or infilling, remobilization by chemical and biological processes, or by other means.

Atmospheric Inputs

These can be local or long range in their origins. Local emissions find their way into the Harbour either directly in precipitation or dry deposition or through run-off. Long range transport of air pollutants will follow the same pathways, although the contaminants may be quite different.

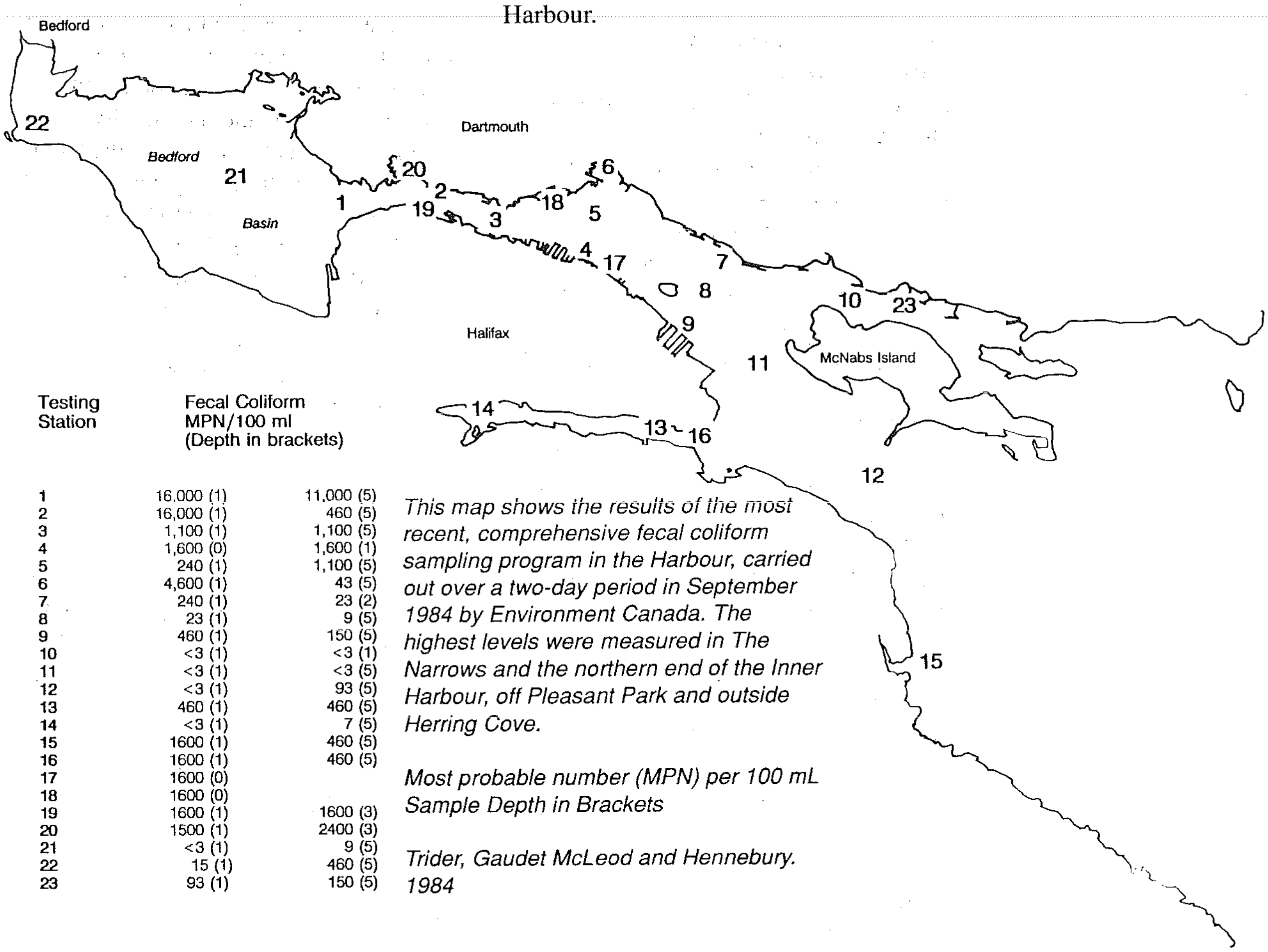
Ship-Related Discharges

Large discharges do not happen often and are normally limited to spills during repairs, loading or unloading operations. Land-based spills occur from time to time and contribute to the overall loading of pollutants in the Harbour. Pleasure craft also contribute sewage wastes to the Harbour.

Major types of contaminants released into the Harbour include:

- pathogenic bacteria and viruses
- metals such as copper, lead, cadmium, arsenic, mercury
- organic compounds such as chlorinated solvents (Eg toluene, tetrachloroethylene), polycyclic aromatic hydrocarbons, pesticides
- petroleum hydrocarbons
- nutrients
- silt and other suspended matter
- plastics and other floating debris
- oxygen demanding organic matter
- heat

Some of these substances occur naturally in estuaries. They come from various sources including precipitation, freshwater runoff, mixing with waters outside the Harbour and decay of organic matter. In some instances, however, increased human activity raises the contaminant levels to the point where they cause problems and are then considered to be pollutants.



Testing Station	Fecal Coliform MPN/100 ml (Depth in brackets)	
1	16,000 (1)	11,000 (5)
2	16,000 (1)	460 (5)
3	1,100 (1)	1,100 (5)
4	1,600 (0)	1,600 (1)
5	240 (1)	1,100 (5)
6	4,600 (1)	43 (5)
7	240 (1)	23 (2)
8	23 (1)	9 (5)
9	460 (1)	150 (5)
10	<3 (1)	<3 (1)
11	<3 (1)	<3 (5)
12	<3 (1)	93 (5)
13	460 (1)	460 (5)
14	<3 (1)	7 (5)
15	1600 (1)	460 (5)
16	1600 (1)	460 (5)
17	1600 (0)	
18	1600 (0)	
19	1600 (1)	1600 (3)
20	1500 (1)	2400 (3)
21	<3 (1)	9 (5)
22	15 (1)	460 (5)
23	93 (1)	150 (5)

This map shows the results of the most recent, comprehensive fecal coliform sampling program in the Harbour, carried out over a two-day period in September 1984 by Environment Canada. The highest levels were measured in The Narrows and the northern end of the Inner Harbour, off Pleasant Park and outside Herring Cove.

Most probable number (MPN) per 100 mL Sample Depth in Brackets

Trider, Gaudet McLeod and Hennebury. 1984

Figure 15: Bacteria Levels in the Harbour

It is often difficult to determine exactly how much of a given chemical occurs naturally and how much is contributed by human activity. On the other hand, some chemicals do not occur naturally. They are synthesized by industry and their presence in the environment is a clear sign of contamination.

6.3 The Environmental Health of the Harbour

Bacteria

As expected, bacterial concentrations are highest near the sewer outfalls (Figure 15). Because of the potential presence of pathogens (bacteria and viruses which carry diseases), fecal coliform bacterial concentrations are monitored by public health officials. Body contact activities such as swimming are not allowed if concentrations exceed 200 fecal coliform per 100 mL of water. These conditions are frequently encountered at beaches in the Harbour. If the median concentration exceeds 14 fecal coliform per 100 mL, shellfish harvesting is not permitted. The entire area has been closed to fishing of clams and mussels for a number of years

Nutrients

Nutrients are inorganic chemicals such as ammonia, nitrate, phosphate and silicate which are necessary for photosynthesis. As nutrient concentrations increase, so does the level of biological productivity which, if unchecked, will create conditions of excessive plant growth, followed by depletion of dissolved oxygen due to bacterial decay, normally referred to as eutrophication. Nutrients are continually recycled as organic matter decays.

Most of the nutrient data available for the Harbour comes from studies in Bedford Basin. In general, nutrient concentrations undergo a very strong seasonal cycle. Similar cycles are found in other coastal inlets, including the less contaminated St Margaret's Bay to the west.

Nutrient concentrations in Halifax Harbour do occasionally appear to be higher as a result of sewage input, near outfalls and after heavy rains for example. However data from 1967 show that concentrations in the upper layer of Bedford Basin are similar to those measured in St Margaret's Bay and in many other coastal inlets and estuaries along the Atlantic Coast of Canada. These concentrations are not considered to be cause for concern.

Oxygen

Oxygen in seawater is used by organisms in the respiratory process, by microbes in decay, by sediments and by bottomdwelling organisms. In healthy marine ecosystems oxygen levels in the water column are usually close to the limit of the water to contain it.

Available data indicate that oxygen concentrations in surface water of Halifax Harbour are in the range of 77-120% saturation. Lower values have been reported near sewer outfalls along the shoreline. Oxygen levels in the deep water of Bedford Basin vary with time and occasionally approach zero. This occurs because the deepest waters in the Basin are not exchanged often enough, while sediments and particulate matter suspended in the water continue to consume dissolved oxygen. The factors controlling intermittent replacement of water in the Basin are poorly understood.

The oxygen content of water contained in sediments depends on the seafloor environment. Near the mouth of the Harbour, where sand and gravel prevail, surface sediments are slightly oxygenated due to exchanges with the overlying water. In the remainder of the Harbour, where mud and organic matter are higher, oxygen levels can be quite low. In some instances near sewer outfalls surface sediments are entirely devoid of oxygen.

Below the surface, sediments are often naturally free of oxygen, but may contain methane produced by anaerobic decomposition of organic matter, usually at depths greater than 10-15 cm. Methane production has occurred in some sediments deposited in the Harbour thousands of years ago. Where concentrations have become sufficiently high to cause gas pressures to exceed the confining pressures of the sediments, methane bubbles to the sediment surface and enters the water column.

Organic Matter

Organic matter enters the Harbour from a variety of sources including natural runoff, plant growth, domestic sewage and industrial wastes. Most comes from normal plant growth and natural runoff. Suspended particulate matter is slightly elevated by raw sewage input, but falls within the range observed naturally for coastal inlets.

As with oxygen, the amount of organic matter in sediments depends on environmental conditions at the seafloor. Where currents and wave action are strong, sediments are coarse and with little organic matter. Organic matter concentrations are greatest in low energy regions such as the bottom of Bedford Basin, the Northwest Arm and near major sources such as sewer outfalls. Sediments with high levels of organic matter are usually devoid of oxygen. Compared to other estuaries in eastern Canada, sediments in Halifax Harbour are enriched with organic matter. Sulfur-bacterial mats are visible on the sediment surface near the outfall of the Eastern Passage treatment plant.

Trace Metals

Both freshwater runoff and the inward flow of ocean water contribute trace metals to Halifax Harbour. Since European settlement and especially over the past 100 years, trace metals have increased through disposal of domestic and industrial wastes. Data in Halifax Harbour are available for copper, zinc, lead, nickel, cadmium, manganese, chromium, and mercury.

With one exception, trace metal concentrations in Halifax Harbour waters are roughly the same as those in other inshore Canadian waters. The exception, zinc, exhibits slight localized elevations that are not a cause for concern. However, mussels have accumulated levels of some metals that are a cause for concern with respect to public health standards. Trace metals bind to particles and consequently their distributions are influenced by the processes which affect sediment movement.

Elevated trace metal concentrations are found in the organic-rich sediments north of McNabs Island. Concentrations are greatest near point sources such as sewer outfalls and dumpsites. Available data indicate that enrichment over pre-

1880 levels is highest for mercury and lead (up 1000%), moderate for copper, cadmium and zinc (up 200%) and only slight for chromium and nickel (about 10%). Also, the net movement of fine sediment and associated trace metals is inward in response to bottom currents. Trace metal contaminants will therefore tend to accumulate in areas which have very low flow rates.

Some metals, such as lead, mercury and cadmium, are chemically immobile in organic-rich oxygen-free sediments. However, their mobility is markedly increased when oxygen is introduced. This can occur in several ways: a) by decreasing the organic loading of the sediment, b) by mixing of sediments by organisms and c) by physical disturbance from waves, propeller wash and anchor scour. Trace metals are continually being remobilized into the water column, especially when oxygen supply is increased.

Potential effects of trace metals include acute and chronic toxicity and bioaccumulation in the food chain. The main hazard to humans is associated with consumption of seafood containing high levels. Although elevated levels have been observed in certain areas of the Harbour, such as Dartmouth Cove, recent testing has demonstrated that the levels of cadmium, copper, zinc, mercury and lead in lobsters from the Harbour are within acceptable limits, and that the lobster are fit for human consumption.

Organic Contaminants

Organic contaminants measured in Halifax Harbour are petroleum hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). No data exists on other contaminants such as pesticides and industrial chemicals. Organic contaminants reach the Harbour from both point and non-point sources. Little is known about these inputs.

Harbour water contains hydrocarbon levels often ten times higher than those on the continental shelf. They are derived primarily from petroleum which is transported, refined and burned in and around the Harbour. Concentrations are present which can affect certain biological processes. However concentrations change seasonally with higher values occurring during the winter months when fuel consumption is higher in the Metro area.

Like trace metals, many organic contaminants bind to particles so concentrations tend to be higher in fine, organic-rich sediments. Unlike trace metals, however, concentrations cannot be defined in any detail. Some organic contaminants are generally less mobile chemically than trace metals. If not broken down by microbes, they can persist for many years in sediments.

Available data indicate that PAH concentrations in Harbour sediments are higher than the proposed Canadian Environmental Protection Act (CEPA) Interim Screening Level for ocean disposal of 2.5 mg/L. Therefore they are potentially capable of affecting sensitive marine organisms. Concentrations range from 3 to 300 mg/L. The highest reported levels occur next to the Nova Scotia Power Corporation thermal generating station in Tufts Cove, a receiving area for effluent from Burnside Industrial Park. Overall concentrations in the Harbour are in fact lower than those found in highly contaminated areas such as the South Arm of Sydney Harbour and Boston Harbour.

Recent testing indicates that PCB levels in the edible tissue of Harbour lobsters, while elevated, fall below the tolerance level for human consumption which is 2.0 µ/g. Tolerance levels for human consumption have not been determined for PAH but are judged on an individual basis by National Health and Welfare. At present, lobsters caught in the Harbour are considered safe to eat.

Litter

Marine litter is both an aesthetic problem and a hazard to marine animals. A litter survey conducted by graduate students from the School for Resource and Environmental Studies at Dalhousie University in the fall of 1989 (Butler et al, 1989) helped to quantify the serious problem of litter pollution in the Harbo During one sampling period, as many a 250,000 pieces of litter were estimated lie along the shoreline of the Harbour. Approximately 22% of the litter came from sewer outfalls while the remainde was attributed to littering from the shor and from boats.

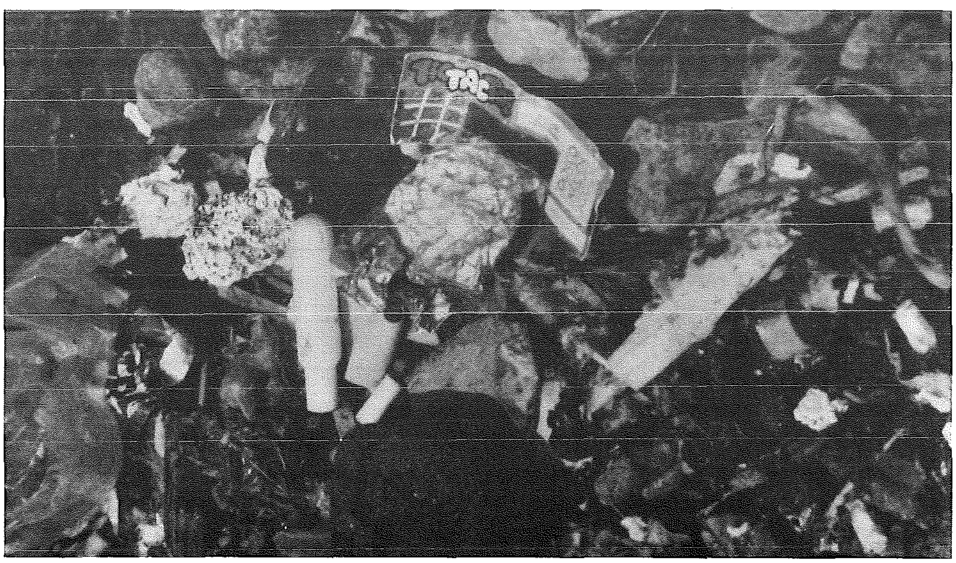


Photo 16: Shoreline Litter

III
Setting Objectives

7.0 What the Public Said

At the seven public meetings, and in letters and briefs to the Task Force, the public raised the following concerns, questions and ideas:

Humans are Not the Only Users of the Harbour

It was widely felt that the Task Force should put much more emphasis on maintaining the Harbour as a healthy marine ecosystem over the long term. Humans are not the only users of the Harbour. The ocean is a life support system for countless species including humans. More attention needs to be paid to retaining wildlife habitat in the Harbour.

A Multi-Use Harbour

There was widespread support for maintaining and expanding, wherever possible, the full range of activities in the Harbour, both commercial and recreational. Pollution is not so severe that certain areas have been written off to specific uses. In particular, it was suggested that the existing commercial and recreational fishery should be maintained. Fishing is already competing for space with other Harbour uses, and should not also have to contend with deteriorating environmental quality.

What Future is There for Swimming in the Harbour?

Notwithstanding this support for multiple use, some people felt that objectives for swimming need to be looked at carefully because swimming is already limited by access, water temperature and water quality. While some believed that there should be more opportunities for swimming in the Harbour, others thought this was perhaps not realistic.

The Harbour as an Aesthetic Resource

The Harbour is a valuable aesthetic resource. One of its major functions is providing a setting for walking, fishing and simply viewing the Harbour. This aspect should not be ignored just because it is difficult to assign a dollar figure.

Dealing with Problems in Our Own Backyard

There was a general feeling that we have a responsibility to manage our wastes in our own "backyard", and not send the problem on to someone else. It was clear, however, that people can interpret the boundaries of "our own backyard" very differently. There was broad agreement that we should not export our sewage problem (by way of an extra long outfall with no treatment for example) and that the Task Force should consider how an equitable distribution of risks and benefits could be achieved.

Maintain and Improve Existing Water Quality Throughout Harbour

Related to the "backyard" issue is the concern that no area in the Harbour should be reduced in quality because of the sewage treatment system. An improvement in one part of the Harbour should not be traded off against a drop in quality in another.

A Conservation Approach: Treating Sewage as a Resource

There were many suggestions made about promoting water conservation as an integral part of the sewage management strategy, and also considering sewage as a resource. Many people were interested in the possibilities associated with separating and recycling "gray" water (non-toilet wastes) and of composting or drying sewage sludge for use as fertilizer.

Costs and Benefits

Costs were obviously of real concern to many people, but with an emphasis on full disclosure of the range of costs and benefits associated with different treatment options. In that way trade-offs could be assessed in both quantitative and qualitative terms. People were willing to pay for treatment provided they could see clear benefits.

Questions were asked as to how the funding formula in the Federal-Provincial Agreement would influence decisions. Which would take precedence - environmental protection or not exceeding the $195.7 million specified in the Agreement. There were strong feelings expressed that protection was more important than cost.

New Sewage Collection and Treatment Technologies

Many were interested in the possibility of using new technologies, particularly collection systems that do not use water, and forms of treatment using aquatic plants to remove contaminants. Even if none of these technologies is currently applicable, there was concern that future options not be closed off by short sighted planning or lack of proven technology today.

Treatment Level

There was a range of views on treatment levels. Some people felt that primary was quite adequate and would keep operation and maintenance costs down. Others felt strongly that secondary treatment should be used, especially if the outfall(s) was to be located in the Inner Harbour. Few people were familiar with advanced primary treatment, but there was considerable interest in it as a possible compromise between primary and secondary. A few people said that the ultimate goal should be tertiary treatment.

Out of Sight, Out of Mind?

Some people thought that there were advantages to locating both the outfall(s) and the plant(s) in the Inner Harbour, because they felt there would be constant public pressure to maintain high operating and maintenance standards.

Multiple Plants

There was also support for the idea of decentralizing the sewage treatment system into two or more smaller plants. In that way the impact of one of several smaller plants breaking down would be less than that of one large plant. This option was also supported as one way to distribute potential negative impacts more fairly among the municipalities.

Local Community Impacts of a Treatment Plant

People held very different views about treatment plants. Some saw them as inevitably unsightly and smelly, and therefore to be kept as far away from residential land as possible. Others believed that treatment plants could be operated with minimal local impacts and were in fact best located in populated areas to maintain constant community oversight.

Controlling Toxics

Control of toxics at source was seen as crucial, although considerable concern was expressed that this would not occur consistently. Some people also felt that one advantage of a multi-plant scenario would be that wastes from mainly industrial areas could be segregated and perhaps receive special treatment.

Mill Cove and Eastern Passage

There appeared to be somewhat more local dissatisfaction with the Eastern Passage plant than with the Mill Cove plant, but in both cases residents wanted the advantages and disadvantages of bringing sewage from these two areas into a regional system to be examined carefully.

Combined Sewer Overflows

Residents of Bedford and Eastern Passage recognized from experience that treatment does not solve all problems, and talked about the need to manage combined sewer overflows. This was echoed in other areas. Concern was also expressed about the sizing of the collection system, and whether 4 times average dry weather flow was adequate.

Oil from Sludge

Some people were uneasy about the status of oil from sludge as an unproven technology at the scale which would be needed here, and about its potential environmental impacts. There were also concerns that the requirement to use oil from sludge, built into the Federal funding agreement, might have undue influence on the selection of the preferred sewage treatment system. In general, it was felt that not enough was known about it.

Look Beyond Sewage Treatment

There is more to cleaning up the Harbour than sewage treatment. We need to look at other aspects of Harbour management, and to continue public information and involvement.

8.0 Environmental Quality Objectives and Guidelines

8.1 General Principles

Based on general knowledge regarding the current state of the Harbour, information about Harbour uses, and the concerns and opinions expressed by the public, the Task Force adopted the following basic principles which were used to formulate recommendations:

1. The sewage management strategy must place highest priority on improving and sustaining the Harbour as a healthy marine ecosystem.

Halifax Harbour is a multi-use port which provides habitats for many species, a livelihood for thousands of people, and commercial and recreational opportunities to countless Nova Scotians. But the main goal is environmental health: waters and sediments which provide healthful habitats for all species using the Harbour.

2. The sewage management strategy should enable all existing commercial, recreational, aesthetic and wildlife uses of the Harbour to continue and, where possible, expand.

The strategy should particularly aim to avoid impacts on both commercial and recreational fishing by improving water quality, avoiding spatial conflicts, and recognizing the crucial effect of public perception on the ability to market fish.

3. The sewage management strategy must reflect our responsibility to reduce and manage our own wastes.

As the Task Force indicated in its first Newsletter defining the Harbour limits, "There is no intention to solve the sewage problem in the Harbour by simply exporting it elsewhere." The municipalities around the Harbour form a single regional community in terms of their effects on the Harbour. The sewage problem is a regional problem; we must solve it within the region rather than export it elsewhere.

4. The sewage treatment strategy must generally improve environmental quality throughout the Harbour, and should place high priority on protecting portions of the Harbour where environmental quality is currently good.

As a general principle, no area in the Harbour should be worse after sewage treatment begins than it was before treatment. However, the Task Force recognizes that any consolidation and relocation of outfalls may result in a localized drop in water and sediment quality.

5. Reduction of wastes at source must be an integral part of the sewage management strategy.

Water conservation and source control of toxic materials are important components of the strategy required to maximize the capacity of the collection system, reduce treatment costs and minimize environmental impacts on the Harbour.

6. The sewage management strategy should incorporate management of combined sewer overflows.

Even after treatment facilities are in operation, combined sewer overflows (CSOs) may continue to raise bacterial levels and cause aesthetic problems. The strategy should therefore consider CSO locations and a planned program of improvements for them.

7. The cost of the strategy needs to be within the taxpayers' ability and willingness to pay; however, achieving environmental quality objectives should take precedence over existing funding formulas.

The relative costs of different options need to be taken into consideration, but the Task Force did not consider that the $195.7 million, negotiated in the agreements between the three levels of government, should be an absolute ceiling on initial capital cost.

8. Sewage management should be seen as part of an overall and ongoing plan to manage all environmental aspects of the Harbour.

A total Harbour environmental management program will be needed, which must emphasize anticipation and prevention, rather than reaction to existing environmental quality problems.

8.2 Environmental Quality Guidelines

Both the 1987 MAPC Report and the 1988 Environmental Control Council Report recommended that environmental quality guidelines be established for the Harbour. How clean is clean? What water and sediment quality do we need to achieve?

Establishing such guidelines anew would be a lengthy and complex process, and clearly beyond the abilities and mandate of the Task Force.

Instead, the Task Force reviewed environmental criteria and reported levels of contaminants in other urban harbours around the world, and compiled a table of recommended guidelines based on studies undertaken by groups convened by the United Nations, the United States Environmental Protection Agency, the United Kingdom Ministry of Agriculture and Fisheries, the Puget Sound Water Quality Authority, the US Office of Technology Assessment, the Fraser River Estuary Management Program, and a draft report on marine criteria prepared for Environment Canada.

Table 2 shows the guidelines derived from the literature review (see Appendix H) and used by the Task Force to determine whether various options would deliver the level of environmental quality required to meet the general principles. Figure 16 shows the current state of the Harbour compared to the guidelines for certain parameters.

Variable	Water	Sediment	Biota
Dissolved oxygen	SA>[a] 8.0 mg/L[b]		
	SB> 7.0		
	SC> 6.0		
Fecal Coliform Bacteria	14 per 100 mL[c]		
	200 per 100 mL[d]		
Suspended Particulate Matter	10% above ambient[b]		
Metals			
Copper	2.9 µg/L	40.0 mg/kg[e]	20.0 µg/g[g]
Lead	5.6 µg/L	45.0 mg/kg[e]	2.0 µg/g[g]
Zinc	86.0 µg/L	40.0 mg/kg[e]	50.0 µg/g[g]
Cadmium	9.3 µg/L	0.6 mg/kg[f]	0.5 µg/g[g]
Chromium	50.0 µg/L		
Mercury	0.025 µg/L	0.75 mg/kg[f]	0.5 µg/g[g]
Manganese	100.0 µg/L		
Nickel	8.3 µg/L		
Organic Chemicals			
Total PCB	0.03 µg/L	100.0 µg/kg[f]	2.0 µg/g[g]
Total PAH	5.0 µg/L	2.5 µg/kg[f]	100.0 µg/g[i]
Oil and grease	10.0 µg/L[h]	10.0 µg/kg[f]	
Total pesticide		100.0 µg/kg[f]	
Total OHs		100.0 µg/kg[f]	

a See Table 3
b Based on Fraser River Estuary recommended objectives.
c Shellfish water quality standard (14 fecal coliform per 100 mL, 10% not >43)
d Swimming water quality standard (200 fecal coliform per 100 mL,10% not >400)
e Based on Puget Sound apparent effects threshold.
f CEPA levels for ocean dumping control
g For consumption normally judged by National Health and Welfare on individual situation
h To prevent tainting
i Recommendation in GESAMP review (the Joint Group of Experts on the Scientific Aspects of Marine Pollution, a body sponsored by several international organizations including UNEP, UNESCO, and FAO.

Table 2: Proposed Environmental Quality Guidelines for Halifax Harbour Derived from Review of Literature, Used to Assess Impacts of Different Outfall Locations

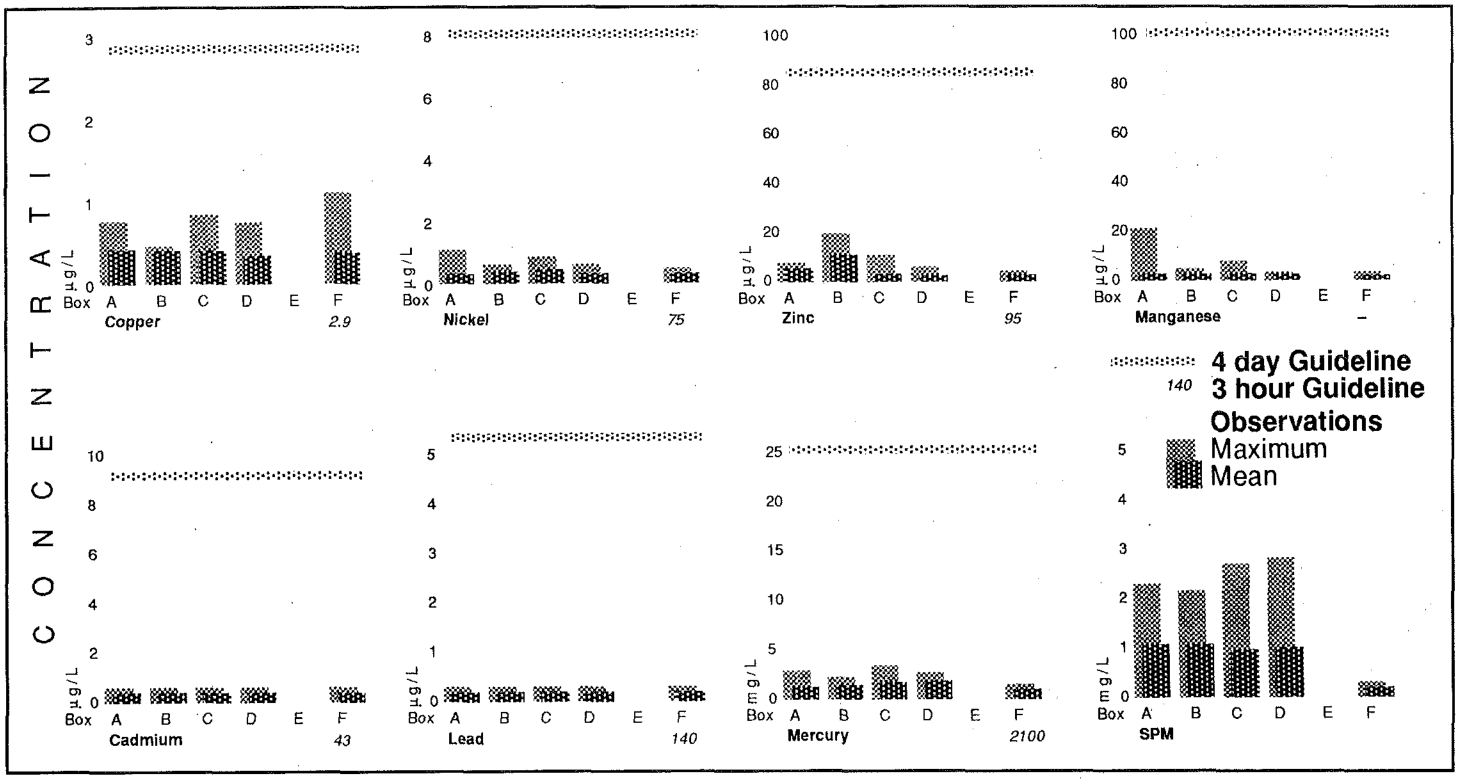


Figure 16: Current State of the Harbour Compared to Environmental Quality Guidelines

The vertical axis shows concentrations; the horizontal axis shows Harbour subdivisions (Box A - F). Two guidelines are shown: a 4-day guideline (the horizontal dotted Line) and the 3-hour level (the much higher level shown in the bottom right hand corner). All of the observed concentrations are well below guidelines, although copper is the closest.

Dalziel et al. 1989.

Class SA	- bathing and contact recreation
	- shellfish harvesting for direct human consumption
	- fish and wildlife habitat
Class SB	- shellfish harvesting for human consumption after depuration
	- bathing and other primary contact recreational activities
	- fish and wildlife habitat
Class SC	- boating and other secondary contact recreational activities
	- fish and wildlife habitat
	- industrial cooling
	- good aesthetic value

Table 3: Environmental Quality Classification: Rhode Island

8.3 Priority Areas for Environmental Protection

These environmental quality guidelines refer to the overall, long term water and sediment quality objectives which must be achieved throughout the Harbour. However, the Task Force recognizes that by consolidating the existing 40 plus outfalls, there will be the potential for localized impacts in the area of the plume, even though the sewage will be treated. Operational problems also occur even at the best run and maintained plants, which means that for limited periods the sewage effluent may be of a poorer quality. While it is important to minimize both of these effects through plant design and operation, decisions about outfall location must also take into account priority areas within the Harbour for environmental protection.

Rhode Island has developed the following classification scheme for groups of water uses requiring different minimum levels of environmental quality. Identical or similar schemes are used by other municipalities (for example Boston). Class SA would refer to areas with the most stringent environmental quality requirements.

Based on this classification scheme and on Harbour use information, the Task Force agreed on the priorities for different areas of Halifax Harbour as shown in Figure 17.

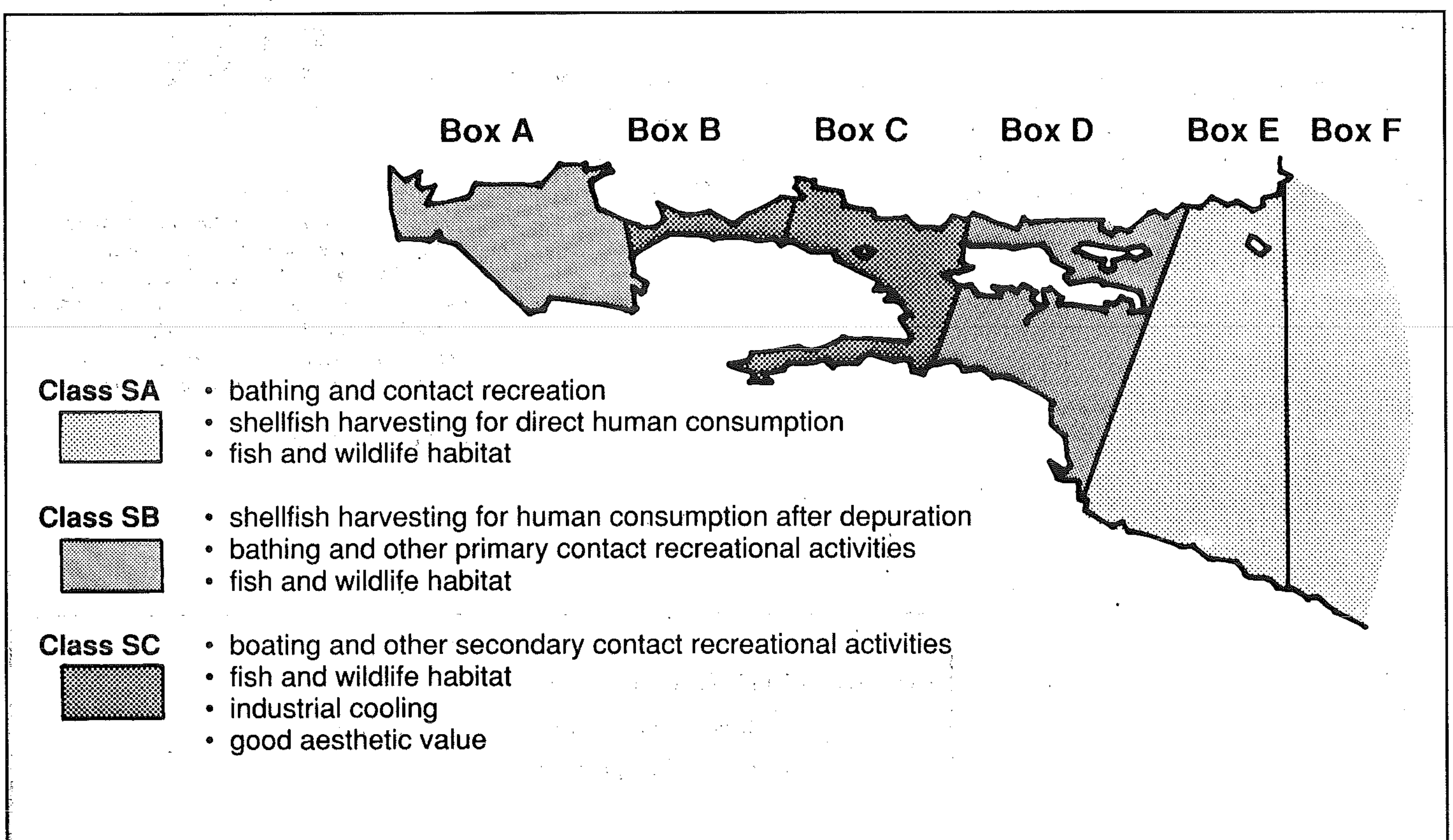


Figure 17: Priority Areas for Environmental Protection

9.0 Scientific Analysis

After identifying Harbour uses, establishing objectives and setting environmental quality guidelines, the next step was to assess how treated effluent from a regional system, together with the effluent from two existing plants, might affect water and sediment quality in the Harbour. To do this the following assumptions were made about the total volumes of wastewater entering the Harbour:

	Cubic Metres/Day	Treatment Level
New regional system [1]	185,000	Undetermined
Mill Cove plant[2]	45,000	Secondary
Eastern Passage plant[3]	18,000	Primary
Total	248,000 (54.6 Imgd)	

1 Based on estimates in the MAPC Phase 3 Report
2 Based on a doubling of current flows to accommodate future growth in Bedford and Sackville
3 Based on a slight increase in existing flows only, because the Eastern Passage plant cannot expand

Table 4: Projected Sewage Flows

Actual concentrations of heavy metals (nickel, iron, lead, cadmium, manganese, zinc, mercury and copper) in untreated wastewater were analyzed from the outflow of Herring Cove and Northwest Arm pipes and the inflow of the Eastern Passage treatment plant. In addition, suspended particulate matter, nutrients and fecal coliform bacteria concentrations were taken from the MAPC Phase 3 Report.

To estimate the potential impact of these projected flows a series of mathematical models was developed to attempt to duplicate the present state of the Harbour waters and, if successful, to predict environmental change resulting from sewage treatment. Using salinity data, a simple mean circulation model was produced for the Harbour. It was tested by predicting both current velocities and concentrations of contaminants discharged from existing outfalls, and comparing both of these with actual measurements made in the Harbour. Both were found to be in reasonable agreement. The model was then used to simulate the distribution of these variables in various sewage treatment scenarios.

However, this circulation model will only give the long term picture for larger areas of the Harbour such as Bedford Basin, The Narrows etc. It cannot be used on a smaller geographic scale nor can it forecast changes in fecal coliform bacteria, since they are living organisms which die off rapidly in seawater and therefore cannot be properly assessed by the model. Consequently other models were used to look at both of these concerns.

Parallel to this effort, ASA Consulting Ltd. was contracted by Halifax Harbour Cleanup Inc. to refine an earlier water quality model in order to use it to examine five scenarios for sewage treatment in the Outer Harbour. Their model is capable of discriminating between two points only 200 m apart, a much finer scale of resolution than the efforts of the Task Force. However, they consider the fate of only two variables in their scenarios, fecal coliform bacteria and suspended particulate matter.

Two other questions required answers. At what rate will the treated effluent be diluted as it leaves the diffuser and makes its way from the Harbour bottom on its way to the surface; and, given the amount of mixing in the Harbour due to the variable circulation, how far will a plume of material be dispersed from an outfall site. Each process is different and occurs over a different time interval: initial dilution lasts possibly minutes, dispersal of contaminants such as fecal coliform bacteria lasts hours or days, while longer term variations such as the transport of fine sedimentary material can take up to several months. The analysis of these processes therefore required different approaches.

In summary then, the plan was to attempt to predict the impacts of possible outfall placement in different areas of the Harbour, and then to relate those impacts to environmental quality guidelines and Harbour uses.

9.1 Dispersion

Sewage treatment will not alter the total volume of wastewater entering the Harbour. It will, however, concentrate the discharge through one or several outfalls instead of the present forty plus. This will obviously concentrate the impacts, but of course the effluent will be considerably cleaner than it is now.

In order to carry out an analysis for dissolved metals, nutrients and suspended solids, the Harbour was subdivided into six areas or "boxes" which have already been described: Bedford Basin (Box A), The Narrows (Box B), the Inner Harbour (Box C), the Middle Harbour (Box D), the Outer Harbour (Box E), and the Harbour Approaches (Box F). Each box was divided vertically into two layers: 0 to 10 meters and 10 to 20 meters. Each layer had a different volume (due to the variable shape of the Harbour), different rates of horizontal and vertical water movement and a different density structure.

Copper

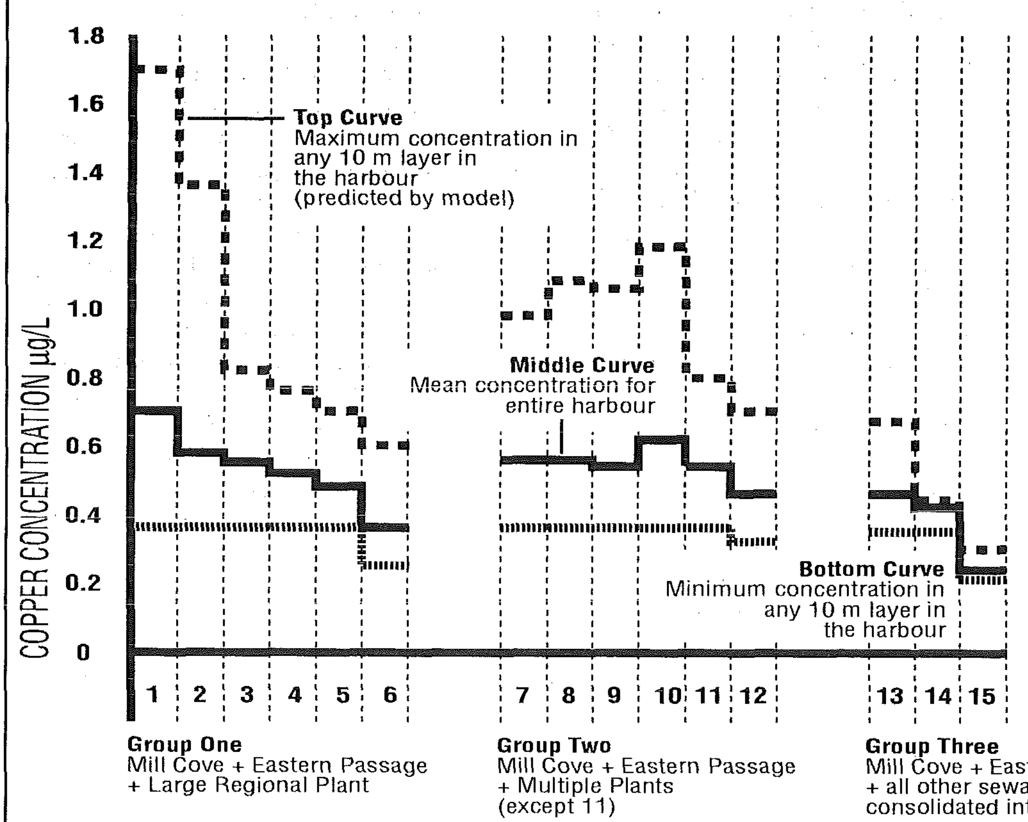
Copper was chosen as the prime metal to examine for three reasons:

1. Copper is the metal least likely to be affected by chemical reactions in the Harbour waters and consequently its distribution will mostly be determined by the circulation.

2. The average concentration of copper in the water column in the Harbour is closer to the relevant environmental quality guideline than other trace metals and is therefore potentially of greatest concern (see Section 8.2).

3. The water quality modelling produced the most accurate results for copper, indicating that the present information about concentrations and the form of copper in the sewage entering the Harbour is reasonably accurate (see Appendix A).

Fifteen different scenarios were considered for the Harbour (Figure 18) using a wastewater concentration for copper about 45% higher than the present input. In all of these scenarios it was assumed that copper was being discharged into the upper layer, and that its concentration would not be affected by the level of treatment. It should be noted that effluent may not rise to the upper layer after being discharged from a diffuser if the density of the water varies too much from top to bottom. In any event, these calculations reflected a conservative estimate of the influence of treatment on pollutants entering Halifax Harbour.



SCENARIOS \ BOXES	A	B	C	D	E	F
1	92	-	8	-	-	-
2	18	74	8	-	-	-
3	18	-	82	-	-	-
4	18	-	8	74	-	-
5	18	-	8	-	74	-
6	-	-	8	-	-	74
7	18	38	44	5	-	-
8	18	44	33	5	-	-
9	18	44	7	31	-	-
10	51	-	44	5	-	-
11	18	-	77	5	-	-
12	18	-	8	48	-	26
13	-	-	-	100	-	-
14	-	-	-	-	100	-
15	-	-	-	-	-	100

Concentrations of copper predicted for each of 15 scenarios. The vertical axis shows copper concentrations in millionths of a gram per litre while the horizontal axis shows each scenario. The 15 scenarios are divided into three smaller groups. The table above shows the percentage of effluent expected to flow into each box for a given scenario. For example, Scenario 4 had 18%, 8% and 74% of treated effluent going into Boxes A, C and D respectively. The estimates for maximum, minimum and average concentrations for Scenario 4 are 0.8, 0.35 and 0.55 µg/L. The accepted guideline (Figure 16) is 2.9 µg/L.

Figure 18: Concentrations of Copper Predicted for Scenarios

Using a mathematical model tailored to the characteristics of a particular layer it was possible to examine conditions before and after the introduction of an outfall. At this very preliminary level of analysis, the exact physical location of the outfall within a given box was not important since it was assumed that any material entering the layer was instantly mixed. The significance of this approach is the recognition that each layer is unique, with its own set of physical characteristics; and that only when set against that backdrop can the addition of large quantities of new material be properly evaluated.

The results achieved from this approach did not show large differences between any two scenarios. The model outputs plotted on Figure 18 show that wastewater with the composition measured at Herring Cove, Northwest Arm and Eastern Passage, introduced into the layers, as defined, will not exceed the accepted environmental guidelines.

Suspended Particulate Matter

Similar model simulations were run for suspended particulate matter (Figure 19). The present conditions in the Harbour were best duplicated when the particles, regardless of size, were considered to have a sinking velocity of 2.2 m/day. This sinking velocity was adopted for all further model runs. Besides sewage, additional sources of suspended particulate matter were also incorporated into the model. These included the plants responsible for primary productivity and materials carried by both the Sackville River and the shelf waters.

For the 15 scenarios, a removal efficiency of 55%, equivalent to a primary level of treatment, was adopted. It is possible that, because most of the larger particles are removed by treatment, the remaining finer particles may sink more slowly. However, this was not considered in the calculations.

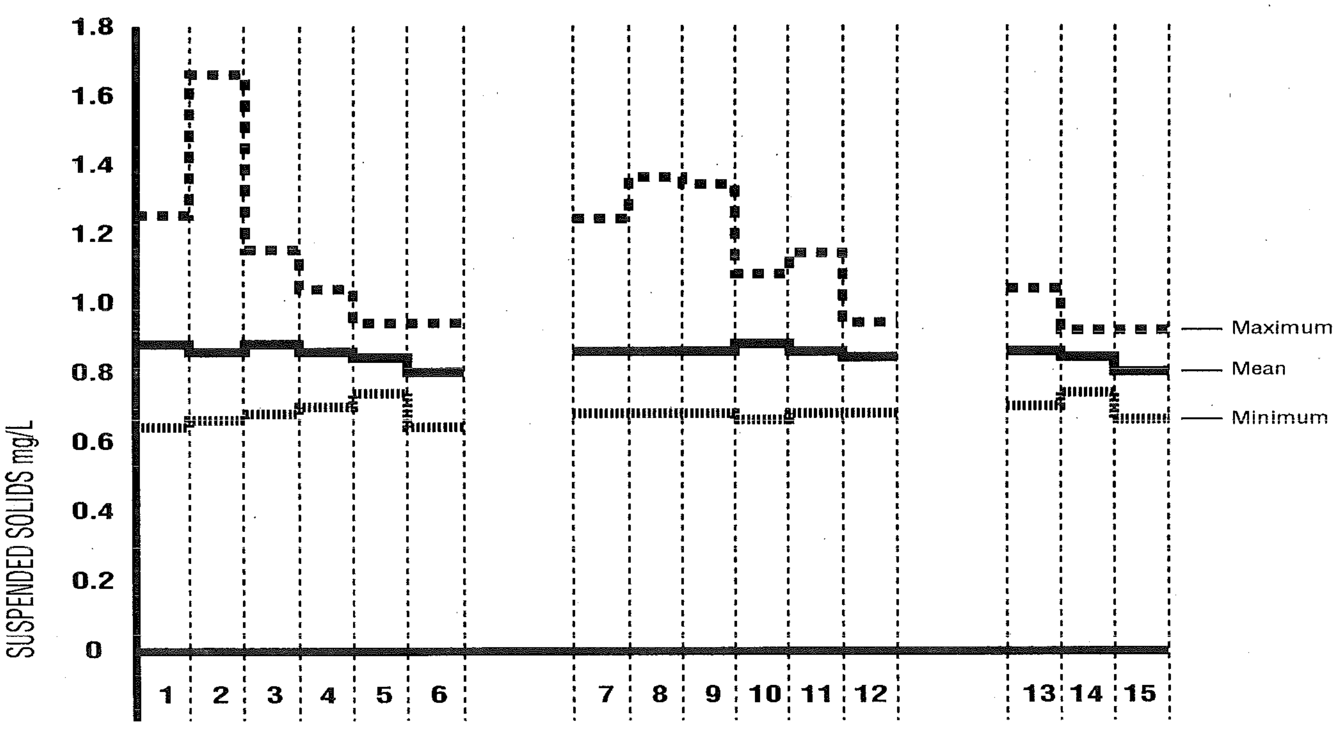
The results show that:

1. Average levels over the entire Harbour are more or less constant regardless of outfall location. This is due to the overriding effect of indigenous primary productivity on SPM levels.

2. Sewage impacts appeared mainly in the form of high concentrations predicted for The Narrows, where the level of primary productivity is low.

Fecal Coliform

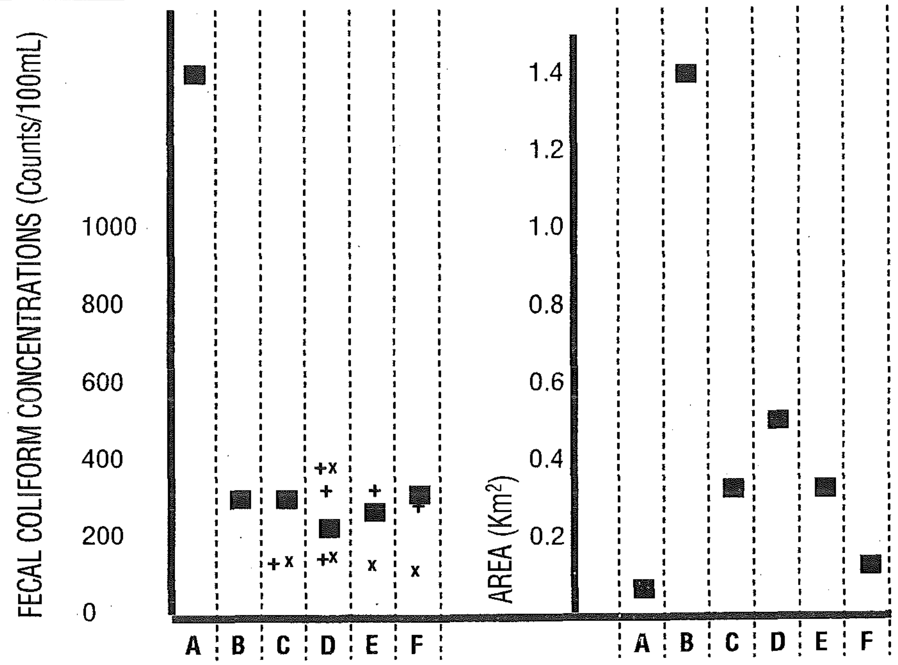
A different type of model (see Appendix A) was developed to examine fecal coliform because bacteria concentrate in a much smaller area than the large boxes used to investigate trace metals. In each case, all bacteria were discharged from a single outfall 200 m long into a volume defined by that length, the lateral tidal motion and the layer depth.



Suspended Particulate Matter values for harbour from the following sources:
a) Sewage from primary plant (55% suspended solids removed)
b) primary productivity
c) Sackville River
d) shelf waters

Total estimated suspended particulate matter from effluent from proposed system plus three other natural sources. Each estimate is for an outfall location scenario identified in Figure 18

Figure 19: Concentrations of Suspended Particulate Matter Predicted for Scenarios



■ Task Force Calculation

x ASA Calculation (concentrations above diffusers)
Note two different locations in Box E, (upper layer)

+ ASA Calculations (lower layer)

Area (Km 2) with Fecal Coliformcount shown in adjacent figure

The diagram on the left shows calculations by the Task Force and ASA for concentrations of fecal coliform above a single regional outfall located in each of the six boxes. The diagram on the right shows the area in km^2, according to Task Force calculations, with the fecal coliform concentrations shown in the adjacent diagram. For example, if a single outfall were placed in Box E, the concentration of fecal coliform would be approximately 300 per 100 mL over an area of 0.35 km^2.

Figure 20: Concentrations of Fecal Coliform Predicted for a Single Regional Outfall in Different Locations

The results are shown in Figure 20 along with the computations carried out by ASA Consulting Ltd. (ASA, 1990) using their 200 m resolution numerical model. The two computations had other major differences besides resolution. The calculations made by the Task Force assumed a layer depth of 5 m; the ASA layer depth was approximately 10 m. The Task Force assumed a die-off rate equivalent to 16 hours, while ASA chose 12 hours. Both of these differences will tend to make the Task Force's estimates higher.

Except for Bedford Basin, the Task Force results are similar for all boxes and lie between 225-300 fecal coliform per 100 mL. These are generally higher than the results obtained by ASA. Except for The Narrows, the areas enclosed by these counts are less than 0.5 km^2 (for example, a rectangle 1000 m x 500 m). With currents of 0.07 km/h and a die-off rate equivalent to 16 hours, the counts could be expected to fall to one third of the values given in Figure 20 in about one kilometre.

As important as the actual count of fecal coliform is the area for which the value exceeds 200 fecal coliform per 100 mL. This can be translated into a distance a diffuser should be placed from areas which require counts less than this value. For the Inner and Middle Harbour, the Task Force estimates that this distance is about 2 km. This computation, outlined fully in Appendix A, is highly dependant on the dilution rate, the effectiveness of the disinfection process, mixing, and currents.

On the other hand, the ASA (1990) calculations for the Harbour indicate that this distance is smaller. For comparison with the Task Force calculation, they indicate that the count will exceed 200 fecal coliform per 100 m/L in a 200 x 200 m box around a diffuser placed off Ives Knoll in the Inner Harbour only 25% of the time, or off Sandwich Point in the Middle Harbour only 35% of the time. Other calculations carried out by the Task Force (see Appendix D) are in closer agreement with these values than the more conservative one above.

The heavy metals, nutrients, suspended particulate materials, and fecal coliform bacteria will be sufficiently diluted and dispersed, even with only primary treatment, to fall well within acceptable limits. Consequently, these considerations cannot be used to discriminate one potential site from another.

9.2 Dilution

A subsurface sewage outfall normally terminates with a device referred to as a diffuser. The outflowing wastewater is forced upward through a series of ports which have been designed to maximize turbulence and dilution. Modern diffuser pipes are often designed so that one part of effluent will mix with about 50 parts of the receiving waters.

In order to determine the dilution characteristics of the diffuser, and from that the nature of the effluent plume, three quite variable environmental conditions must be taken into consideration. The first is the degree of stratification of the column of water above the diffuser. The vertical distribution of water density can markedly affect the level to which a sewage plume can rise after it is introduced into the ocean. If water density at the diffuser depth is much greater than that of the surface waters, it is quite possible that the diluted effluent may not reach the surface.

Based on knowledge of density distributions collected over a two year period by the Bedford Institute of Oceanography, calculations were made as to the height that the effluent plumes would rise in various places throughout the Harbour. The average density differences (0-20 m) were greatest in the Basin and The Narrows, least in the Outer Harbour and on the shelf, and intermediate in the Inner and Middle Harbour and the Harbour Approaches.

Generally, the closer the diffuser was placed to the head of the Harbour, the more frequently the plumes stayed subsurface. Moreover, since density differences from surface to deeper waters are greatest in summer, plumes will stay below the surface more often during that season. Opting for a shallower diffuser depth will encourage the plume to reach the surface more often but will also result in less dilution. In the earlier Phase 3

Study the waters of the entire Harbour were taken as having a uniform density. In such circumstances, an effluent plume would always reach the surface.

The second consideration is the depth of the diffuser itself. If one accepts that an effluent plume will reach the surface, then the deeper the diffuser, the greater will be the dilution.

The third consideration is the strength of the horizontal currents. Ideally, the water which is being mixed with the effluent should be clean, that is, free from sewage. This requires a fresh supply equal to the sewage flow times the dilution rate. We have combined representative currents from each box in the Harbour, a sewage flow of 2 m^3/s, a dilution rate of 50 and a depth of 20 m to determine an approximate length of diffuser required so that clean water is continuously supplied.

The results (Table 5) indicate that, except for Bedford Basin, a diffuser of reasonable length could be constructed for any area. Because of the weak flows in the Basin, a very impractical diffuser (approximately 2.5 km in length) would be required. This effectively excludes Bedford Basin as an area for a major outfall location.

		Representative Average Flow	Length of Diffuser[1]
Box A	Nearsurface	0.12 km/h	2500 m
	Subsurface	0.12	
Box B	Surface	1.2 km/h	170 m
	Middle	1.2	
	Bottom	1.8	
Box C	Nearsurface	0.96 km/h	300 m
	Subsurface	0.96	
Box D	Nearsurface	1.2 km/h	250 m
	Subsurface	1.2	
Box E		1.2 km/h	250 m
Box F	Western side	4.2 km/h	70 m
	NE side	1.5	200 m

1 Length of diffuser required to make water flux = 50 x sewage flux.

$$L = \frac{2 \times 50}{20 \text{ m} \times \text{mean flow}}$$

Table 5: Length of Diffuser Required to Achieve Desired Dilution in Each of the Six Harbour Boxes

9.3 Sediments

Sediments which have accumulated on the Harbour floor contain a history of uses, both natural and human, but especially the Harbour's role as a repository for waste. They can be read by experts and used as a guide to help understand potential impacts on the system.

A major sediment issue which has arisen is a concern for trace metals identified in certain parts of the Harbour. Are they stable within the sediments or are they released through natural or other processes? Will future treatment/outfall scenarios alter the amount, location and type of materials discharged into the Harbour? Can these contaminants enter the food chain?

Early models of this system were simplistic and suggested that the Harbour waters were exchanged regularly and sediments were removed by this process. The oceanographic data collected most recently, together with a knowledge of sediment and contaminant distributions on the seafloor, indicate that conditions are much more complex and that a large part of the discharged material remains on the Harbour floor.

The Importance of Waves, Currents and Tides.

Average water circulation can lead to sediment transport and subsequent deposition in regions of very weak flow. High energy currents from tides, storms or waves can scour some areas of fine-grained sediments leaving behind gravel and bedrock. Sedimentary deposits which reflect water movement over years can tell the physical oceanographers if their short duration current meter records are representative of long term conditions. Halifax Harbour is an inlet whose average circulation is known on a broad scale. Areas of strong, variable currents have been identified. Recently, the Harbour has been the subject of thorough marine geological acoustic studies by the Atlantic Geoscience Centre which have provided a regional understanding of the surficial and bedrock geology. In addition, sediment samples have been collected to provide support for the acoustic data and as well to examine the geochemical changes the Harbour has experienced since the beginning of its use for waste disposal.

Observations on Harbour circulation indicate a general tendency for finer sedimentary particles on the bottom to move inward towards Bedford Basin. Sewage particles in a plume which reaches the surface layer would be carried outward towards open water, but, as they sink, would be trapped in the deeper inflow and move back up the Harbour. In cases of strong stratification, the plume may not reach the outflowing surface layer, and therefore particles would be carried directly back into the Harbour.

In addition to the average circulation in the Harbour, there are currents that can change rapidly, with perhaps the most familiar variation being tidal flows. Wind also can bring rapid, dramatic changes to the circulation by causing water borne material to cross the Harbour in perhaps an hour or by stirring up the bottom sediments through wave action.

These variable currents are weakest in the Basin with flows of about 0.1 km/hr. Sediment deposition can occur at these low levels. The highest values, ranging from 0.6-1.4 km/hr, are found in The Narrows and are largely due to the tides. This is one area in the Harbour that should not contain fine sediments. From Sandwich Point to the Harbour Approaches, the time-varying flows have amplitudes equivalent to 0.2-0.6 km/hr with the lowest values occurring off Herring Cove. These areas, though having lower current variability than The Narrows, are more exposed to ocean waves which can affect sediment transport significantly. No data are available for the Northwest Arm or Eastern Passage but it is anticipated that these areas would have varying currents more like those in the Basin than in The Narrows.

Sediment Transport

No direct measurement of sediment transport has been carried out in Halifax Harbour. However, many characteristics of seabed sediments can be used as qualitative indicators. These include the patterns of distribution of gravel, sand, silt and clay; bedforms in sand and fine-grained gravel; scour features around seabed obstructions, and the distribution of sewage banks and geochemical anomalies.

The most easily identified sediment transport indicators are the surface sediment patterns and bedforms in the Outer Harbour. Here the so-called megaripples in sand cover a broad area of the seabed. Megaripples usually form where the average flow is between 1.5-2.5 km/hr. Some features suggest stronger and even more turbulent flows. The shape of the megaripples indicates bottom sediment transport up the Harbour to the north with the incoming current.

In many areas, in slightly more shallow water adjacent to the megaripples, large areas of ripples formed in gravel are present. These often flank the outcropping bedrock shoals between the bedrock and the megaripples. They do not indicate sediment transport but are formed in place by oscillatory motion associated with waves. The areas of gravel ripples and megaripples in the Outer Harbour indicate that fine-grained silt and clay sediments are not depositing in these areas. Silt and clay sized-sediments discharged there would be transported either further offshore to the inner Scotian Shelf, or transported up the Harbour to the north.

The distribution of chemical elements in Harbour sediments provides another indicator of sediment transport. Many of these distributions suggest dispersion and settlement of material from the sewage discharge locations along the shores of the Harbour in a northerly direction up the Harbour in agreement with average bottom water movement. Variations in mercury concentrations suggest that material discharged from the Duffus St. and Tuft's Cove area are transported through The Narrows and deposited on the southeast side of Bedford Basin. In a similar fashion, the Pier A sewage outfalls can be traced geochemically up the Harbour to an area north of Georges Island.

The presence of anchor marks on the seabed of the Harbour is an important bench mark that can also be used to assess the history of sedimentation and sediment transport. Large areas of Bedford Basin and the Inner Harbour are covered with crisscrossing patterns of anchor marks. Since they occur in most areas of the Basin and in the major shipping channel of the Harbour where anchoring is presently prohibited, they are interpreted as being relict, that is, formed at some time in the past with little subsequent modification or burial. Those in the Basin are interpreted to have largely been developed during assembly of the second world war convoys while those in the Inner Harbour may date back even further to the founding of Halifax. Adjacent to the Halifax Harbour shoreline, recent sediment covers the old anchor marked surface. As the relief on the anchor marks is between 1-2 m, this indicates deposition of greater than 2m of sediment to bury the anchor marked surface. The area of buried anchor marks projects up the Harbour from the major sewer outlets and suggests that the material is dispersed in a northerly direction as it settles to the seabed.

In summary, both the oceanographic and geological data are in good agreement that bottom currents move up the Harbour under most conditions. The distribution of megaripples in the Outer Harbour suggests that currents are strongest to the south of Lichfield Shoal. This has prevented the deposition of fine-grained silt and clay sediments. North of Lichfield Shoal, and adjacent to Herring Cove, an area of seabed with a lack of bedforms in sandy sediments agrees with the oceanographic data suggesting lower velocity bottom currents. This local oceanographic anomaly may result from topographic sheltering by Lichfield Shoal.

Coarse sediments in The Narrows are predicted from the oceanographic data and the geological information confirms this prediction. In the Northwest Arm adjacent to Fleming Park, a similar lack of fine-grained sediments in a constricting channel suggests the presence of strong currents in an area where no measurements have been made. The eastern part of the Outer Harbour is dominated by bedrock and gravel at the seabed. Many of the bedrock outcrops in this area are flanked by rippled gravel deposits which indicate that wave energy is reaching the seabed and that they are zones of high energy.

Muddy sediments in the Harbour are confined to the area north of Maugher Beach. Their presence in the Inner Harbour, Eastern Passage area and the Northwest Arm reflects lower current velocities. Sediment geochemical anomalies and sewage banks deposited over older anchor marked sediments indicates sediment transport up Harbour even in these areas of lower current velocities.

Sediment Quality

It is more difficult to predict the impact of sewage effluent on sediment quality than on water quality. Modelling the dispersal and ultimate fate of particles in the sewage effluent is a complex task, and one well beyond the resources of the Task Force. Within the time available, the only other option was to draw some conclusions from the extent of the existing contamination of Harbour sediments.

Table 6 shows the existing mean and maximum concentrations of four trace metals observed in Harbour sediments from about 250 samples compared to the environmental quality guidelines (section 8.2). Any value under 1.0 indicates that the existing concentrations exceed the guideline.

Clearly, the concentrations of zinc, copper, lead and mercury in the existing sediments in the Inner Harbour do not meet the guidelines. Assuming that (a) the existing concentrations result mostly from sewage input (which, at least for lead, is probably not the case), and (b) treatment, other than tertiary, will not significantly reduce trace metals in the effluent, it follows that concentrations in new sediments deposited from an Inner Harbour outfall following sewage treatment may not meet guidelines either. (It is estimated that primary treatment would reduce metal concentrations in the sediments by about 5%, and secondary treatment would reduce concentrations by 20%).

The trace metals on particles in the sewage effluent could be dispersed more widely by locating the outfall in the Outer Harbour or the Harbour Approaches. However, this would not follow the general principle adopted by the Task Force that *the sewage treatment strategy must generally improve environmental quality throughout the Harbour* (section 8.1), because contaminated sediments would be deposited in areas which are now uncontaminated. The resulting deterioration in environmental quality would probably be marginal, but the fact remains that it would be almost impossible to know where the sediments would end up and what impact they might have over time.

If, on the other hand, an outfall is located in the Inner Harbour, the impact of adding new contaminated sediments to existing contaminated sediments is not cumulative. Usually only the top layer of sediments has the potential to affect water or biota quality. Furthermore, the new layer of sediments will be somewhat cleaner even if it does not meet guidelines, and if an effective source control program is developed and enforced, this layer may become substantially cleaner.

Metal	Ratio of Guideline to Observed Mean Concentration	Ratio of Guideline to Observed Maximum Concentration
Zinc	0.17	0.06
Copper	0.44	0.02
Lead	0.28	0.03
Mercury	0.77	0.07

Source: Buckley and Hargrave (1989)

Table 6: Ratio of Environmental Quality Guidelines to Observed Mean and Maximum Concentrations of Trace Metals in the Sediments in the Inner Harbour

9.4 ASA Conclusions

Box 5 provides a summary of some of the conclusions of the report prepared by ASA Consulting Ltd. Their findings, based on fieldwork carried out in the Outer Harbour, are presented here simply to demonstrate the high degree of convergence between the conclusions drawn by the Task Force as discussed in this chapter and those derived independently by ASA Consulting Ltd.

Box 5: Conclusions of the ASA Report

Fecal Coliform

Previous work investigated the implications of sewage treatment on fecal coliform distributions within the inner harbour. Based on comparisons of simulations for an outfall at Sandwich Point, the predicted mean fecal coliform concentrations in the present study are in agreement with the predictions of the previous work. This would indicate that the results of the previous study remain valid as an indicator of mean conditions within the inner harbour. The inclusion of mean currents would likely displace the distribution one way or the other but the size of the areas affected would likely be similar.

Swimming

Under the assumption that the sewage plume ends up in the upper layer, for the outer harbour in general, the mean concentrations even in the vicinity of the outfall are predicted to exceed the primary body contact (swimming) standard of 200 counts/100mL only infrequently (<10%), or not at all. The probability of the limit being exceeded decreases slightly with distance out of the harbour, but the variation is not significant. With the plume assumed to stay within the lower layer the concentrations near the outfalls are generally higher and in the mean do exceed the swimming standard in most areas.

. . . the region around Herring Cove and Halibut Bay is anomalous. In this area, as characterized by the outfall simulation off Halibut Bay, the predicted concentrations are somewhat higher, with the swimming limit being exceeded in the immediate vicinity of the outfall at all times. This area does not represent an optimum location for an outfall from an oceanographic point of view.

In all areas including Halibut Bay, and with the plume in either layer, the area predicted to be affected by concentrations exceeding the swimming criteria more than 10% of the time does not extend further than approximately 400 m from the outfall site. This implies that in any region in the outer harbour, a properly designed and sited outfall (i.e., far enough from shore) would be able to ensure that swimming criteria were only violated within the nearfield of the outfall plume and not regularly violated at the shoreline.

Suspended Particulate Matter

In general, the Outer Harbour simulations indicate that SPM levels due to the addition of treated effluent will cause incremental SPM concentrations which are less than that typical of productive coastal waters, which are a few mg/L (NRC,1984). In most parts of the study area, concentrations in excess of 1 mg/L are not predicted to occur at all for a plume in the upper layer, and only infrequently (<10% of the time) and very locally (within a few hundred metres of the outfall) for a plume in the lower layer.

The exception is once again the low energy area characterized by the Halibut Bay site. In this area, upper layer concentrations in excess of 1 mg/L are predicted to always occur in a small area near the outfall and are predicted to occur periodically within a kilometer of the outfall.

Based on these results no acute disruption of the environment would be expected from an outfall in deep water anywhere in the Outer Harbour. However as discussed for fecal coliform, the Herring Cove-Halibut Bay region is probably less suited to outfall siting than other areas of the Outer Harbour.

The areas affected by elevated SPM concentration at the 0.1-0.2 mg/L level are predicted to change significantly with outfall location within the study area. Generally, the further out of the Harbour the outfall is sited the smaller the area affected by elevated SPM levels.

The net inward flow in the lower layer tends to bring material from a plume in the lower layer further into the Harbour. The model simulations indicate that an outfall located in the Inner reaches of the study area, as characterized by the Ives Knoll site, with the plume assumed in the lower layer, could result in water column concentrations of sewage solids in the Inner Harbour of approximately 0.2 mg/L. This value drops as the outfall is moved further out of the Harbour until the effect on the Inner Harbour becomes negligible at sites outside of the south end of McNabs Island.

The Inner Harbour is a region where organic sediments presently deposit and where sewage solids would tend to deposit if they were present in the water column. In the Outer Harbour the sediments are much coarser, most likely due to the increase in wave energy. Sewage solids present in the water column will not tend to deposit in the Outer Harbour.

While it was not our intent to address the deposition of sewage solids in sediments, it appears that all simulations considered represent a major improvement over existing conditions. To account for the observed SPM levels (assuming that the spatial distribution is reasonably resolved both horizontally and vertically), requires that a large fraction of the existing sewage load rapidly settle in the Inner Harbour. In the outfall simulations, negligible settling is assumed and in the worst case, the predicted water column concentrations in the Inner Harbour, where deposition might occur, are still small. Any contribution of sewage treatment plant effluent to contaminated sediments will be significantly less than that associated with stormwater runoff and combined sewer overflows.

IV
The Regional Sewage Treatment System

10.0 Selection of Outfall Site

The process of outfall site selection involved the application of several types of criteria. First, the Task Force considered the Harbour use objectives and general principles which it established following consultation with the community. Second, the available scientific information dealing with dilution and dispersion rates in various parts of the Harbour was considered, along with the possible distribution and impact of effluent derived sediments.

Some important conclusions, derived from the previous chapter, must be kept in mind. Calculations pertaining to the dilution and dispersion of the various constituents of wastewater showed that one outfall delivering 185,000 m^3/d of primary-treated wastewater would, with the exception of Bedford Basin, meet the environmental guidelines described in Section 8.2. This means that water quality alone could not be used to determine the preferred outfall location.

A second conclusion which influenced the outfall siting choice is the belief that particulate-borne trace metals might pose a more important health hazard than materials dissolved in the effluent. Particulates eventually settle to the sea floor and accumulate in deposits which reflect the influences of local circulation. As the particles settle, metal-rich sediments may accumulate and create potential environmental hazards (for example, toxicity to marine organisms) or health hazards (for example, ingestion of contaminated fish or shellfish).

10.1 Dispersion Versus Containment

The Task Force spent a considerable amount of time debating the relative merits of outfall locations inside or outside McNabs Island. In essence this devolves to a debate over the diametrically opposed positions of containment versus dispersal. This debate is not unique to Halifax Harbour. Traditionally, the objective in designing and siting marine outfalls has to been to achieve as much dispersion as possible. In Boston, for example, a 12 km long sub-seafloor outfall pipe which is about to be constructed off Boston Harbour. This very expensive operation is an attempt to deposit Boston's effluent on the Inner edge of the continental shelf where dispersal is greater.

The arguments in support of dispersal reflect the belief that increased dispersion will reduce concentrations of contaminants to acceptable or even undetectable levels. The dispersion approach would tend to favour the Outer Harbour or the Harbour Approaches, where there is a greater volume of water available to dilute the effluent. There is also an increasing likelihood that sewage particles will not become entrained in the inflowing bottom waters. The drawback to this approach is that it is difficult to predict long term or cumulative effects of dispersing contaminants widely through an environment. While currents in the Outer Harbour could reasonably disperse and dilute any effluent, there remains the possibility that any contaminants discharged in that area may concentrate in unexpected ways or places. It would be difficult to monitor any effects on the environment.

The containment approach argues that the only responsible way to address sewage treatment in the last decade of the 20th Century is to clean it up at home. In other words, if our effluent is not good enough to keep then we should not be sending it elsewhere. In centuries past, dispersal was commonly practiced communities were few and far between and most wastes were biodegradable. Today, the continuing growth of population and chemical composition of wastes makes this more.problematic.

The containment approach is consistent with the Guidelines for the Protection of the Marine Environment Against Pollution from Land-Based Sources (Appendix E), developed under the auspices of the United Nations Environmental Programme (UNEP). Canada is a signatory to these Guidelines which are also known as the Montreal Guidelines because of where they were finalized. In those Guidelines, jurisdictions are encouraged to adopt measures to prevent , reduce and control pollution from land-based sources within their capabilities and particularly to minimize to the the fullest extent possible the release of harmful toxic substances. Jurisdictions are also encouraged not to transfer damage or hazards from one area to another.

It is important to realize that the two approaches to sewage treatment are not necessarily mutually exclusive. It is quite possible, for example, to develop a plan which is based on the dilution and dispersal of constituents such as dissolved heavy metals, nutrients or fecal coliform bacteria while simultaneously encouraging containment of other materials such as suspended particulate material and the metals and organic chemicals associated with it. The choice or mix of these approaches depends on environmental factors, the quality of the wastewater and the goals set by the community.

Implicit in any approach is the understanding that predictions are being made on knowledge which is less than perfect. The practical result is that the final effluent could contain materials which will behave in an unexpected manner. This can then bring about unexpected consequences such as containment of elements which are best dispersed or vice versa. The only solution to such a possible state of affairs is to establish a monitoring program which regularly assesses the success or failure of whatever approach has been chosen. Routine monitoring is the only way to measure the "goodness of fit" between original expectations and the actual environmental result.

10.2 Evaluation of Outfall Locations

With the above considerations in mind, each Harbour subdivision (Box) was evaluated in turn. Each scenario considered included the following assumptions: that the existing secondary treatment plant in Bedford Basin (Mill Cove), and the primary treatment plant in Eastern Passage would continue to operate as independent entities, unless otherwise indicated; also, that in Herring Cove either a small treatment facility would be built or a forcemain would be installed to move local sewage to a regional facility. For the purposes of this exercise the omission of these facilities did not materially alter the outcome of the scenarios.

What follows is a consideration of each box independently. The following question was asked for each: would an outfall in this part of the Harbour satisfy defined objectives and principles? Information, which both supports and detracts from these locations is presented.

A. Bedford Basin

Bedford Basin is an area of the Harbour which enjoys a variety of uses which include recreation, military, shipping, fishing and research activities. In order to sustain these uses a water quality of SB is required (see Table 3).

Estimates made on the relationship between circulation and water quality indicate that Bedford Basin could not reasonably accommodate the total loading of a single regional treatment plant. The observed circulation is insufficient to dilute and disperse the effluent properly. In the Task Force's opinion, the probable outcome of increased waste disposal in this area would be significant degradation of both water and sediments. This result would be incompatible with present and planned uses for that portion of the Harbour.

At the present time the Basin appears to be healthy except for occasional low oxygen events in deep water. However, it is not at all clear how much additional wastewater receiving capacity it contains. Prior to any future decisions regarding expansion of Mill Cove capacity or alternatively, inclusion of this facility into a regional network, additional studies should be undertaken.

B. The Narrows

The Narrows is predominantly an industrial area which is also used as a through channel for shipping between the Inner Harbour and Bedford Basin. Little of its shoreline is accessible to the general public. This area receives a large portion of the raw sewage currently reaching the Harbour. Its present usage suggests the quality rating of SC, which is the lowest available.

As its name indicates, this is the narrowest portion of the Harbour. This reduction in width intensifies current activity and produces very strong vertical mixing, which in turn produces an environment which greatly enhances dispersion of effluent. Conversely, The Narrows is not a depositional area.

Perhaps the most important drawback associated with this location is the strong possibility that a significant percentage of the wastewater delivered to The Narrows will eventually move into Bedford Basin. There, a significant proportion of the suspended solids would probably settle out in the slow moving waters of the Basin. Based on geochemical studies of the present sediments, material from Tuft's Cove and Duffus St. outfalls follows this pattern. While the risk that these sediments may pose cannot be fully assessed, the Task Force has some reasonable grounds for concern.

C. Inner Harbour

The Inner Harbour encompasses a wide diversity of activities: viewing, boating, shipping, fishing and swimming, among others. Portions of this box require sufficient water quality to permit body contact (SB), while for others SC is sufficient. Presently, about one-half of the raw sewage which enters the Harbour does so in this region.

This is an intermediate region in terms of circulation, mixing and depth. The average current velocity is low, relative to The Narrows, because of the gradually increasing width. Consequently, wastewater discharged here is not immediately exported elsewhere. Particulates tend to settle locally rather than becoming more generally dispersed prior to joining the sediments on the Harbour floor. However, the possibility cannot be ruled out that some fine particulates might reach surface waters and conceivably move 8 km (for particles with a sinking velocity of 2.2 m/day which reaches the surface of a 10 m thick upper layer moving out of the Harbour at 0.07 km/h) south of the diffuser site before settling and becoming entrained in the return flow.

Benefits to be derived from placement of an outfall in this box would include a greater probability that sediments would be contained in a reasonably circumscribed area, which in fact already contains the highest level of contaminated sediments. Containment in this manner would greatly assist future monitoring programs which must be carried out in order to routinely assess Harbour impact.

A second benefit is the absence of a significant commercial fishery in this box. Admittedly, some fishing occurs, chiefly for lobster, but by comparison with the boxes further out it is small. Statistics on the recreational fishing in this box (and elsewhere in the Harbour) are not available. Since dissolved materials are not judged to pose a threat, even though they cannot be contained in any one box, reasonably constrained sediment deposition would localize any impact.

A final benefit is that sufficient space exists in this box to accommodate an outfall well outside the minimum 2 km separation distance which the Task Force suggests is essential to ensure adequate water quality for local swimming areas.

Several other shortcomings have been identified with this area as a possible outfall location. These would include some reduction in dispersion resulting from reduced circulation and turbulence, plus the possibility of additional stress on this box resulting from the juxtaposition of both a wastewater outfall and several combined sewer overflows. Should the outfall be located in this part of the Harbour the latter shortcoming would have to be addressed through proper planning and design.

D. Middle Harbour

The Middle Harbour, in addition to being an important fishing area, is a region in which high water quality fosters considerable recreational activity. Water quality which straddles the SB and SA categories is probably appropriate.

The Middle Harbour has in the past been identified as a desirable location for the placement of a wastewater outfall. It is the Task Force's collective opinion that these conclusions were based on a somewhat limited understanding of sediments and circulation. Sandwich Point, located on the western side of this box, was recommended by the Metropolitan Area Planning Commission as the proposed site for a regional treatment facility.

In general, it appears that the Middle Harbour was perceived to be a desirable location because of its proximity to the Harbour mouth and deeper water. Both of these factors are thought to aid in the dispersion of effluents, which are, of course, in keeping with the general philosophy of dispersal. In fact, the Task Force's calculations indicate that dispersal of dissolved materials on to the Shelf is greater for this box than for others farther in the Harbour. However, because of the general nature of estuarine circulation, some effluent released from the diffuser could follow a path generally inward, gradually mixing with the water above and below in its travels.

A further consideration is the role of estuarine circulation on the settling of suspended particulate material. Particulates trapped in the inward flow might settle in existing depositional areas. Some percentage of it will be deposited north of Lichfield Shoal, along the shore between Sandwich Point and the Northwest Arm. Storm activity would probably move these deposits northward, thereby altering existing patterns of potentially contaminated sediments in the Harbour. Particulates trapped in the outward flow would be taken out of the Harbour and be deposited in unknown areas.

A major concern associated with the placement of an outfall into this box is the potential effect upon the substantial commercial fishery which it contains. Although Task Force calculations showed that effluent will not exceed acceptable environmental guidelines, concerns were repeatedly and vigorously expressed that an outfall in this area could undermine public confidence in the quality of the seafood caught locally.

E. Outer Harbour

The principal activities in the Outer Harbour involve a vigorous harvest fishery, as well as a fledgling aquaculture industry. Both require clean water as well as the public perception of an unsullied environment. As there was for Box D, there is a concern that an outfall placed in this are could undermine public confidence in the quality of seafood caught locally. Because of the present very high water quality it has been designated as SA.

The strong currents and excellent mixing in this part of the Harbour would ensure that any effluent placed in this box would probably disperse over a wide area. It is not possible, given the present state of our knowledge, to predict where the particulate matter would settle. Consequently, it would not be possible to offer any hope for containment of these substances.

The eastern side of the Harbour is quite shallow, with an average depth of approximately 10 m. Circulation studies indicate that currents tend to move clockwise from the western to the eastern shore. Accordingly, entrained materials would move in the general direction of Eastern Passage.

As with a Middle Harbour outfall considered earlier, conditions in the immediate vicinity of the diffuser would be perceived to be of lower quality than that which existed prior to its placement. Such an outfall would fall within the environmental guidelines but it would undoubtedly have a pronounced negative impact on the perception of water quality in that area.

F. Harbour Approaches

The Harbour Approaches are a transitional region between the Outer reaches of the estuary and the Inner edge of the continental shelf. There is no question that these waters are of extremely high quality, which is an important factor for both harvest and aquaculture industries. They are also judged to fall within the SA category.

The location of an outfall somewhere off Chebucto Head would maximize dispersion since it is an area which has considerable water depth as well as being rich in turbulent energy. The lack of constraining Harbour boundaries and the prevailing southwest flow of the Nova Scotia current in deeper waters would suggest that effluent might move to the southwest along the coast and away from the community which produced it, although the approximate distance offshore necessary to achieve this flow is not known. Alternatively, if a diffuser was placed in water shallower than 50 m, then it is possible that dilute effluent might move to the northeast, in response to prevailing winds. Wherever the diffuser is placed in this area, wide dispersal of suspended particulate matter is expected. However, such dispersion runs counter to the containment principle accepted by the Task Force, that is that the proper solution to waste management rests with local treatment rather than with exporting the wastes beyond the boundaries of the metropolitan area.

A major additional disadvantage with the two outermost choices is the estimated cost of tunneling which would be required to service either of these two locations. Although cost was not a primary concern in the decision process, it is obvious that an outfall in the Harbour Approaches would require an additional cost of perhaps as much as $150 million.

10.3 Outfall Site Selection

Outfall Location

Based on an exhaustive examination of all relevant factors, the Task Force concluded, although not unanimously, that the Inner Harbour was the most appropriate location for the placement of an outfall diffuser for the following reasons:

a) The required guidelines for water quality can be met with an outfall releasing all of the treated effluent from the metropolitan area into this region of the Harbour. There may be occasions when guidelines for dissolved metal concentrations may not be met in the vicinity of the plume, but this could also be true for other boxes.

b) Trace metals associated with suspended particulate matter may not meet the required guidelines for sediment quality, but the new layer of sediments laid down in the Inner Harbour should be cleaner than the existing sediments.

c) Only in the Inner Harbour is there a reasonable probability of containing much of the particulate matter released in the treated effluent without degrading environmental quality. An outfall in Box D would also probably result in partial containment of sediments, but it is likely that some of them would be deposited in areas of the Harbour which are presently uncontaminated.

d) Except for The Narrows, the Inner Harbour presently has the lowest water quality requirement because its primary use is associated with shipping and commercial activities.

e) The perception of high environmental quality is important for the commercial fishery in the Middle and Outer Harbours.

f) Containment within the Inner Harbour will probably increase the effectiveness of the monitoring process, by increasing visibility should malfunctions occur, which in turn would increase public pressure.

Recommendation 1 General Outfall Location

The main outfall location should be placed in the Inner Harbour.

Diffuser Location

The outfall cannot be placed randomly within the Inner Harbour. The following factors were judged to be important in the selection of the most appropriate location for the diffuser:

a) Subject to the assumptions outlined in Section 9.1 and fully explained in Appendix A, the outfall must be a minimum of 2 km from any beach in order to prevent the risk of contamination from fecal coliform bacteria which may survive disinfection. This distance would be dependant on the design of the diffuser and the effectiveness of disinfection.

b) The diffuser must be placed in a water depth of at least 20 m.

c) The diffuser should ideally be placed on a hard bottom (exposed bedrock or sediments less than 1 m thick) in an area which lends itself to monitoring and assessment of the deposition of particulate material.

d) The diffuser design should aim for an initial dilution rate of about 50 to 1 or greater and should take into account the local circulation so that currents can supply sufficient clean water to maintain this dilution rate.

e) The diffuser should be placed well away from shore in order to limit its intrusion into the aesthetic aspects of the Harbour.

The Task Force therefore concluded, using the conditions outlined immediately above, that the most appropriate location for an outfall diffuser is on the hard bottom of the Inner Harbour between George's Island and the Dartmouth Shore (Figure 21).

Recommendation 2 Siting the Diffuser

A site northeast of Georges Island should be investigated for placement of the diffuser.

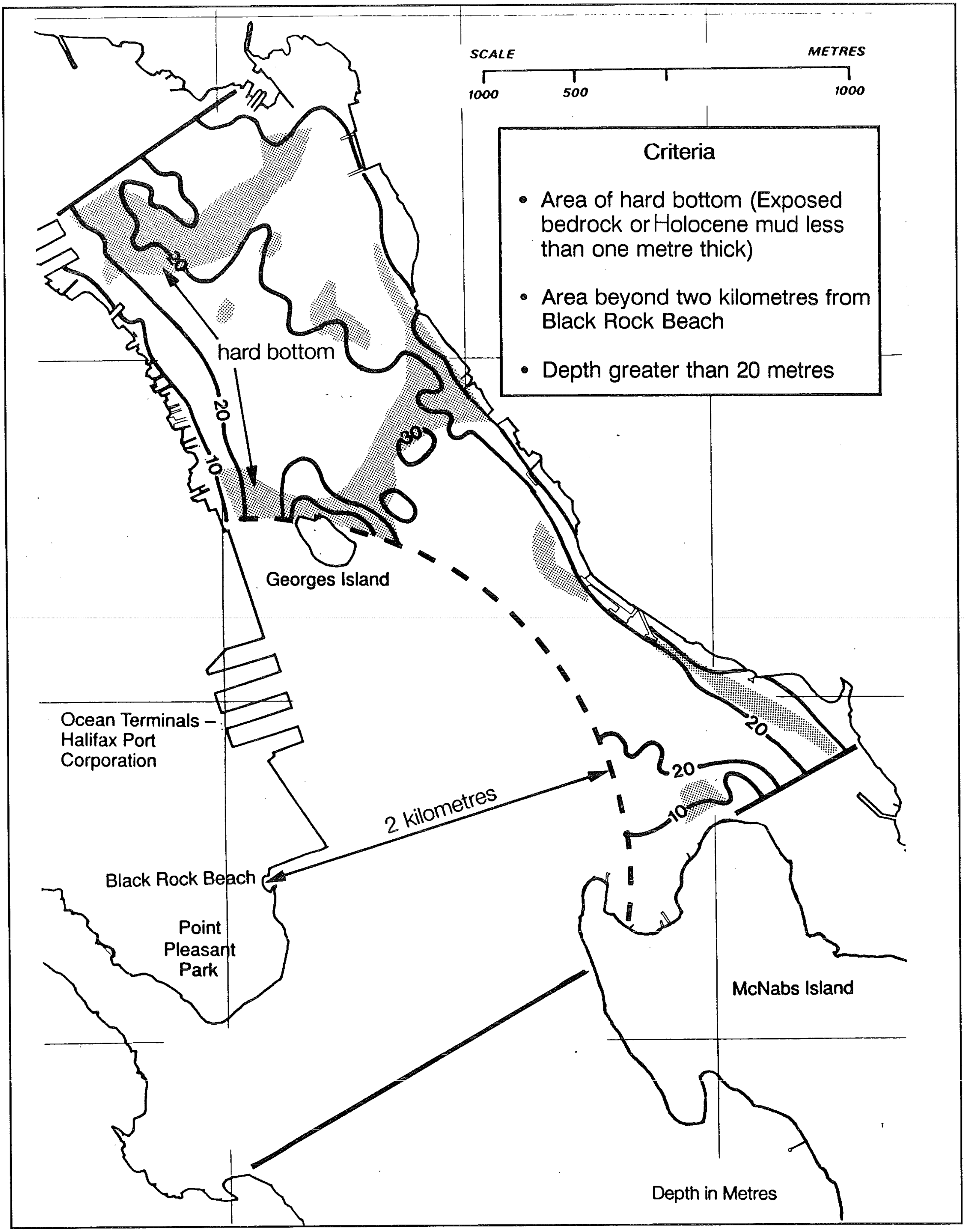


Figure 21: Outfall Selection Criteria: Inner Harbour

11.0 Treatment Level

11.1 Factors Influencing Choice of Treatment Level

The authors of the MAPC Phase 3 Report were required to compare the benefits of outfall improvements with no treatment, preliminary treatment (basically screening), and primary treatment. They concluded that only primary would result in any marked decrease in bacterial levels in the Harbour.

The public has made it clear, both through the ECC hearings and the Task Force community meetings, that higher levels of treatment should be considered for Halifax Harbour. There was a strong sentiment that if Boston is to install secondary treatment, Halifax should not contemplate anything less, especially if the outfall was to be located in the Inner Harbour. However, people recognized that secondary treatment involves larger plants, increased capital and operating costs, and greater sludge disposal problems. The specific level of treatment required should be very carefully assessed using the scientific data on hand, the environmental quality objectives, and the information on Harbour uses.

The following factors were taken into consideration when comparing treatment levels:

Floatables

All levels of treatment will remove floatables (tampon applicators, toilet paper, condoms, large lumps of fecal matter, greases and oils).

Fecal Coliform Bacteria

As the treatment level rises, the efficiency of the disinfection process increases because fewer suspended solids, which tend to shield bacteria from contact with the disinfecting agent, are present in the effluent. However, if necessary, the disinfection process used with primary treatment can be increased to produce results comparable to secondary treatment. For example, the Eastern Passage plant discharges a primary effluent with fewer than 170 fecal coliform per 100 mL, which is comparable to most secondary treatment plants.

If chlorination is the process chosen, then increased quantities can be used and then removed in order to reduce the levels of bacteria. In other words, a higher level of treatment would not be justified solely on the grounds of better disinfection efficiency.

Suspended Solids

Suspended solids in the effluent could affect the aesthetics of the Harbour by making the effluent plume more visible. It could also reduce the health of the ecosystem by reducing light penetration. Ultimately solids which are not biodegradable will settle to the seafloor somewhere, forming sludge banks. If sufficiently concentrated they could affect habitat or Harbour uses.

Removal of suspended solids definitely improves with higher levels of treatment: primary 40-60%, advanced primary 60-85%, secondary 85-95%, and tertiary 95%. With this increased removal however comes increased sludge generation. Both advanced primary and secondary treatment produce about twice as much sludge (by dry weight) as primary, and tertiary treatment produces three times as much.

Biochemical Oxygen Demand

By removing suspended solids, treatment also reduces biochemical oxygen demand. So again higher levels of treatment have pronounced effects: primary treatment removes 25-35% of BOD while secondary removes 85-95% for example. The need to achieve better BOD removal is a major reason why secondary or tertiary treatment is usually required for plants discharging into lakes or rivers, but it is very rarely a limiting factor when discharging into the ocean because of larger volumes of water. Also,constant wave and tidal action ensure higher oxygen concentrations. This is well illustrated in Halifax Harbour by the fact that, even though raw sewage has been discharged for years, oxygen levels in the Harbour are near saturation.

Persistent Toxics

Many different chemicals fall under the heading of persistent toxics, and it is therefore more difficult to generalize about the impacts of treatment. Some toxics tend to be associated with suspended solids. Removing more of the solids will therefore remove more toxic contaminants. But some contaminants will also pass straight through treatment plants attached to the smallest particles, or possibly in dissolved form. The wide range of removal efficiencies for heavy metals cited for each treatment level indicate how difficult it is to predict what will actually be achieved.

Only tertiary treatment will reliably remove a large percentage of heavy metals. There is little data available about the removal of other organic contaminants such as PCBs or PAHs, although secondary treatment will be more effective with these than with trace metals.

A major drawback is that as more toxics are removed from the effluent, larger volumes of contaminated sludge are produced, and fewer disposal or recycling options are available for this byproduct of the treatment process.

Because only tertiary treatment gives, at great expense, predictable results and because higher treatment levels compound sludge problems, the Task Force felt that a treatment level higher than primary could not be justified on the basis of toxics removal alone. However, if a low level of treatment is adopted, a real commitment must exist to make source controls work. Otherwise, the treatment approach is more tangible than promises to enforce regulations. Source controls must be an integral part of the whole sewage management system, not simply a desirable "extra". A source control program must set removal targets, map out a clear process to meet these targets, and monitor the results.

Nutrients

Primary treatment removes anywhere from 0-20% of the nutrients; advanced primary and secondary increase the removal rate to 10-30%. In order to remove most of the nutrients (80-95%) it is therefore necessary to go to tertiary. However, nutrient enrichment and the subsequent algae growth and oxygen depletion is not expected to be a problem in Halifax Harbour, and only rarely a problem in open marine waters.

Costs

Land requirements, capital and operating costs increase with higher levels of treatment. The land requirement is probably not an issue because it makes sense to acquire enough land to allow for future upgrading even if a primary plant is going to be built. Going to secondary treatment could increase capital costs of the total project by 20-30%. Operating costs, however, will at least double and the cumulative impact of this over the years is substantial. The total lifetime costs of the project over 60 years (including major plant refits at 20 and 40 years) could increase by 60-75%.

Controlling toxics at source, as one alternative to higher levels of treatment, also costs money and no estimates of this cost were available to the Task Force. However, source controls put the onus on the waste generator to reduce, recycle or pre-treat the wastes. Therefore most of the costs will be carried by the generator and not by the municipalities. Enforcement of source controls will involve costs, however, and money must be budgeted for this expense.

11.2 Treatment Level Selection

In coming to a decision about treatment level the Task Force considered impacts on the water column, on sediments and on sludge management.

The results of the water quality modelling (see Section 9.0) indicated that a primary level effluent discharged into the Harbour would enable water quality guidelines to be met. Boosting the treatment level to secondary would show minimal improvements in concentrations of contaminants in the water column.

There will be a zone of influence around the diffuser in which fecal coliform concentrations will exceed the standards for primary body contact, but the concentrations of bacteria and hence the size of the zone can be controlled by changes to the disinfection process, independent of the treatment level selected.

The existing sediments in the Inner Harbour do not meet the proposed environmental quality guidelines for trace metals, and it seems highly probable that new sediments from a primary, advanced primary or secondary treatment plant would not meet them either, although there would be progressive improvement in each case. Tertiary treatment would be required to remove the bulk of the trace metals from the effluent.

The current level of contamination in the sediments, although not desirable, has not to date been shown to cause demonstrably harmful effects in marine biota. Secondary treatment will increase the removal of toxics, but not to any great extent. For these reasons the Task Force agreed that the best approach to take would be to begin with primary treatment, a rigorous source control program, and a monitoring program. Enough land would be acquired to enable the treatment level to be upgraded at some time in the future if the monitoring program indicates that the sediment quality is not improving or is causing environmental problems in the Harbour.

The significance of this decision is that source controls must be taken seriously by the operators of the sewage treatment system, by the regulatory bodies, by all Metro municipalities, and by residents and businesses in the area. Sufficient resources must be allotted to the development of the source control program, and the results must be closely monitored.

11.3 Sludge Management

The Task Force did not review sludge management options in any detail. Two main concerns had been expressed by the public. The first was that the requirements of oil from sludge technology might be unduly driving decisions about numbers of plants and treatment level. The second concern was about potential environmental impacts of oil from sludge technology.

Federal funding for the regional sewage treatment system is predicated on the use of oil from sludge technology. If another sludge management method is selected, the project would presumably forfeit $73.4 million of federal assistance. However, the Task Force is confident that oil from sludge technology does not bias plant and treatment choices. Primary treatment will generate just enough sludge to warrant the operation of a single conversion plant. If a multi-plant scenario were to be chosen (see Section 12.1) sludge would have to be transported from the different locations at greater operating costs.

Although higher levels of treatment generate more sludge, their potential to generate oil is not the same because the character of the sludge is different. A large proportion of advanced primary sludge is a chemical rather than organic and the organic component of secondary sludge has been digested more fully than that of primary. Therefore, moving to higher levels of treatment would still not make it feasible to build more than one conversion plant. Contrary to concerns expressed in the Environmental Control Council report, sludge from oil technology can be used with any level of treatment, not just primary.

This is an argument in favour of a single plant option because of the cost and possible nuisance impacts of transporting sludge. However, the same holds true for other sludge management methods which involve any degree of sludge conditioning and treatment.

The Task Force was unable to assess the environmental implications of oil from sludge technology and therefore felt that this should be done through the process of formal environmental assessment review. The Task Force also recently learned that Toronto will soon install two conversion units, using both primary and secondary sludge. It is expected that they will be in operation within two years. This will provide useful information on the process before construction begins here.

Recommendation 3
Treatment Level

Primary treatment should be provided, but the plant site should be of sufficient size to permit future upgrading to higher levels of treatment, if required.

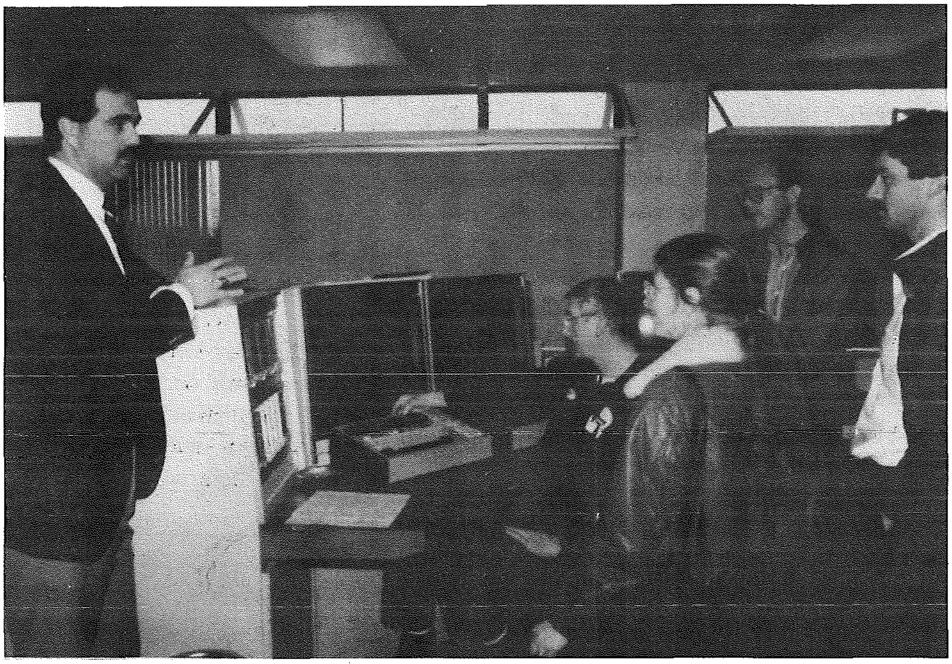


Photo 18: Inside the Control Room, Providence, RI

Mill Cove and Eastern Passage plants in the Metro Area, and the old Deer Island primary plant in Boston, and a secondary treatment plant in Providence, Rhode Island.

The Task Force drew the following conclusions from these visits:

A plant which is well designed, well run, and well maintained will not create major odour or noise problems on a daily basis. When there have been serious odour problems (at Eastern Passage for example) they are often associated with the handling of sludge.

From time to time breakdowns may occur or routine maintenance may result in the temporary release of unpleasant smells. For this reason, sites should be well buffered from residential land if at all possible.

Secondary treatment facilities have slightly more potential to produce odours than primary facilities because the biological process involved is more variable.

Adequate and active maintenance is the key to odour control, but it is possible to minimize odour risk even further by covering all open tanks and installing air scrubbers.

If a site is well chosen and a plant well designed, sewage treatment facilities can fit unobtrusively into their surroundings.

While few communities will welcome a treatment plant in their midst, the siting, construction, and long term operation of the plant will proceed more smoothly if some form of siting agreement is negotiated with the community. This siting agreement can be used to identify and minimize local impacts, to provide nearby residents with guarantees that plant operators will carry out all agreed upon procedures. It may also be used to provide some form of individual or community compensation.

A thorough and effective effluent and receiving environment monitoring program is essential.

Operators need to develop good community relations by encouraging group visits and by routine communication with the public. The operators should be prepared to explain any problems and the measures being taken to solve them promptly.

Multi-plants Versus Single Plants

Many people who spoke or wrote to the Task Force recommended the principle of decentralized sewage treatment, using two or more local plants. The following arguments were presented:

A multi-plant approach means that the two municipalities generating the most sewage could each have a plant within their own boundaries (or backyards).

Smaller plants could be sited closer to the centres of Halifax and Dartmouth and would therefore involve less tunnelling. Money saved could be spent on higher levels of treatment.

Several smaller plants are inherently safer than one large plant. If a smaller plant breaks down, only a portion of Metro's sewage will be affected. If the large plant breaks down, the environmental impact could be much greater.

Other large urban areas, such as Vancouver and Montreal, have opted for the multi-plant approach.

More than one plant would probably mean more than one outfall, which could be helpful in achieving sufficient dilution and dispersal.

A multi-plant approach might allow for a partial separation of industrial wastes from wastes coming from predominantly residential areas. The industrial wastes could then be treated to a higher level at a separate plant.

While many members of the Task Force were sympathetic to these arguments, it was felt that the following factors also needed to be taken into consideration:

A multi-plant solution is not the only way, nor necessarily the best way, to address "fairness" in siting facilities. This important issue can also be addressed through inter-municipal agreements and negotiated siting agreements with the community in the immediate vicinity of the treatment facilities.

The capital costs of a multi-plant scenario are likely to be less, but the operation and maintenance costs, which will be totally borne by the municipalities, will be much higher.

Larger plants are usually modular in design. If there is a breakdown, only a portion of the equipment would be out of operation at any given time: perhaps one clarifier in five for instance. Because of economies of scale it is easier to keep replacement parts in stock or build back-up facilities into the design. A larger plant also allows better use of trained staff. The larger modern treatment plants generally have a better safety track record than smaller plants.

There is a considerable difference in scale between large cities such as Vancouver and Montreal where multi-plant options are being pursued, and Halifax-Dartmouth. For example, while the smallest plant in Vancouver is designed to accommodate 118,000 m^3/day (26 Imgd), the two largest have capacities close to 591,000 m^3/day (130 Imgd). In comparison, a single plant for the Metro area would have a capacity of 185,000 m^3/day (40 Imgd).

The most effective way to get toxics out of industrial waste is through source controls. Industries can meet these controls through elimination of certain materials, reuse and recycling, or specialized on-site treatment. In each case the management strategy is tailored to the specific waste and is paid for by the industry itself. A large variety of successful examples of waste minimization exists for industries.

It would not be practical to have an oil from sludge conversion process at more than one plant. Therefore, if this technology is to be used with a multi-plant scenario, sludge would have to be transported from the other sites. This would increase handling and transportation costs and potential nuisance impacts.

12.2 Potential Sites

The Task Force undertook to recommend an outfall location, and a treatment level but not a specific site for treatment facilities. The Task Force recognized that land availability could be an important issue in locating a plant and by association with the related outfall. This could then result in trade-offs between outfall and plant locations.

The Task Force therefore decided to develop basic site identification criteria and use them to prepare a list of possible sites around the Harbour. In the first pass, the net was deliberately thrown widely.

The identification criteria used are as follows:

(a) A site had to be within 1.6 km of the shoreline or inside the watershed boundary.

(b) The land had to be vacant or obviously underused.

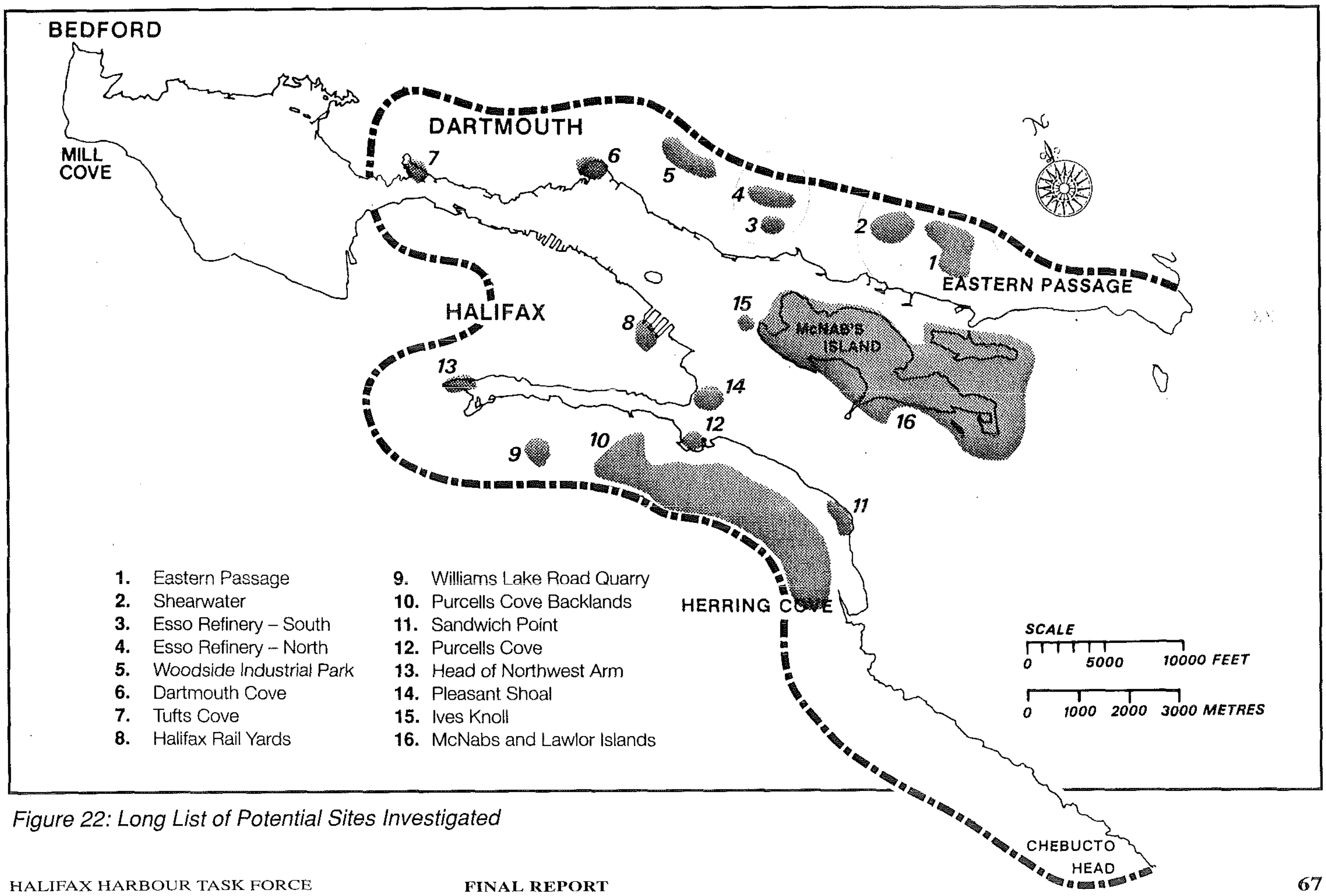


Figure 22: Long List of Potential Sites Investigated

(c) The minimum size had to be 6 hectares (15 acres), to allow a plant of at least 90,000 m^3/day (20 Imgd) capacity.

(d) A site could be created or extended by infilling at the water's edge to a depth of 10 m.

Sixteen sites were identified and are shown in Figure 22. Basic information about each can be found in Appendix E.

Eight of the sixteen sites would permit gravity drainage to the Inner Harbour. These were investigated further using the following criteria:

- Ownership
- Potential for expansion
- Residential buffer
- Proximity to shore
- Access to receiving waters
- Length of outfall
- Highway access
- Rail access
- Sea access
- Availability of municipal services
- Prevailing winds
- Physical conditions
- Significant cultural or environmental resources
- Visual impact
- Land values
- Population density
- Replacement value

Three of these sites (Dartmouth Cove, Pleasant Shoal, and Purcells Cove) were immediately eliminated because of difficulty achieving an adequate residential buffer or because of their potential for high visual impact. The five remaining sites were assessed further (Figure 23).

Ownership information was obtained from provincial Land Registration Information System records, while land values were based on assessments. Planners from each of the jurisdictions involved were contacted: the City of Dartmouth, the City of Halifax, Halifax County, Nova Scotia Department of Lands and Forests, Parks and Recreation, and the Canadian Park Service. The Curator of Natural History at the Nova Scotia Museum was also interviewed.

Oil Refinery Lands

There are three parcels large enough to be considered, including lands owned by Petrofina, Imperial Oil, and Irving Oil. All of these lands are zoned Industrial and have access to municipal services. All lie on the same landform: Halifax slate covered with thick deposits of glacial till. The value of raw land in this area, based on assessed values, is in the range of $12-24 thousand per hectare ($5-10 thousand per acre). Shearwater is downwind of all of these sites.

The Petrofina site is adjacent to Shearwater and is essentially undeveloped. The property lies on both sides of Route 322 and includes shorefront and rail access. It is smaller than the other oil company properties, and part of it lies between residential areas. However, there is a block of at least 24 hectares (60 acres) of useable land. This area is at least 700 m (2300 feet) from the shore but is further than the other two areas from the centre of the Inner Harbour. Opportunities for expansion are limited due to the size and shape of the parcel. Flight paths for Shearwater may limit other development options on this site because of noise exposure and height limitations.

The Imperial Oil property is intensively developed. However, there is a large area of undeveloped land to the northeast of the tank farm, about 60 hectares (150 acres) within the study area and more land outside. This land is at least 1000 m (3300 feet) from the shore. Although Imperial Oil owns the shore property on both sides of the railroad and highway, it is not clear that there would be easy access due to existing development.

The Irving Oil property includes about 24 hectares (60 acres) of undeveloped land southeast of the Circumferential Highway (Route 111). The vacant land has no rail or sea access but it is adjacent to the Woodside Industrial Park which has access to common user wharf and rail facilities. Only a small portion of this property, about 8 hectares (20 acres), is within the study area, and it lies at a distance of 1070 m (3500 feet) from the shore. However, this is the closest of the oil company lands to the centre of Box C. Access to the water would be along the Highway right-of-way.

Woodside Industrial Park

When appropriate buffer zones are included, the Woodside Industrial Park includes about 40 hectares (100 acres) of suitable land. It is owned by Industrial Estates, Ltd, is zoned Industrial and is for sale. The site is underlain by Halifax slate and thick glacial till, but about 8 hectares (20 acres) of it has been graded.

Beyond this area, the land rises steeply in a cut slope. The cost of the land may be about $150 thousand per hectare ($60 thousand per acre) or more. Other uses that would be considered incompatible with a sewage treatment plant, including senior citizens housing, are being considered for adjacent parcels. The Industrial Park has access to rail and wharf facilities, and it is adjacent to a sewer right-of-way along the Circumferential Highway. The vacant land in the Industrial Park is at least 1100 m (3600 feet) from the shore, but it is close to the centre of the Inner Harbour.

Halifax Rail Yards

The Halifax Rail Yards are considered under-utilized, but land values are high at perhaps $620 thousand per hectare ($250 thousand per acre), and it is not clear that the existing uses could be relocated. A recent study commissioned by the City of Halifax and the Nova Scotia Department of Industry Trade and Technology "proposes a framework for assessing the impact of alternative development scenarios for the Southend Halifax Waterfront Lands". The scenarios include varying amounts of available land, and consider open space, residential, and commercial uses as well as the traditional waterfront uses. The study does not propose policy, but does point out that this area is the last remaining large parcel of developable land on the peninsula.

This area is zoned Industrial and includes about 60 hectares (150 acres) held by the Halifax Port Corporation, and about 20 hectares (50 acres) held by Canadian National Railway. The site has limited highway access, but excellent access to rail and sea. It is also directly adjacent to the centre of Box C. However, the Port of Halifax is thriving, and it is unlikely that the Port Corporation would be willing to turn over waterfront land in such a prime location.

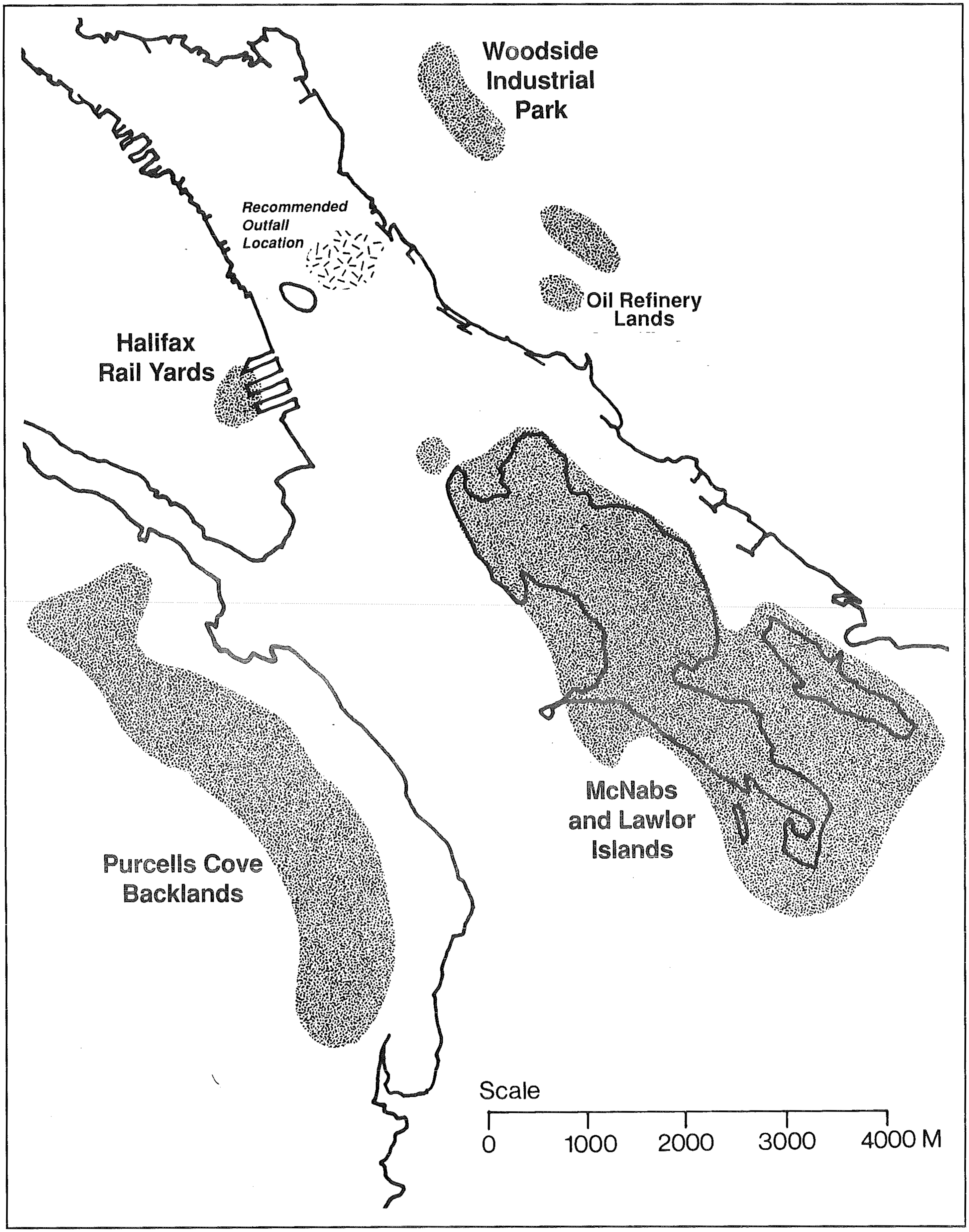


Figure 23: Sites Draining into the Inner Harbour

Purcells Cove Backlands

There is a large area of undeveloped and unserviced land in the study area portion of Halifax Mainland South. This land includes large areas of exposed granite and environmentally sensitive boggy wetlands. In the Municipal Development Plan, the entire area is designated as "Residential Development District (RDD)" on the "Future Land Use Plan", but is currently zoned "Holding" because servicing is not available. The goal of the RDD is "to produce residential areas that are planned and developed as a whole with related recreational, neighbourhood commercial and open space uses". The RDD zone permits R-1 (Single Family Residential) and R-2 (Two Family Residential) development "as well as some commercial and institutional uses and community facilities through the development agreement process". If a sewage treatment plant is considered a community facility, then it would be consistent with planning policy for this area.

In this area, all of the lands within Halifax City limits are privately owned. Current land values are relatively low, ranging from $2.5- 5 thousand per hectare ($1-2 thousand per acre). Due to the large area available, there would be a low visual impact and high potential for expansion and for buffer zones. Much of this land is within 305 m (1000 feet) of the shore, and has access to the shore, but this area is remote from the recommended outfall location. These lands are accessible to Purcells Cove Road, but there is no rail or sea access. Local residential areas and downtown Halifax are downwind of this location.

In the adjacent lands within the Municipality of the County of Halifax, most of the land is owned by the Crown. Large areas are held by the Nova Scotia Department of Lands and Forests, and are zoned for "Conservation". Lands held by the Canadian Park Service include York Redoubt and are zoned "Park". The Department of National Defense lands are zoned "Defense". The Land Use Bylaw does not provide for sewage treatment plants in any of these zones.

McNabs Island

McNabs Island is designated by the Province as a Regional Park. Accordingly, the Municipality of the County of Halifax has zoned the island as Regional Park, which does not include sewage treatment plants as allowed uses. The island is very large and essentially uninhabited, including a few thousand hectares almost evenly split between the Canadian Park Service and the Nova Scotia Department of Lands and Forests. The lands held by the Canadian Park Service (CPS) have been transferred from the Department of National Defense (DND) with the provision that if the land is not required for park purposes, it is to be returned to DND. In fact, DND retains a few small areas on the island for military purposes. The CPS and the Nova Scotia Department of Lands and Forest are negotiating for the transfer of most of the federal lands to the Province for the purpose of developing a regional park. CPS will retain certain areas, including Fort McNab, as part of the Halifax Defense Complex.

Land values are difficult to determine in this case, but the argument can be made that in terms of replacement value, they are very high. This kind of recreational and wilderness land is simply not otherwise available in such close proximity to the Metro area. Many areas of the island have historical and archaeological value, and there are sensitive osprey and heron nesting areas, although they are not rare or endangered species. The island is highly valued as a heritage and natural area within the Metro region, as was demonstrated by the strong response when McNabs was discussed as a possible site at the community meetings.

McNabs Island is close to the centre of Box C, but plant location would determine outfall length. Eastern Passage and Shearwater are downwind of the island. The island is currently inaccessible from the mainland by road or rail, and municipal services are not available. There is potential for access by sea, and road access is possible, though at considerable expense. The terrain is hilly, consisting of thick deposits of glacial till underlain by Goldenville Quartzite. The visual impact of a treatment facility on McNabs would depend where and how it was sited. It should however be possible to site a plant with minimal visual impact. One suggestion offered was to infill the intertidal shallows on the northern edge of the island, immediately south of Georges Island.

There was considerable divergence of opinion, both within the Task Force and the general public, about whether a sewage treatment plant could or should co-exist with a future regional park on the Island. One view is that the construction of a treatment plant on the Island would enable a park to develop more quickly because funding would be available to build a bridge to provide better access. The Island is large, the site could be well buffered and screened from view, and would not intrude on other uses of the park. Other people feel that a treatment plant would be the thin edge of a wedge, leading to further development inconsistent with Regional Park designation. They do not want to see a bridge built, and feel that designated park land should not be used for a regional sewage treatment plant.

Next Steps

Public input into the siting process is indispensable. Public input provides local knowledge and ensures that many factors are considered in the decision. There may not necessarily be local opposition to whatever site is ultimately chosen however, any opposition will be more intense if the public has not been given adequate opportunities to participate in the decision making process. In its public meetings the Task Force attempted to focus public discussion on possible outfall locations, treatment levels and the resulting impacts on the environment. While people were eager to talk about plant siting issues and particularly the relative merits of Sandwich Point and McNabs Island, the Task Force did not provide information or carry out consultation on siting criteria or potential sites.

The Task Force developed siting criteria, identified a preliminary list of 16 sites, and from that list found 5 potential sites which could be used with an Inner Harbour outfall. The next step must include public consultation on the siting criteria and the 5 identified sites. The consultation process should address both socio-economic and technical factors, and should lay the groundwork for the environmental assessment review. This would be most appropriately carried out by the project proponent, namely Halifax Harbour Cleanup Inc., in consultation with the municipal governments.

Recommendation 4
Single Regional Plant

Halifax Harbour Cleanup Inc. should develop a single regional treatment facility to serve Halifax, Dartmouth and portions of Halifax County.

Recommendation 5
Public Consultation on Site Selection

Halifax Harbour Cleanup Inc. should provide information on the short list of viable sites and, in association with the three municipalities, consult with interest groups and the public on the factors to be used in evaluating these potential locations.

Recommendation 6
Community Siting Agreement

Before a final site is selected, Halifax Harbour Cleanup Inc. should open discussions with the community or neighbourhood immediate to the proposed site in preparation for the development of a siting agreement. This agreement could include issues such as the mitigation of possible nuisance impacts during construction and operation, the minimization of visual impacts, development of community liaison, local monitoring, performance agreements and community compensation.

Recommendation 7
Treatment Facility Design and Landscaping

The visual appearance and upkeep of the treatment facility should be given high priority. The plant should be designed and landscaped to fit into its surroundings.

V
Integrated Harbour Management

13.0 Harbour Management

The construction of sewage treatment facilities, while a vital step, will not necessarily ensure that environmental quality objectives for Halifax Harbour will be achieved. There are three basic reasons for this; the first two relate to the regional treatment system itself. The ongoing operation and maintenance of the system will require careful management, and the environmental impacts of discharging the treated effluent will need to be monitored to ensure that predictions about the composition and ultimate fate of the effluent were correct. The third reason relates to the wider environmental context, because obviously the outfall from the regional treatment system will not be the only source of contaminants entering Harbour waters. Therefore the communities surrounding Halifax Harbour must move towards cooperating with each other and higher levels of government to develop an integrated harbour management approach.

13.1 Combined Sewer Overflows

While new housing developments are now required to build separate storm sewers, combined sewer systems have both advantages and disadvantages. The main disadvantage is that periodically raw sewage will continue to be discharged because the volume of stormwater will be too great for the interceptor pipes. The advantage is that some portion of the stormwater runoff will receive treatment.

In other areas, municipalities have found that by dealing only with sewage treatment and not addressing the combined sewer overflow (CSO) problem, they have not been able to achieve their environmental quality goals at all times. In Boston, for example, CSOs continue to close popular beaches on a regular basis. This is particularly frustrating to the affected residents who are having to pay large sums of money through taxes or user charges for sewage treatment which is meant to correct environmental problems.

In the 1960s and early 1970s substantial research was done into the problems of combined systems. Three categories of solutions were identified:

- eliminating combined systems
- eliminating overflows at specific points by building larger interceptors
- providing storage and treatment for stormwater.

Not one Canadian city has opted to separate and rebuild existing combined systems because of the cost (estimated to be $4.5 billion in 1969 dollars for the whole of Canada), the disruption, and the limited effectiveness when total loadings from separate and combined systems are compared. The advantages of eliminating raw sewage overflows by installing a separate system are balanced out to a certain degree by the treatment of a certain portion of the stormwater provided by the combined system.

In addition, if a combined system was to be gradually replaced by separate pipes in the course of routine maintenance, the benefits would not be realized until the whole system had been converted which could take many decades. Until then, separate storm sewers in the upper parts of the watershed would have to be connected into older combined sewers.

The use of larger interceptors simply transfers the CSO problem to another location, although this may be considered a reasonable compromise if it gets the raw sewage away from a recreational area where swimmers or boaters might come into contact with it.

The preferred approach is now to look at storing the stormwater in tanks, deep tunnels or interceptors during storm periods. When the flows decrease after the storm is over, the combined stormwater and sewage can be directed through the treatment plant. When this storage capacity is exceeded (which it invariably will be at some time, however big the tanks or tunnels), some form of treatment such as screening or chlorination can be provided for the overflows.

At this time there is not enough known about the potential impact of CSO problems in the Halifax Harbour. Elevated bacterial counts are responsible for the closure of local beaches at certain times. Whether this would continue to occur after construction of treatment facilities will depend to a large extent on the proximity of the CSOs to the beaches. The continued discharge of floatable waste would cause aesthetic problems and may be a hazard to some marine animals. The Task Force recognizes that by recommending the Inner Harbour as the outfall location, there is the possibility that after certain high rainfall events, the cumulative impact of plant-discharged residual coliform bacteria and CSO-derived coliform bacteria may force temporary beach closures.

Overflows to Bedford Basin may impact on future proposals to provide swimming facilities at Seaview Park. These effects would be aggravated if the Mill Cove system were to be connected to the present interceptor tunnel, which could make storage and treatment of overflows necessary.

The Task Force therefore recommends that a thoughtful approach be taken regarding the location of CSOs, screening and overflow improvements, and routine monitoring.

Recommendation 8 Combined Sewer Overflows

Overflow discharge points in the Inner Harbour should be located and screened or otherwise treated in order to avoid pollution by floatables and adverse impacts on existing swimming areas. Planning for the regional interceptor system should take into consideration the possible need for future storage and treatment of combined sewer overflows that discharge into Bedford Basin.

13.2 Mill Cove, Eastern Passage and Herring Cove

Mill Cove and Eastern Passage

Since a regional sewage treatment system is under consideration, what roles do existing plants at Mill Cove and Eastern Passage play? The Task Force was impressed by the high standards of management at each plant, both in terms of the facilities and quality of effluent. The operators were open about problems that have occurred in the past, especially at Eastern Passage, but have now been solved. Problems associated with by-passing remain at both plants, although they are more severe at Mill Cove. There they are due in part to groundwater infiltration and illegal roof drain connections, rather than to the design or operation of the treatment plants.

The Task Force heard complaints from some local residents about the impact of the Eastern Passage plant on the receiving waters but it appears that large sludge banks are not building at either outfall, and water quality is still acceptable. However, neither Eastern Passage nor Bedford Basin would be considered an ideal location for an outfall because of the restricted circulation. Bedford Basin was specifically ruled out as a location for a regional outfall because of the low dilution and dispersal potential and a possible risk of nutrient enrichment.

The County of Halifax has already determined that the Eastern Passage plant will not be expanded. Additional development in the Cole Harbour area could be serviced more easily by a gravity fed system draining to the south. No other realistic options exist for the Sackville River watershed area, which is served by the Mill Cove plant. Furthermore, by electing to infill and develop the area immediately adjacent to the plant, the Town of Bedford may have reduced the capacity of Mill Cove to expand further.

Significant future population growth will take place in the Cole Harbour and Bedford-Sackville areas. In the analyses carried out by the Task Force, it was assumed that 18% of the total sewage load could be discharged into Bedford Basin. This represented a doubling of the existing load to allow for growth. However, in the long term, this percentage could be much greater. If studies indicated that the assimilative capacity of Bedford Basin would be exceeded, the Town of Bedford and Halifax County would have no choice but to either tie-in to the regional system or to build a new facility with tertiary treatment. Several previous studies have indicated that more knowledge of the capacity of Bedford Basin to receive wastes is needed in order to make sound

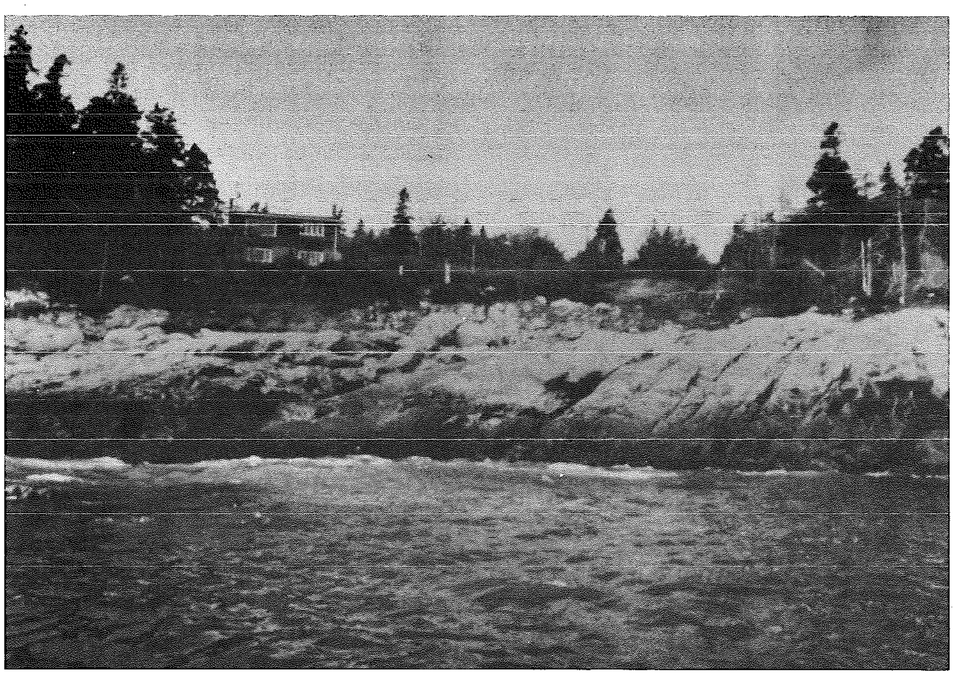
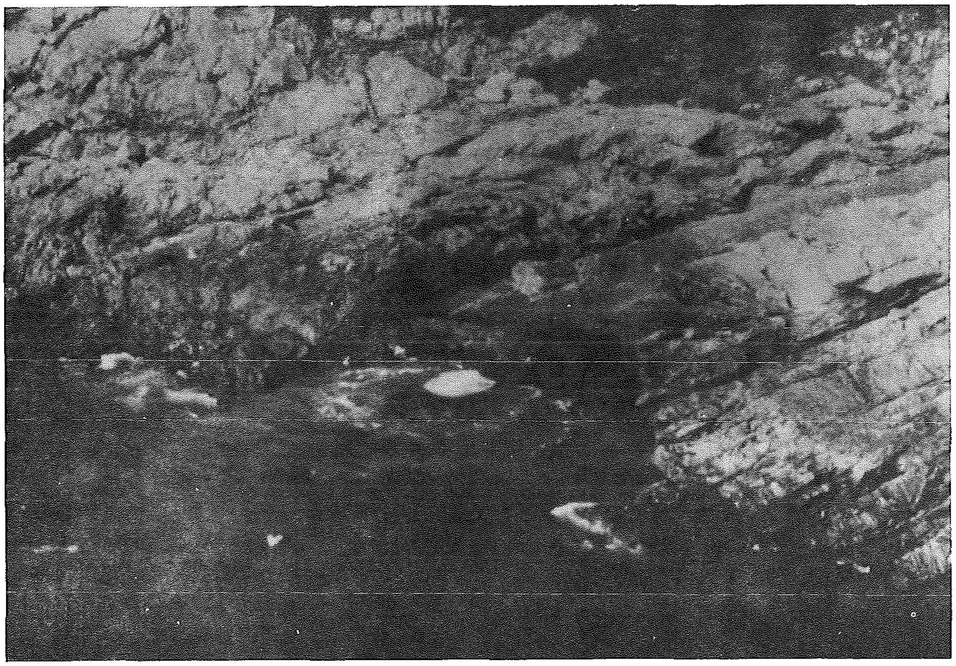


Photo 19: Watleys Cove



Phot 20: The Outfall at Watleys Cove

decisions, and the Task Force also considers this to be a priority.

On the basis of information currently available there appear to be no pressing environmental reasons why the two existing plants should be closed, and the areas they service incorporated into the regional system. It does, however, seem sensible to ensure that the interceptors and tunnels are sized to accommodate future flows from these areas, because of the cost involved in trying to increase the capacity of a collection system at a later time.

Recommendation 9 Mill Cove and Eastern Passage Plants

The existing plants at Mill Cove and Eastern Passage should continue to operate, but Halifax Harbour Cleanup Inc. should make certain that interceptors and tunnels for the new regional system should be sized to accommodate projected flows, assuming the possibility of later connection.

Recommendation 10 The Assimilative Capacity of Bedford Basin

Before any decisions are made to expand Mill Cove or add any additional treatment facilities discharging into Bedford Basin, the Town of Bedford and the County of Halifax should commission a study to determine the assimilative capacity of the Basin to receive treated effluent.

Herring Cove

It is clear that the situation at Herring Cove has been unsatisfactory for a very long time and deserves prompt attention. The outfall at Watleys Cove is poorly designed and located, and there are still overflow problems in McIntosh Run and the Cove itself. There are two options. The first would involve diversion of sewage flows from the Mainland South area of Halifax, either by reversing the flow at the Princeton Avenue/Roachs Pond pumping station or by constructing a new interceptor along the City boundary. The flow would then be directed into the new regional system. The remaining sewage from approximately 200 homes in the County could then be treated by a very small treatment plant located in the Herring Cove area. The second option would involve treatment of all sewage currently discharging at Watleys Cove via a new plant constructed in the Herring Cove area. This plant would have to be sized to accommodate expected growth in Mainland South Halifax.

The decision between these two approaches should be made in consultation by the parties involved: the County of Halifax, the community of Herring Cove, the City of Halifax and Halifax Harbour Cleanup Inc. The Task Force was unanimous in agreeing that speed is of the essence.

Recommendation 11 Herring Cove

Raw sewage discharges at Watleys Cove, near Herring Cove, should be remedied as soon as possible. A decision as to the proper engineering approach should be made through a consultative process involving the County of Halifax, the community of Herring Cove, the City of Halifax and Halifax Harbour Cleanup Inc.

13.3 Other Aspects of Harbour Management

It will take more than sewage treatment to satisfy all the environmental quality objectives established for Halifax Harbour. As many members of the public pointed out, a comprehensive approach to managing all wastes discharging into the Harbour will be necessary. An environmental management program should include:

- land, seabed and water use controls
- reduction of the volume and toxicity of wastes
- recovery of materials where feasible
- treatment and stabilization of wastes

which cannot be recovered
- non-point source control program
- adequate dispersion of those wastes which can be safely assimilated into the environment
- a thorough monitoring program

In effect, the adoption and application of the Guidelines for the Protection of the Marine Environment from Pollution by Land-Based Sources, issued by UNEP (known as the Montreal Guidelines, see Appendix C) would go a long way toward a comprehensive environmental management program for Halifax Harbour.

As the World Commission on Environment and Development has agreed, management of environmental problems such as those facing Halifax Harbour must place greater emphasis on "anticipation and prevention" rather than "reaction and curing". Therefore careful consideration should be given to how new developments will affect the quality of the Harbour in the future.

Non Point Sources and Stormwater Run-off

Stormwater runoff contributes hydrocarbons, metals, nutrients and pesticides to the Harbour. Because much of Halifax and Dartmouth are still served by combined sewers some of the stormwater run-off will eventually receive treatment, but a range of non-point source controls is available and should be investigated by the municipalities and other responsible agencies. Examples could include retention ponds, landscaping to provide natural infiltration, household hazardous waste collection facilities, and public education programs.

Dredging and Dumping

Dredging and dumping are already regulated under the Canadian Environmental Protection Act. Since industrial harbours such as Halifax, contain contaminated sediments, control is warranted and should be strongly enforced to limit the remobilization of potentially harmful materials. This is particularly important when efforts are underway to improve water quality. Other activities also deposit contaminants into the waters of Halifax Harbour, including ship repair, boat painting, creosoting pilings, and loading and unloading ships.

Planning for Prevention

Land use planning in conjunction with supportive by-laws should be used to prevent deterioration of the Harbour environment. Certain activities and uses of watersheds, other lands adjoining the Harbour or water lots could be restricted. Zoning and designation of specially protected areas could be used to limit activities or uses in specific areas. Design specifications for housing developments could be employed. Novel technologies could be encouraged to reduce the quantity and quality of domestic wastes (much in the way that energy efficiency or conservation standards are used). Large green belts might be maintained along watercourses or on hills of a certain slope in order to reduce runoff into streams and eventually into the Harbour.

Regional Harbour Management

If water, sediment and biota quality are to improve in Halifax Harbour, the three levels of government must take a comprehensive regional approach to the control of existing sources and the prevention of new problems. In addition, the municipalities of Halifax, Dartmouth, Bedford and the County of Halifax must also begin to view the Harbour as a waterbody common to all. The Environmental Control Council, the Halifax Harbour Task Force, the Harbour Committee of the Ecology Action Center and the Northwest Arm Heritage Association among others have begun building a constituency with an interest in the quality of Halifax Harbour. Initiatives should be taken to expand that effort in a structured fashion.

While some actions are clearly outside the jurisdiction of the municipalities (for example, those undertaken on federal land) goals and objectives set by residents will certainly influence activities of all levels of government. The authority of each agency must be recognized but the inlet must also be managed as a whole. Coordination of planning, regulatory initiatives, research and monitoring activities, and educational programs should be encouraged. To set this effort in motion, a forum should be established to review usage goals and environmental quality objectives. The full range of problems need identification, followed by definition of priorities.

This process could lead to a comprehensive conservation and management plan for the Harbour, its shoreline and its watersheds, addressing not only the quality of the water, sediments and biota but also management of living resources, preservation of sensitive areas, public access and rehabilitation of degraded areas.

The next step required is a consultation process involving all Harbour stakeholders: the three levels of government, commercial Harbour users, local scientists and public interest groups. The Task Force anticipates that Halifax Harbour Cleanup Inc. could play a key role in this process. The purpose would be to identify communication and coordination needs and opportunities, and to work towards the development of a body whose mandate would be to promote and achieve regional Harbour management.

Recommendation 12 Environmental Impact Assessment

A full federal-provincial environmental impact assessment review of the proposed regional treatment system, including sludge management options should be carried out.

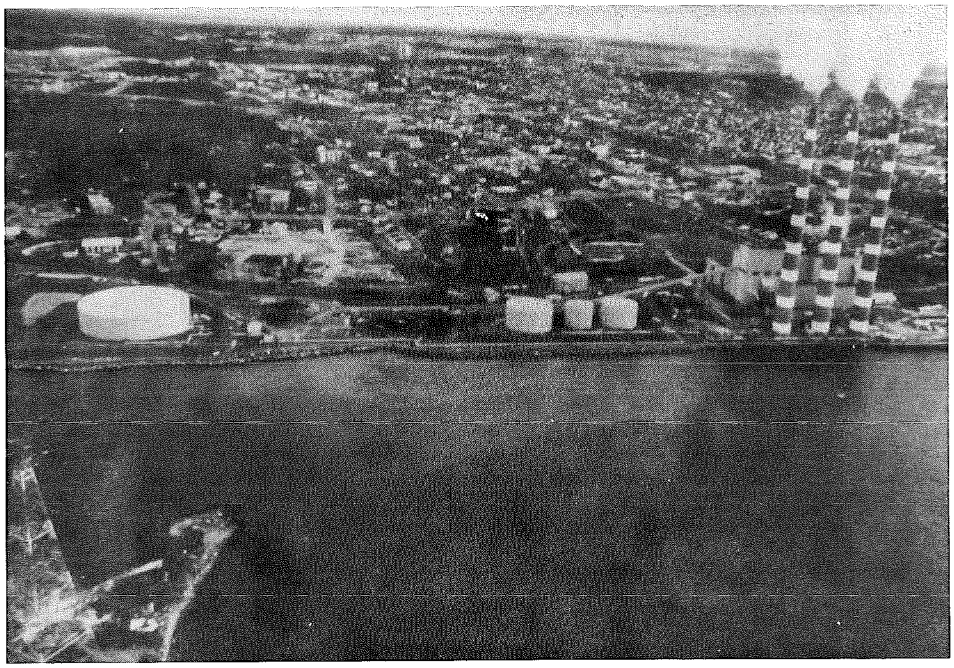


Photo 21: Tufts Cove

Recommendation 13 Citizens Advisory Committee

An advisory committee should be formed, made up of individuals representing diverse Harbour interests, the local scientific community and citizens, to advise Halifax Harbour Cleanup Inc. and the participating municipalities. Specific responsibilities should include: organizing an annual conference to deal with the state of the Harbour and involvement in local monitoring and management programs. Funds for the support of this group should come from Halifax Harbour Cleanup Inc.

Recommendation 14 Source Control Program

A source control program to remove toxic waste materials should be developed immediately, proceeding in parallel with the design and construction of the treatment facilities. The cost of developing and implementing this program should be an integral part of the overall cost of sewage treatment. This effort should be prosecuted through public education, provision of alternative disposal options and enforcement of municipal sewer by-laws. The latter enforcement should become the responsibility of a single agency, preferably the operators of the treatment facilities.

Recommendation 15 Monitoring Program

An environmental quality monitoring program for Halifax Harbour should be developed and implemented by Halifax Harbour Cleanup Inc. in association with its advisory committee. Specifically, this should include:

***A.** The frequency and impact of combined sewer overflows near recreation areas should be monitored for the first three years to determine whether further storage, treatment or scrutiny will be required;*

***B.** Contaminant monitoring in biota and sediments with special emphasis on heavy metals and hazardous organic compounds. These items should be assessed prior to the commencement of the operation of the treatment facility.*

***C.** Operations of the regional treatment facility should be required to monitor effluent quality daily and report to the Department of Environment monthly. Compliance monitoring should be carried out by the Department on a regular basis.*

D. Routine monitoring of the fishery should be carried out by Halifax Harbour Cleanup Inc. in conjunction with the Federal Department of Fisheries and Oceans. Items monitored should include numbers of fishermen, catches, loss of fishing sites, and gear fouling problems.

Recommendation 16 Sewage Treatment Operating Certificate

The Nova Scotia Department of the Environment should revise its current permit process to include an annual renewable operating certificate. This permit would stipulate effluent quality standards for BOD removal, fecal coliform, heavy metals, organic chemicals, nutrients and other key parameters.

Recommendation 17 Evaluation of Sediment Resuspension

The impact of sediment resuspension due to ship anchoring should be evaluated by Halifax Harbour Cleanup Inc. New sedimentation zones and outfall siting zones should be included in a re-evaluation of present anchoring locations.

Recommendation 18 Data Archiving

Archiving of data related to Halifax Harbour from this study and others should be routinely carried out by Halifax Harbour Cleanup Inc.

Recommendations

Recommendation 1
General Outfall Location

The main outfall should be placed in the Inner Harbour.

Recommendation 2
Siting the Diffuser

A site northeast of George's Island should be investigated for placement of the diffuser.

Recommendation 3
Treatment Level

Primary treatment should be provided, but the plant site should be of sufficient size to permit future upgrading to higher levels of treatment, if required.

Recommendation 4
Single Regional Plant

Halifax Harbour Cleanup Inc. should develop a single regional treatment facility to serve Halifax, Dartmouth and portions of Halifax County.

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Public Consultation on Site Selection

Halifax Harbour Cleanup Inc. should provide information on the short list of viable sites and, in association with the three municipalities, consult with interest groups and the public on the factors to be used in evaluating these potential locations.

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C. Operations of the regional treatment facility should be required to monitor effluent quality daily and report to the Department of Environment monthly. Compliance monitoring should be carried out by the Department on a regular basis.

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Glossary.

Activated Sludge - the sludge that results when primary effluent is mixed with bacteria-laden sludge and then agitated and aerated to promote biological treatment.

Aerobic - life or processes that require, or are not destroyed by, the presence of oxygen.

Anaerobic - life or processes that require, or are not destroyed by, the absence of oxygen such as bacteria which digest sludge.

Bacteria - one-celled microscopic organisms commonly found in the soil that perform a variety of biological treatment processes.

Biochemical Oxygen Demand (BOD) - a measure of the amount of organic material contained in water.

Combined Sewer - a sewer that carries both sewage and stormwater runoff.

Disinfection - the application of chlorine, sodium hypochlorite or a similar compound to wastewater in order to kill pathogenic bacteria before the wastewater is discharged into the ocean.

Dissolved Oxygen (DO) - a measure of the amount of oxygen in a given amount of water. Adequate levels of DO are needed to support aquatic life. Low dissolved oxygen concentrations can result from inadequate waste treatment.

Effluent - treated wastewater that flows out of a treatment plant, sewer or industrial outfall.

Environment Canada - the federal regulatory agency charged with enforcing water quality and other pollution control standards.

Environmental Assessment Act - the guiding provincial law for the preparation of environmental impact reviews.

Grit - sand, gravel and other solid particles which settle out of wastewater during primary treatment.

Halifax Harbour Cleanup Incorporated - the public agency responsible for the Halifax Harbour Project.

Headworks - a preliminary treatment device or structure, usually involving a screening and degritting operation, that removes large or heavy materials (such as wood and sand) from wastewater prior to primary treatment.

Holocene- geological time term to define the last 10,000 years of earth's history.

Infiltration - entry of groundwater into a sewer system through such sources as defective pipes, pipe joints, connections or manhole walls.

Inflow - entry of water into a sewer system from sources such as basement drains, manholes, storm drains and street washing.

Influent - water, wastewater or other liquid flowing into a reservoir, basin, treatment plant or treatment process.

Interceptor Sewers - the collection system that connects main and trunk sewers with the wastewater treatment plant. In a combined sewer system, interceptor sewers allow some untreated wastes to flow directly into the receiving waterways so that the plant won't be overloaded.

Methane - a colourless, nonpoisonous, flammable gas produced as a byproduct of anaerobic sludge processing.

Microorganisms - microscopic organisms, either plant or animal, invisible or barely visible to the naked eye. Examples are algae, bacteria, fungi, protozoa and viruses.

Mitigation - includes: (a) avoiding the impact altogether by not taking a certain action, (b) minimizing impacts by limiting the magnitude of the action, (c) rectifying the impact by repairing, rehabilitating or restoring the impacted area, (d) preventing an impact by preservation and maintenance operations and (e) compensating for an impact by replacing or providing substitute resources or environments.

Nova Scotia Department of the Environment - the provincial agency responsible for regulating air, land and water quality.

Nutrients - any substance that is assimilated by organisms and promotes growth; generally applied to nitrogen and phosphorus in wastewater, but also applied to other essential and trace elements.

Operation and Maintenance (OM) - the organized procedure for causing a piece of equipment or a treatment plant to perform its intended function and for keeping the equipment or plant in such condition that it is able continually and reliably to perform its intended function.

Outfall - the place where effluent is discharged into receiving waters. (May also be used to describe the conduit which carries effluent to receiving waters).

Pathogens - disease-causing bacteria.

Plume - the rising discharge of treated effluent from a treatment plant outfall pipe.

Pretreatment - the removal of industrial wastewater at its source before discharge to municipal collection system.

Primary Treatment - an initial stage in wastewater treatment. Screens and sedimentation tanks are used to remove most material that floats or will settle. Primary treatment results in the removal of a substantial amount of suspended matter but little or no dissolved matter.

Pumping Station - mechanical devices installed to push the sewage to a higher elevation.

Receiving Waters - a river, lake, ocean or other waterway into which wastewater or treated effluent is discharged.

Residuals - the byproducts of the sewage treatment process, including scum (floatables), grit and screenings, primary sludge and secondary sludge.

Sanitary Sewer - a channel or pipe that carries only household and commercial wastewater.

Screenings - rags, sticks, plastics and other trash which is removed from wastewater as it passes through screens during the primary treatment process.

Scum - floating pollution, such as plastics and grease, skimmed off wastewater as part of the treatment process.

Secondary Treatment - a level of wastewater treatment that removes about 90 percent of suspended solids and biochemical oxygen demand.; a biological process in which wastewater is mixed with air and sludge to encourage the growth of bacteria that consume organic pollutants.

Sewage - the organic waste and wastewater produced by residential, commercial and industrial establishments.

Sewer - a channel or pipe that carries wastewater and/or storm water runoff from the source to a treatment plant or receiving waterway. Sanitary sewers carry household and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers are used for both purposes.

Sludge - the accumulated solids separated that either float on the surface of, or are suspended in, wastewater.

Tertiary Treatment - wastewater treatment beyond the secondary or biological stage that includes the removal of nutrients such as phosphorus and nitrogen and the removal of a higher percentage of suspended solids and organic matter.

User Charges - charges made to users of water and wastewater systems for services supplied.

Wastewater - the spent or used water from a community or industry that contains dissolved or suspended matter as pollutants.