An Evaluation of Canadian Towing Tanks and Maneuvering Basins as Substitute Test Facilities for OHMSETT

with

Counterspil Research Inc.

Environment Canada
Environmental Emergencies
Technology Division

and

U.S. Department of the Interior
Minerals Management Service
Technology Assessment and
Research Branch

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by

D. Dickins and L. Solsberg

for

Environment Canada
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March 31, 1989

prepared by

DF Dickins Associates Ltd.
503A, 21 Water Street
Vancouver, British Columbia
Canada V6B 1A1
in association with
Counterspil Research Inc.

ADDENDUM

Since completion of the final report the authors have learned that Esso Resources Canada Ltd. has added a travelling bridge to their outdoor maneuvering basin in Calgary.

The bridge is intended for viewing and equipment mounting. It spans the width of the basin and has a load capacity exceeding 4,000 kg in the vertical direction and 2,300 kg in the horizontal direction. The bridge can move at variable speeds up to 0.3 m/s (the potential exists to increase this speed if necessary).

The report's conclusion that the only two Canadian tanks capable of conducting OHMSETT type stationary tests can not perform advancing tests is no longer true. Many types of advancing tests at low speeds are now possible in the Esso basin with the new travelling bridge. Limitations of length, wave height, and carriage speed still prevent the Esso basin from acting as a complete OHMSETT replacement.

The Ocean Engineering Centre at B.C. Research in Vancouver is in the process of upgrading the wavemaking capabilities of their maneuvering basin. In addition, they have added improved computing services, and will now accept synthetic oil in the towing tank. B.C. Research is actively marketing their facility for oil spill research.

ABSTRACT

This report identifies all tank and basin test facilities in Canada and evaluates their capabilities to test oil spill equipment and clean-up techniques. The 1988 closure of the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) at Leonardo, New Jersey provided the motivation to seek alternate facilities in Canada to continue the program of oil spill testing funded by the U.S. Minerals Management Service and Environment Canada. Test protocols used at OHMSETT provided the basis for the evaluation of Canadian facilities.

The project proceeded through three phases: (1) documentation, (2) engineering assessment, and (3) on-site evaluation at selected facilities in Calgary, Ottawa, and Burlington.

The study concludes that although there is no one facility in Canada which can duplicate the capabilities of OHMSETT, there is a large potential to carry out significant test programs of moderate cost. Two Canadian facilities can accomplish a full range of stationary tests with large pieces of oil spill equipment in open water and ice: the Esso tank in Calgary (the only Canadian basin which will accept burning as a normal operation), and the National Research Council's M-42 basin in Ottawa. Several world class facilities are available in Canada for basic hydrodynamic work with oil spill devices in the absence of oil.

The report recommends that future spill research programs in Canada and the United States use a staged approach to equipment development and testing to reduce overall development costs and provide effective equipment. Three development stages are identified: (1) basic hydrodynamic research to optimize collection efficiency, sea-keeping and other marine engineering aspects crucial to the design of offshore equipment; (2) tank and/or basin testing with oil; and (3) full-scale field trials under realistic operating conditions (not always attainable in a controlled environment).

Canadian facilities are available to contribute to all three of these development stages including the co-ordination and management of large-scale field trials.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable contributions of Martin Poulin in preparing the documentation of the different facilities (Section 4 and Appendix B) and Ann Godon in reviewing the hydrodynamic capabilities of Canadian facilities (Section 5.3).

The authors also wish to thank the representatives of Canadian tank and basin facilities for providing the information necessary to conduct this evaluation and in particular Richard Griffiths (E.P.A.), Hugh Brown (Esso), Ruby Denison and Stefan Grochowalski (NRC), John Lawrence and Michael Skafel (C.C.I.W.), and Gerry Stensgaard and Mark Shaver (B.C. Research) for providing the time to conduct personal tours and answer technical questions.

CONTENTS

1.0 INTRODUCTION AND OBJECTIVES

The principal objective of this study was to evaluate Canadian tank and basin testing facilities in terms of their capability to continue a program of oil and chemical spill equipment testing initiated in the United States. That program was terminated in 1988 with the closure of a facility known as OHMSETT located in Leonardo, New Jersey. (At time of writing approval is pending to reopen the OHMSETT facility in early 1990 to fulfill the goals of a greatly expanded national oil spill research and development program sparked by the Valdez spill in March 1989.)

The U.S. Minerals Management Service (M.M.S.) and the Conservation and Protection Branch of Environment Canada (EC/C&P) have a continuing requirement to assess the performance capabilities of different equipment and techniques (e.g. burning) under controlled and repeatable conditions in a test tank. Even with the proposed reopening of OHMSETT, the anticipated level of oil spill R&D will require the services of a number of Canadian facilities for different types of tests.

The most desirable situation was that of finding a single Canadian facility which could duplicate the capabilities of OHMSETT in all or most respects. In that manner, the test protocols developed over many years at the U.S. facility could be continued, and results from older tests could be applied to tests carried out at a new facility through a series of calibration experiments. In reality, the situation was one of finding a number of facilities that could duplicate part of what was accomplished at OHMSETT.

It was not the intent of this project to evaluate the worth or validity of continuing the OHMSETT test program in the future. A detailed review of previous oil spill projects carried out at OHMSETT was outside the scope of work specified for this evaluation.

Individual Canadian tanks were evaluated with regard to their deficiencies and/or lack of capability with reference to OHMSETT as a baseline for comparison. The evaluation did not include an assessment of the consequences of such deficiencies or the future effectiveness of oil spill research.

2.0 METHODOLOGY

The initial phase of the project consisted of petitioning the known tank/basin facilities across Canada by letter. The letter requested that the facilities respond with information outlining the physical layout of the tanks/basins, the capability of field simulation, and the background support offered by the facility . Selected material received from the different facilities, a sample of the letter sent to each facility, and a full list of contacts at each facility are included at the beginning of Appendix B.

The facility survey of tanks and basins was divided into two parts: major tanks and basins and secondary ones. The major facilities are assessed in detail in the following chapters. Secondary facilities are listed in Appendix B for completeness but are not included in the detailed evaluation; these facilities comprise hydraulic test basins and/or small tanks associated with universities, and consulting companies.

Most facilities replied promptly with information packages describing their tanks/basins as requested in the letter. All of the facilities were then phoned to clarify a number of technical points and to discuss their reaction to oil spill testing in their facility. The only site visit at this stage was to the facilities at B.C. Research in Vancouver.

The second phase of the project involved a "paper" assessment of each facility according to set criteria derived from an independent assessment of OHMSETT as a baseline facility. This phase was expanded from the original study scope to cover not only an assessment of Canadian facilities against the OHMSETT baseline, but also a separate assessment in terms of pure hydrodynamic testing (with or without oil). The expanded scope of assessment was necessary because (1) only two Canadian facilities will permit oil to be spilled in their basins, and (2) the study team concluded that future programs will benefit substantially from the introduction of hydrodynamic tests as part of the development process.

The final study phase involved site visits to the Esso tank in Calgary, the National Research Council basin in Ottawa and the National Water Research Institute in Burlington.

3.0 OHMSETT BACKGROUND INFORMATION

3.1 OHMSETT Test Programs

The OHMSETT facility was specifically designed to evaluate a wide range of spill control technologies. The physical features of the facility are described in detail in Appendix A.

Boom and skimmer test requirements dominated the demands placed on the OHMSETT facility and largely accounted for the tank and carriage system design. The OHMSETT facility was also used to examine other technologies such as oil treating agents, oil behaviour in ice, and burning.

The tank was used to measure boom performance according to different loss mechanisms (entrainment, splash-over, drainage, instability). Skimmer evaluations covered throughput efficiency, oil recovery efficiency, and oil recovery rate for a given set of conditions (slick thickness, oil type, relative velocity, sea state and various skimmer settings).

Test procedures included those recommended by Committee F-20 (A.S.T.M.), various literature sources, and assessment techniques developed by the OHMSETT staff.

The performance evaluations and different aspects of tests conducted at the New Jersey tank are summarized as follows:

<u>Boom Tests</u>

Booms were assessed primarily according to two deployment configurations, catenary and diversionary modes. Performance was evaluated in terms of:

Oil Retention vs. Oil Lost (%)
Tow Speed
Stability in Waves
Failure Modes, Wave Conditions, Oil Encounter Rate

Testing also considered the reduction of tank effects (retention by side walls) as well as various design parameters: freeboard, flotation, skirt depth, tension members, anchor points, connectors, seams, stiffeners. OHMSETT personnel were able to comment extensively on the design of the booms examined in the tank.

Skimmer Tests

A wide range of commercial and prototype skimmers were tested in the OHMSETT tank. Three main parameters were studied as part of the detailed engineering assessments of the equipment.

1. Oil Recovery Rate (L/min - tonnes/h)
2. Recovery Efficiency (oil collected/oil and water recovered - %)
3. Throughput Efficiency (oil collected/oil encountered - %)

Testing was conducted in both constant slick thickness (oil was added during testing) and in diminishing oil layers (i.e., the skimmer removed oil and no additional oil was added to the slick). OHMSETT test engineers and technicians attempted to optimize performance by adjusting the main skimmer pickup mechanism. Machines were tested in both the stationary and advancing modes. Independent study variables included tow speed, slick dimensions, sea state, oil properties, skimmer settings, and weather conditions (temperature).

As with the boom trials, comprehensive assessments of machine design usually evolved during testing programs. Insights were provided to manufacturers on device stability, wave response, water plane area, vortex formation, debris processing and equipment problems together with recommendations on possible means to improve the oil recovery rate.

Other technologies examined at OHMSETT included the following items:

Pump Evaluations

Experimental parameters included the pumping rate, emulsification, debris tolerance, portability, drainage characteristics, cold weather operations, ease of use, chemical tolerances, and hoses.

Sorbent Evaluations

oil recovered/weight of sorbent - %

Slick Detectors

Oil Treating Agents

herders, other viscosity/surface tension modifiers, "sinkants"

Dispersant Application

dosage, oil concentration in water column, slick characteristics

Oil Behaviour Experiments

Combustion Tests

oil removal rate, smoke plume characteristics, burn temperature, burn residue

The contractor studied OHMSETT test protocols and experimental setups to understand the scope of work accomplished at OHMSETT (including the range of variables examined and the environmental conditions which could be simulated in the tank). Results of this phase of the work were combined with a review of test programs (interview with Mr. Griffiths of the United States Environmental Protection Agency) to produce the assessment criteria listed below in Section 3.2.

3.2 Unique Features of OHMSETT

A meeting held January 18, 1989 with Mr. Richard Griffiths (Chief, Releases Technology Section, Releases Control Branch, United States Environmental Protection Agency) provided insights into the technical requirements of an alternative Canadian test tank facility. These requirements are based on Mr. Griffiths' perception of future testing based on his planning and management experience at OHMSETT.

The discussions identified essential technical items applicable to any alternative facility considered in Canada. Potential improvements to OHMSETT were also discussed so that both the design and intended function of the tank's features were clearly understood (including shortcomings of the U.S. tank).

The terms of reference for this study dictated that alternative Canadian tank facilities be evaluated in terms of their ability to perform tests consistent with the previous OHMSETT program. Projected test requirements related to future spill research programs were not considered in the initial evaluation. Section 5.3 outlines the potential of existing Canadian facilities for specialized hydrodynamic testing of spill devices (not necessarily in the presence of oil).

The unique design of OHMSETT is apparent in a review of its physical features. This is presented in a format corresponding to the criteria used to evaluate Canadian tanks in Section 5.0.

- Configuration
- Bridges
- Waves
- Ice
- Data Gathering
- Analysis
- Test Fluids
- Saline Water
- Test Setup
- Water Quality
- Ancillaries

3.2.1 Configuration & Construction

OHMSETT was designed primarily to conduct the dynamic testing of skimmers and booms. The dimensions of the tank and its bridges were therefore key factors in its design.

The tank was constructed with a 10-15 year life span; its actual operating period was about 14 years. Problems were encountered with the neoprene seals used between cast concrete blocks. The blocks suffered from spalling (pitting). Visible leaks were aggravated by cold weather when shrinkage of materials occurred (additional leaks were suspected toward the base of the tank but were hidden by the surrounding terrain and vegetation). At peak loss periods, about 100 gpm was thought to be escaping from the tank. Losses were considered to be minor given the total capacity of 27 000 gal/in. (2.6 million US gallons).
The epoxy paint used in the tank wore away over time but adverse effects on the tank were not pronounced except as already noted. A wave-height grid painted on the tank walls faded over time.

3.2.2 Bridges

The most important bridge at OHMSETT was the main bridge used for towing. This bridge housed test instrumentation, oil distribution systems, and oil collection apparatus. It also served as the main platform for observers.

The auxiliary bridge was used for oil collection as well as for support for the connecting video bridge. It also provided the means to tow back the device under test to its starting position for the resumption of testing.

The vacuum bridge was used to remove materials from the tank bottom primarily entering as wind-blown debris and algae from the neighbouring swamp. The cleaning mechanism consisted of a vacuum head, roller and brushes which conveyed water and debris to a trough paralleling the tank and on to the water treatment system.

Theoretically, a large bridge could accommodate all technical needs including oil collection but would have to be substantial in size. A single bridge concept would seriously reduce the flexibility inherent to the OHMSETT configuration. A single bridge would (1) necessitate hard-fastening of mobile skimming systems directly to the main bridge to enable tow-back to the starting point, (2) limit above-water visual recording, and (3) limit oil application and collection systems.

Maximum relative velocities of 2-3 knots are sufficient to permit testing of the majority of advancing skimming systems. This represents a target velocity considerably lower than the OHMSETT capability of 6.5 knots.

3.2.3 Test Setup

The tank, test media, analytical capabilities, knowledgeable staff, and support facilities at OHMSETT suited the evaluation of a wide range of oil and chemical spill clean-up technologies.

Oil burning tried toward the end of the tank's operating life presented concerns to U.S. regulatory authorities. These concerns also apply to most facilities in Canada, especially in urban areas, where permitting must comply with local air emission regulations and guidelines.

The burning slicks at OHMSETT were effectively isolated using wooden 2 x 6's or other simple means. Wind direction was carefully monitored to avoid danger to observers.

3.2.4 Waves

OHMSETT was limited to wave heights in the 0.4-0.5 m range. This was a primary criticism of the tank. Wave heights to 1 m are required to represent the maximum operating conditions for many hardware items marketed for open water work.

Breaking and standing waves are also important for testing of equipment. Breaking waves occur when the energy density within a wave exceeds the limit for stability. Breaking waves are typically seen on beaches where they are caused by the reduction in water depth. They can also arise in open water from the interaction of waves propagating across each other or from the superposition of several wave components of different frequencies. Standing waves typically occur in or near harbours and result from the superposition of reflected waves on the incoming wave train. This type of wave pattern is often referred to as harbour chop. (A. Cornett, 1989 - pers. comm.)

Standing and breaking waves can cause different responses in test equipment. Equipment which may operate successfully in standing waves may fail in breaking waves that are only half the height. The absence of breaking and standing waves is a valid criticism of previous tank tests.

3.2.5 Ice

Testing in ice was carried out toward the end of the OHMSETT operating period. This capability is viewed as an important issue for both the Canadian and U.S. test programs. Ice can be grown either in outdoor tanks in areas of below freezing temperatures or in refrigerated facilities. With the proper climate controls, a refrigerated tank can duplicate specific field conditions. The advantage of outdoor tanks is that conditions representative of the tank's climatic region can be produced at very low cost. Outdoor tanks present difficulties in reproducing specified ice conditions.

3.2.6 Saline Water

Salt water was necessary for oil flotation in tests conducted with Bunker C. Crude oil also requires saline conditions for realistic testing of physical open-sea conditions. A minimum of 7 and preferably 10 ppt was found to be suitable.

Salt is relatively inexpensive to purchase (especially from dye plants) and could be readily secured for most facilities. The main problem is reluctance on the part of tank owners to introduce salt. Their concerns centre around the potential for adverse interaction between the saline water and rubber seals or other components (accelerated corrosion).

3.2.7 Test Fluids

Synthetic oils referred to as circo oils were used for the most part in testing at OHMSETT. Refined products could also have been used in the tank but likely represented safety concerns.

Problems associated with the test fluids used at OHMSETT centred around the disposal of the waste (expended) oils containing salt and water, and minimum volumes of 50 000 gallons being presented to reprocessors. A municipal sewage treatment plant with secondary treatment might accept hydrocarbons in water within certain specified limits, for example, of concentration and flow rate (as is the case with Esso's basin in Calgary).

Gravity separation was fairly effective in removing oil from the water at OHMSETT. However, salt buildup occurred over time, with each successive reuse, and interfacial tension, in particular, exceeded allowable limits.

3.2.8 Water Quality

Water quality maintenance was an important aspect and readily achieved at a particle size removal of 5 μ or less depending on the selection of the filter media. Three grades of diatomaceous earth were used together with a filter medium of a cellulosic material with surface active properties. The prime purpose of the filter was to remove algae.

Biodegradation of hydrocarbons was promoted by shutting down the chlorinator. Eliminating light also reduced algae growth.

Generally it was found that oil removal was not a problem. A combination of evaporation, biodegradation and filtering usually resulted in hydrocarbon levels below detectable limits. Once water quality fell below acceptable limits it was a substantial job to return it to an acceptable state.

When acids and bases were utilized in earlier testing programs, the chlorinator had to be shut down to prevent the formation of precipitant salts. Algae growth subsequently occurred.

A component of the tank which needed improvement was the simple weir system that accepted hosed-down oils following testing.

3.2.9 Data Gathering

Data collection activities were conducted primarily on the main carriage. For evaluations involving ice as well as open-water tests, video recording capability on the tank bottom is desirable. Video instrumentation would move on a submerged track at the speed of the main bridge and allow data gathering without disturbing surface waters. Otherwise, the connecting video bridge employed at OHMSETT was useful. Pan, tilt, and zoom capability were built into its recording cameras.

Plexiglass viewing ports 1 m x 2 m allowed underwater observations at four vantage points. Two other ports were 1 m x 4 m in size. These had polysulfide seals which leaked from time to time. The oversized ports were particularly useful for setting up recording equipment.

Cranes were also used to support viewing hardware when required, as was the case for combustion tests.

3.2.10 Analysis

A comprehensive but standard collection of physical chemistry instrumentation was assembled at OHMSETT (refer to Appendix A).

3.2.11 Ancillaries

Wood and metal working shops, lifting capability, firefighting, medical assistance, and computerized data processing were several of the ancillary aspects available at OHMSETT.

3.2.12 Dispersants

Dispersants were effective at OHMSETT when introduced as a premixed solution of oil and dispersant. Two to three days were needed to clean the tank after the use of 35 litres of the mixture. Viewing ports were important for dispersant work. Ice experiments were conducted using dispersants but without discernible effects.

4.0 DESCRIPTION OF FACILITIES

Table 4-1 summarizes the technical specifications of major Canadian tank, basin, and flume facilities. A column entitled *Availability* is intended as a guide to the expected proportion of time which each facility may have free to devote to spill research projects (with or without oil). As shown in the Table, only two Canadian facilities are willing to accept real oil. (Several facilities may accept an oil substitute such as *canola*). Appendix B contains additional specification tables and extracts from the information packages sent by the different facilities in response to a letter request.

The relative sizes of the different facilities in Canada are compared visually to OHMSETT in Figure 4-1. The white outline shows the tanks in plan view while the shaded portion shows the relative water depths (in exaggerated scale). A divider line in the shaded portion indicates a variation in depth over the test length.

It is important to note in this illustration that with the exception of the main towing tank at the Institute for Marine Dynamics in St. John's, all of the other Canadian towing tanks are a small fraction of the size of OHMSETT. A number of maneuvering basins are comparable in area but lack the necessary test length or moving bridges for a comprehensive program of advancing tests.

All but two of the facilities shown are indoors which automatically precludes oil burning tests. It should be noted that specific oil combustion tests are conducted at a number of outdoor sites in Canada (e.g. Fleet Technology in Kanata, University of Waterloo). Additional oil burning sites include airport fire training exercises and offshore fire training schools for the oil industry.

Table 4-1 Summary of Canadian Tank and Basin Facilities

Facility	Type of Tank	Housing	Dimensions Length (m)	Width (m)	Depth (m)	Number of Carriages	Ice Production	Maximum Wave Height**	Real Oil Use?***	Availability
B.C. Research	Towing	Indoor	67	3.7	2.4	1	No	0.25 m	No	Hydrodynamic only.
B.C. Research	Maneuvering Basin	Indoor	30	26	2.4	0	No	0.25 m 1.0 m standing	No	Available for extended periods.
Fleet Tech	Mod-Ice	Indoor	30.5	7.3	1.4	2	Yes (synthetic ice)	No specs.	Yes	Available on contract.
Fleet Tech	Ice	Indoor	15.6	4.9	1.5	1	Yes	No specs.	Yes	
Esso	Maneuvering Basin	Outdoor	56	30	1.4 to 3	2*	Yes	0.3 m	Yes	Available with notice.
IMD St. John's	Ice	Indoor	76	12	3	2	Yes	N/A	No	Limited.
IMD St. John's	Towing	Indoor	200	12	7	1	No	1 m 1.5 m irregular	No	Limited.
IMD St. John's	Maneuvering Basin	Indoor	75	32	0.5 to 3.5	0	No	1 m 1 m irregular	No	Limited.
IMD Ottawa	Maneuvering Basin (M-42)	Outdoor	122	61	3.7	0	Yes	0.6 m	Yes	Available with advance planning.
IMD Ottawa	Towing (M-22)	Indoor	137	7.6	2	1	No	No specs.	No	Not available.
National Water Inst.	Towing	Indoor	122	5	2.7	1	No	N/A	No	Limited.
National Water Inst.	Wind-Wave Flume	Indoor	103	4.5	1.25	0	No	0.6 m	No	Limited.
Institute of Fisheries	Recirculating Flume	Indoor	22.5	8	4	1	No	N/A	No	Available for specific projects.
Memorial University	Towing	Indoor	58	4.6	2.4	1	No	0.4 m	No	Available for extended time periods.
DME-NRC Ottawa	Coastal Wave Basin	Indoor	63	14	1.5	1 (manual)	No	0.5 m	No	Available for limited periods for specific projects.
DME-NRC Ottawa	Multidirectional Wave Basin	Indoor	50	30	3 (12 m pit)	0	No	0.75 m	No	
DME-NRC Ottawa	Ice Basin	Indoor	21	7	1	1	Yes	N/A	No	

* The carriage consists of two trolleys running along sides of the tank (upgraded 1989 to an overhead bridge).
** For irregular waves the significant wave height is given. *** None of the facilities evaluated have adequate oil filtration capabilities.
Note: none of the facilities evaluated will officially permit combustion tests with the exception of Esso Resources.

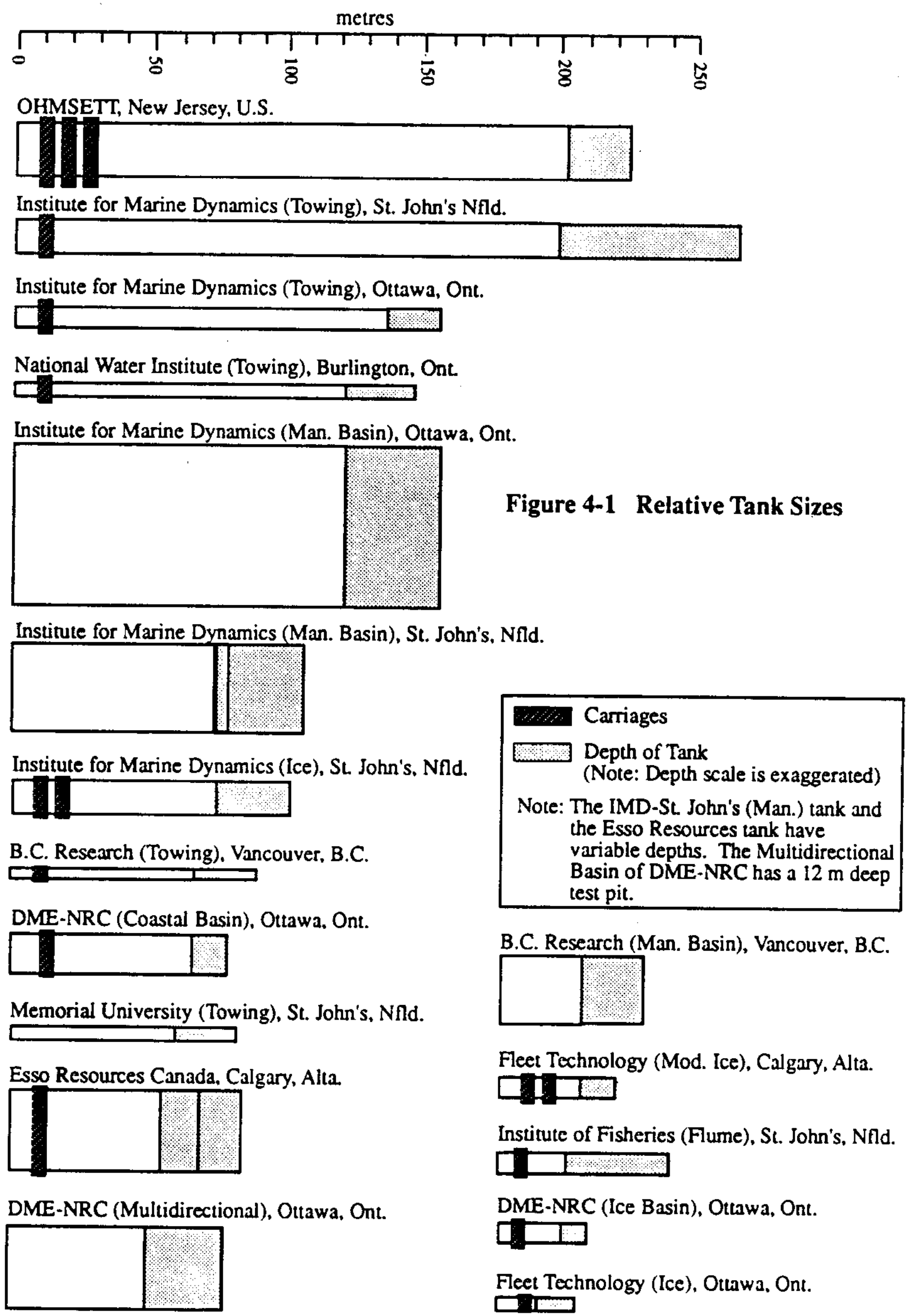

Figure 4-1 Relative Tank Sizes

5.0 ASSESSMENT OF FACILITIES

5.1 Methodology

The fourteen Canadian tanks were critically examined according to information pertaining to their physical features and ancillary hardware. The data were related in turn to a detailed study of the OHMSETT facility and programs (Section 3.0).

As a result of the OHMSETT program review, a matrix was drawn up which related individual items or techniques to tank requirements. For example, the matrix listed skimmers, booms, pumps, hoses, sorbents, dispersants, and combustion then related these to tank features considered necessary to achieve such tests (in both stationary and advancing mode).

The matrix was subsequently condensed because of the overlap of setup requirements for the evaluation of different devices. The Canadian tanks were then assessed according to their potential to accommodate four basic categories of testing programs:

1. *Advancing Tests*	skimmers and booms.
2. *Stationary Tests*	skimmers, booms, pumps, hoses and sorbent trials, monitoring, detection, tracking and treating agents.
3. *Dispersant Applications*	
4. *Burning Experiments*	

The perception of the facility(ies) required to equal OHMSETT in capability was further augmented by the discussions held with Mr. R.A. Griffiths of the E.P.A., a past manager of OHMSETT equipment assessment programs (Section 3.2). Factors discussed included tank dimensions, the activities conducted on the OHMSETT bridges, relative velocity requirements, wave and water quality characteristics and analytical and other support needs (workshop, lifting capability, personnel).

The contractor decided to evaluate the candidate tanks according to 11 criteria:

1. *Configuration*

   - comparison to OHMSETT (203 m x 20 m x 2.4 m)
   - ability to accommodate sections of boom
   - large commercial skimmers, dispersant tests, burning
   - size sufficient for test duration of 2-3 minutes

2. *Bridges*

   - carrying capacity
   - relative speed of 1-1.5 m/sec (2-3 knots)
   - two bridges preferable

3. *Test setup*

   - deck space
   - arrangement of bridge(s)
   - overall configuration (e.g., deck area, overhead height)

4. *Waves*

   - maximum height 0.5 m (adequate), 1.0 m (preferred)
   - availability of beach
   - breaking and regular waves

5. *Ice*

   - natural ice preferred with reliable growth conditions

6. *Saline water*

   - use of salt water (preferred) or allowance for additives

7. *Test fluids*

   - use of real oil preferred (possible synthetic oil use)
   - potential for other chemical agents

8. *Water quality*

   - filtering capability to maintain water clarity
   - filtering to allow oil use

9. *Data gathering*

   - potential to obtain information on oil distribution & collection,
   - viewing platforms and ports
   - equipment (data loggers, wave spectra)

10. *Analysis*

- laboratory space (including chemical analysis capability)
- instrumentation
- personnel

11. *Ancillaries*

- wood and metal working shops
- cranes and other substantial lifting devices
- presence of permanent staff
- firefighting*
- medical assistance*
- proximity to major airport and transportation routes*

* indicates important items in overall selection criteria but not a factor in Canadian evaluation (all facilities are in close proximity to urban centres and meet these criteria)

Based on the summary description contained in Section 4, and the detailed information contained in Appendix B, a preliminary engineering assessment of each Canadian candidate tank was conducted using the criteria described above. The results of this preliminary assessment are presented in Appendix C as a series of tables which take into account the four groupings of tests and 11 criteria. Each facility is summarized according to its ability to serve as a replacement for OHMSETT.

5.2 Preliminary Rating of the Candidate Tanks

An examination of the major test facilities in Canada (Appendix C) revealed that there is no tank willing to accept oil which has the dimensions, filtering system, and ancillary facilities necessary to provide a replacement for OHMSETT. This is not surprising since the U.S. tank was designed and constructed specifically to evaluate spill control technologies whereas the Canadian tanks were built for other reasons. The institutions and companies overseeing Canadian tank operations generally have priority uses and concerns in mind other than spill control equipment trials (ship model testing, and hydraulic testing).

An assessment of the fourteen Canadian tanks resulted in two distinct facility groups being identified:

Facilities Lacking the Necessary Attributes to Serve as a Partial OHMSETT Replacement

FACILITY	MAJOR LIMITATIONS
B.C. Research Towing Tank	- too narrow, no burning, lack of ice
Fleet Technology Ice Tanks (2)	- no advancing tests/burning, too small
Institute for Marine Dynamics Ice Tank, St. John's	- no-oil policy, no wave-maker, no burning
Institute for Marine Dynamics St John's Tanks	- advanced technical facility which would otherwise be considered if it were not for management's "no oil" policy
Institute for Marine Dynamics Ottawa Towing Tank (M-22)	- indoor towing tank has modern instrumentation but restricted by the same "no oil" policy as the IMD St. John's facilities
National Water Institute Towing Tank	- too narrow, no wave generator/ice/burning
National Water Inst. Wind/Wave Flume	- too narrow, no ice/burning
Memorial University Towing Tank	- narrow, simple filter, no salt water/burning/ice
DME-NRC Coastal Wave Basin	- narrow, no oil, no advancing tests, no ice/burning
DME-NRC Multidirectional Wave Basin	- no oil, no advancing tests, no ice/burning
DME-NRC Ice Tank	- no oil, too small, no burning

Facilities Warranting Further Technical Evaluation

FACILITY	COMMENTS
Esso Tank	- limited for high speed advancing tests - unique among Canadian facilities in allowing both real oil and burning
B.C.Research Maneuvering Tank	- no advancing tests/ice/burning - enthusiastic management supporting oil spill research initiatives - available at moderate cost - suitable for stationary testing with synthetic oil in a variety of sea states
Institute for Marine Dynamics Ottawa M-42 Basin	- outdoor tank M-42 equivalent in ranking to the Esso Tank in being able to accomplish a wide variety of oil tests (much deeper and larger but without the ability to burn oil)
Institute of Fisheries and Marine Technology- Recirculating Flume	- considerable potential for specialized hydraulic testing of components in the absence of oil - requires completely different testing concepts from previous oil spill research programs

Many of these facilities are not suited for OHMSETT type tests as they will not accept oil. In spite of this limitation, they still offer considerable potential for specialized hydrodynamic tests of spill equipment.

On the basis of this initial "paper evaluation" the contractor selected for site visits three facilities: the Institute for Marine Dynamics tanks in Ottawa, the Esso tank in Calgary, and the National Water Research Institute facility in Burlington, Ontario (relatively close to Ottawa). It was recognized beforehand that the Burlington facility offered limited potential for any extensive oil spill test program but the opportunity was taken to evaluate one of

Canada's premier hydraulic research institutes for specialized testing of small devices. The B.C. Research facilities were visited at an early stage in the project; the results are reported in Appendix C.

In spite of their technical merits the St. John's facilities were not selected for further evaluation: (1) IMD management stated that their policy of no oil in any of their facilities was not open to negotiation (M-42 outdoor basin in Ottawa being the only exception), and (2) the Fisheries and Marine Technology Flume although offering potential for basic fluid-flow work with different devices, was considered outside of the study scope of work to evaluate in any more detail.

5.3 Capabilities of Canadian Facilities With Respect to Hydrodynamic Testing of Spill Control Equipment

Several of the Canadian facilities are impressive world-class facilities with the ability to simulate the various environmental parameters of waves, ice, and operating speeds and having widths or lengths comparable to OHMSETT and in many cases with depths exceeding OHMSETT.

Unfortunately, it is the most hydrodynamically attractive facilities which are the least receptive to oil spill research. They have been designed for pure hydrodynamic/hydraulic testing without provisions for any fluids other than water. The presence of contaminants such as oil, which if not completely removed will alter the viscosity and surface tension of the water, is strictly out of the question. However, these facilities could be taken advantage of by introducing a hydrodynamic test phase into the overall equipment evaluation procedure (refer to Recommendations).

The history of testing oil spill control equipment has been one of advancing almost immediately from the design concept to full-scale prototype to full-scale tank trials with oil. As a result, equipment underwent the costly testing with oil without an examination of the basic physical principles of operation. Many unsuccessful devices could have been eliminated or revised before trials in oil if an initial hydrodynamic phase of testing had been available.

Parameters which could be examined in an initial "oil-less" phase are seakeeping abilities in various wave conditions, flow fields around devices, loss mechanisms, maneuverability in open water and ice, behaviour in cold weather, open-water drag, wave making and vortex creation, and powering requirements. The purpose of the testing would be to find inherent design faults at an early stage. The net result would be a more effective use of testing in oil with shorter and fewer test programs required. The overall evaluation procedure could be reduced in cost.

An initial phase of hydrodynamic testing could involve both advancing and stationary tests of booms and skimmers evaluated according to the following topics:

Booms

- tow speed
- stability in waves
- flow field
- failure modes
- resistance
- configuration
- deployment in ice

Skimmers

- tow speed
- seakeeping
- maneuvering in various sea states
- resistance
- maneuvering in ice
- flow field
- wave making and vortex creation
- speed of drums and belts
- configuration (e.g., angle of attack, draft) of drums and belts
- powering requirements
- cold weather performance

Equipment which would not receive much benefit from hydrodynamic testing are pumps, sorbents, slick detectors, dispersants, and other oil treating agents.

If an oil substitute which displays some of the properties of oil could also be introduced into the tests, the value of the testing increases. *Circo*, the principal test fluid at OHMSETT, was an oil substitute which had been processed to remove the lighter oil hydrocarbon components. Another substance which has been tried in the past is *canola*, a vegetable oil (Allen and Nelson, 1983).

However, it has been the contractor's experience that canola is a poor substitute, not behaving as oil in skimmer tests, nor having the characteristic droplet formation of oil and therefore, not experiencing the same loss under booms (in spite of its higher specific gravity). If oil substitutes are used they should be used to analyze possible oil loss mechanisms and oil encounter rates, and not to measure oil recovery rates. Equipment required for clean-up of the circo oils are a collection weir system similar to OHMSETT 's and a simple filtration system for water purity and clarity.

If the object of the test is to study the behaviour of equipment in its operating environment then the primary requirement becomes the ability to simulate the environment. The following characteristics are considered desirable:

- maximum carriage speed or flume current of 1.5 m/s
- regular waves and harbour chop
- maximum wave heights of 1 m
- salt water
- air temperature ranges from -20 to 15 °C
- water temperature from freezing to 15 °C
- ice
- hydrodynamic analysis
- ice interaction analysis
- for open water testing: a width and a depth 6 times that of the equipment width and depth and with neither less than the equipment length
- for ice testing: a depth 4 times that of the equipment width, width 6 times that of equipment width and greater than the equipment length

The rules for tank size versus equipment size are usually applied to "ship" like equipment such as skimmers but the same general rules (especially of depth) apply to booms.

Fortunately not all of these characteristics are likely to be required in any one test. The presence of thick ice usually means the sea state is relatively calm due to the damping effects of the ice. Tests in thick ice sheets are assumed not to require any wavemaking. This not the case for thin ice where wave action will play a significant role in altering the oil distribution. Wind is not included directly as an environmental parameter — most equipment is inoperable in very high winds because of the high seas created. Low wind speeds play a significant role in the creation of waves rather than affecting the device directly.

The purely hydrodynamic capabilities of each facility are reviewed briefly below and summarized in Table 5-1 (Table 4-1 provides an overall technical summary of the different facilities). For strictly hydrodynamic work the size of the carriage or bridge is dependent only on the size of equipment which must be towed, and the data to be collected (oil distribution and collection systems are not factors as was the case with the previous evaluations in Section 5.2).

B.C. Research Towing Tank and Maneuvering Basin

Analytical services are available. B.C. Research is exploring the possibility of upgrading the wave making equipment to produce 0.6 m waves. The maximum carriage speed of the towing tank is 4.5 m/s which is more than adequate. Regular and irregular waves are possible in the tank but harbour chop or breaking waves would only be possible if the beach was removed.

The biggest limitations of the towing tank are the narrow width, 2.4 m, and the low wave heights. Scale model tests of small sections of skimmers in an advancing mode are possible because of the high carriage speeds. The information gathered would be similar to that of ship model testing: open water resistance, powering requirements, seakeeping, and wave making/vortex creation.

Like most maneuvering basins, the B.C. Research basin does not have a carriage. Wave making is similar to the towing tank but in addition a harbour chop with heights up to 1m can be produced. A position tracking system is required for detailed measurements of seakeeping abilities of equipment during tests (this equipment may be available on loan through cooperative agreements with NRC). The staff have indicated that oil substitutes such as circo could be used in the basin. This would be valuable in analyzing the flow field and the loss mechanisms.

Table 5-1 Hydrodynamic Aspects of Canadian Tank and Basin Facilities

Facility	Type of Tank	Max. Equipment Dimensions Length (m)	Breadth (m)	Draft (m)	Max Test Speed (m/s)	Climate (ice, salt water temp. range)	Maximum Wave Height and Type	Oil Substitute Use
B.C. Research	Towing	2.4	0.6	0.4	4.5	Salt Water Ambient	0.25 m regular**	No
B.C. Research	Maneuvering Basin	2.4	2.4	0.4	N/A	Salt Water Ambient	0.25 m regular** 1.0 m standing	Yes
Fleet Technology	Mod-Ice	7.3*	1.2	0.35*	1.0	Ice, Salt Water Ambient	No specs.	Yes
Fleet Technology	Ice	4.9*	0.8	0.4*	1.5	Ice, Salt Water -20 to 15° C	No specs.	Yes
Esso	Ice & Maneuv-ering Basin	3.0	5.0	0.2 to 0.5	0.3	Ice, Salt Water Ambient - outdoors	0.3 m regular	Yes
IMD St. John's	Ice	12.0*	2.0	0.75*	4.0	Ice -30 to 15° C	N/A	No
IMD St. John's	Towing	7	2.0	1.1	10.0	None Ambient	1 m regular 1.5 m irregular	No
IMD St. John's	Maneuvering Basin	3.5	5.3	0.1 to 0.6	N/A	None Ambient	1 m regular/irreg.	No
IMD Ottawa	Maneuvering Basin (M-42)	3.7	10.0	0.6	N/A	Ice Ambient - outdoors	0.6 m regular	Yes
IMD Ottawa	Towing (M-22)	2.0	1.3	0.3	6.0	None Ambient	No specs.	No
National Water Institute	Towing	2.7	0.8	0.45	6.0	None Ambient	N/A	No
National Water Institute	Wind-Wave Flume	1.25	0.75	0.21	0.5	Salt Water Ambient	0.6 m regular	No
Institute of Fisheries	Recirculating Flume	21.5	1.3	4.0	1.0	None Ambient	N/A	No
Memorial University	Towing	2.4	0.8	0.4	5.0	None Ambient	0.4 m regular	No
DME-NRC	Coastal Wave Basin	1.4	2.3	0.2	N/A	Salt Water Ambient	0.5 m regular/irreg.	No
DME-NRC	Multidirectional Wave Basin	2.7	5	0.4 (2.4 in test pit)	N/A	Salt Water Ambient	0.75 m regular/irreg directional waves	No
DME-NRC	Ice Basin	7*	1.2	0.2*	0.5	Ice -20 to 15° C	N/A	No

Breadth and draft based on dimensions that are 1/6 that of tank. Maximum length is lesser of tank width or depth.
* Maximum length and breadth for testing in ice. ** Planning to upgrade the wavemaking equipment to produce 0.6 m regular waves.

Institute for Marine Dynamics (IMD) in St John's.

The ice tank, towing tank, and seakeeping basin when viewed together outperform OHMSETT in hydrodynamic capabilities. Tests in ice can be performed in one tank and tests in waves in either of the other two. Availability is limited and analytical services are not available. Salt water, real oil, and oil substitutes can not be used in any of the tanks.

The ice tank has carriage speeds up to 4 m/s. Ice and climate can be modeled. Because of its width it could test skimmers up to 12 m long in ice. The towing tank can produce regular waves up to 1 m high and irregular waves up to 1.5 m. Skimmers up to 7 m long could be tested in it.

The seakeeping/maneuvering basin is expected to be completed in June 1990. When finished it will have excellent wave making facilities but it will not have a carriage. It will also have a six degree of freedom tracking system for measurement of model motions in the basin.

Institute for Marine Dynamics in Ottawa

The towing tank and maneuvering basin in Ottawa do not have the impressive hardware of the St John's facility. The major advantages with respect to hydrodynamic testing are the larger size of the maneuvering basin and the fact that climate can be varied according to natural winter conditions. Salt water is not possible. The waves in the outdoor basin are limited. Analytical services are available.

National Water Research Institute Tanks

The towing tank is only acceptable for limited tests due to its small size, absence of waves, and poor viewing . The wind-wave flume has currents of 0.5 m/s and waves up to 0.6 m high but low headroom and general lack of space would make it very difficult to get equipment in and out.

Institute of Fisheries & Marine Technology Recirculating Flume

This facility is attractive because of its panoramic underwater viewing windows and its size (compared to any other flume facility in North America). The bottom floor moves at the same speed as the water to eliminate depth effects. Equipment with lengths up to 21.5 m and drafts approaching that of the tank, 4 m, could be tested. The flume can operate at speeds up to 1 m/s.

Excellent results have been obtained when examining oil spill recovery equipment in a flume. Depth of submergence, rotational speed of recovery component, and oil losses are precisely documented. Flumes are also excellent for the assessment of specific components within a single device and for optimizing configuration design.

The advantage of flumes is that the effective duration of a simulated advancing test is limitless. The only drawback is that waves in any form are not available. This could be an excellent facility for studying boom characteristics.

Memorial University Towing Tank

This tank is roughly the same size as B.C. Research's towing tank. The tank depth is listed at 2.4 m but the working depth is only 1.8 m. The wave heights are slightly larger at 0.4 m but still too low for real seakeeping tests. The main advantage is the development of a position tracking system for self-propelled models. Position measurements are essential if seakeeping and behaviour of equipment in waves is to be analyzed in detail. As with B.C. Research's towing tank this facility would be valuable for hydrodynamic model tests of advancing and stationary devices.

6.0 RESULTS OF SITE VISITS TO THREE CANDIDATE FACILITIES

The purpose of the site visits was (1) to more thoroughly assess the potential of the facilities, and (2) to assess the possibility and feasibility of modifications to better accommodate oil spill testing.

6.1 Esso Resources Canada Ltd. Test Basin, Calgary, Alberta

A meeting was held with Dr. Hugh Brown of Esso Resources Canada Ltd. on March 13, 1989 to review the possible application of the Esso tank to future spill control equipment evaluations. The tank was closely inspected along with its computer facilities, refrigeration units and trolley system (seen in operation during the testing in ice against a drilling platform). The main discussion points are outlined below.

Tank Availability

In about six months time, property on which the company's buildings are located will be sold and associated personnel will be moving to facilities at the University of Calgary. The tank and its adjoining land will be kept for future engineering studies; no indication was given that the basin will be duplicated at the new site. One or possibly two staff will remain at the present 50th Street location. Office, lab, shop and other support capabilities will obviously be reduced from current levels. The main machine shop will be relocated along with its machinist.

The Esso tank is primarily utilized for ice-related studies (naturally formed, supplemented by two refrigeration units) but also for other equipment investigations, including various spill technologies. It will be available when not required by Esso at a cost of about $1, 000.00 per day to cover personnel salaries (disbursements are extra). Pre-planning test programs will be necessary since it was indicated that application by outside users will be taken on a case-by-case basis.

Water Quality

Previous estimates by Esso cover the cost of installing filtration units (these costs were not available). There is no compelling reason to pursue either lower hydrocarbon concentrations in the water column prior to discharge or greater underwater visibility (there are no viewing ports and oily water is discharged to the municipal sewer system without any problems). Esso concluded that the high cost of a filter precluded its installation.

The current practice of pumping post-test water to sewer will likely continue since neither oil at up to 100 ppm nor salt at 30-60 ppt has been unacceptable to the municipal STP system. A substantial amount of dust enters the tank from adjacent roads (particularly in the spring). Water clarity in the tank cannot be guaranteed for optimum underwater viewing opportunities.

The Esso tank is limited with respect to an "OHMSETT" style test program in terms of its length (56 m versus 203 m), extended shallow-water section (30 m), low wave-height generation (30 cm), limited towing capacity (unidirectional trolley system that moves at 0.3 m/sec versus OHMSETT's 3 m/sec), inferior water quality, and minimal support facilities. (Note: the trolley speed could be increased at a moderate cost by changing the drive cog wheels).

Refurbishing of the tank floor and back wall in 1988 indicates Esso's intent to maintain the basin for ongoing work, although the moving of personnel might influence the extent to which the company participates in test programs which it does not directly support.

Test Program Potential

The Esso tank could be considered for test programs involving burning and small-scale stationary skimmer trials as well as boom experiments, dispersant work, and other specific tests involving devices or techniques appropriate for introduction into the tank. These would have to be planned well in advance, perhaps as a test series scheduled for a single period during the open-water window, April to October, or during the ice growing season (the tank is often booked during this period for Esso's internal arctic engineering programs).

It is not feasible to consider a carriage or alternative higher speed towing system in view of the limited tank dimensions (length, width and depth). The Esso tank will not accommodate large and/or advancing spill control systems. The creation of a channel in the tank on a temporary basis is being planned to accommodate limited tests requiring a relative current velocity.

Previous oil burning experiments were limited to 100 L oil per time, conducted during low-velocity west winds when the smoke plume impinges upon an adjacent industrial area.

6.2 Institute for Marine Dynamics Maneuvering Tank M-42

On March 14, 1989, Ms. Ruby Denison and Dr. Stefan Grochowalski discussed future prospects for the assessment of spill-response hardware and techniques with real and synthetic oil in IMD's outdoor tank (referred to as M-42). The use of the indoor tank M-22 for such work was reviewed at length but it was rejected because of potential water- quality problems. The following items summarize the findings from the Ottawa site visit.

Tank Limitations

The location, dimensions, and wave-generation capability of tank M-42 are suited to the evaluation of stationary and advancing spill-control hardware (given some physical means of towing). The lack of filtration, proximity of a vocal residential community and limited support facilities would preclude an evaluation program that (1) operated on a continuous basis, (2) included burning experiments, or (3) entailed extensive hardware modifications and analysis work.

Test Program Potential

The M-42 outdoor tank is most suitable for programs planned for one annual period and involving either fixed position trials and/or basic maneuvering tests. Any dynamic evaluations will have much less experimental control than the advancing tests conducted at OHMSETT. In the absence of a bridge, tests will have to be designed around either confined areas within the tank containing oil (a diminishing slick thickness/oil removal test) or the distribution and collection of slicks in direct conjunction with the test device (i.e., with the device serving as the working platform).

Possible modifications aimed at providing some form of moving bridge were reviewed in detail with IMD personnel and Mr. Ian Buist of S.L. Ross Environmental Research Limited. Ideas included winches, side deck and underwater rails, a floating bridge mounted on submerged pontoons (SWATH type hull), and some form of bottom-supported structure. No towing system was identified that could be considered to offer a practical economic solution. Simple electric motor and pulley or rail systems could be designed and utilized to a limited extent for towing containment barriers at low speeds.

Additional Factors and Concerns

The M-42 tank presents an immediate favourable impression: an isolated location well removed from the adjacent residential neighbourhood, restricted access, and layout permitting the entry and deployment of large devices.

IMD clearly indicated that the condition of the M-42 tank following tests is a concern. Tank cleaning is a priority and mandatory requirement. Management personnel are in doubt that the tank can always be returned to pre-test condition following tests with oil.

Support staff and facilities are now limited at IMD, Ottawa. Dr. Grochowalski is the only individual planning programs - without the benefit of woodworking and other shops that were previously active. Most of the hydrodynamic work undertaken by NRC now is carried out at its St. John's research institute. The focus of the Ottawa program will be shallow water towing tests in the M-22 tank. No testing with oil is permitted in M-22.

Salt water cannot be used in M-42 (it is not known whether the tank drains to sewer or to the Ottawa River). The outdoor tank will naturally degrade low concentrations of hydrocarbons remaining after tests; there should be little problem in emptying the tank on an annual basis. A filtering unit is unnecessary if only sporadic oil spill testing is planned. No effort is currently made to remove foreign materials which enter the tank from the surrounding area (e.g., leaves, dust).

The asphaltic tank bottom is protected to some extent by a fibreglass coating. This was not perceived to be a factor in any future decision regarding oil use. The use of synthetic circo oils might reduce the likelihood of oil staining and other similar changes (i.e., penetration of oil into concrete, wood, other materials); this aspect should be further studied.

Test programs undertaken at the IMD tank require insurance against property damage, security clearance, badge identification, and limited noise and odour generation. These are not significant constraints for most test programs (exceptions are programs involving extended use of diesel engines and/or burning).

The observation tower and enclosed building, with electrical power, adjacent to M-42 affords an excellent opportunity to observe and photograph equipment trials. Underwater video recording will be extremely limited. There are no viewing ports and water clarity is expected to be poor.

Dr. Grochowalski, only recently employed at the Ottawa research centre, is apprehensive about the testing of spill-control hardware with oil, because of (1) possible conflict with other test requirements and scheduling of the basin, and (2) the possibility of permanent damage to the tank through the introduction of oil.

The contractor toured the extensive facilities of the Division of Mechanical Engineering (DME) Hydraulics Laboratory in building M-32. These facilities house an impressive array of tanks and flumes actively used in the study of offshore oil-production platforms and other structures. There is considerable technical expertise at IMD and DME that could be applied to hydrodynamic investigations of devices - **without oil** (see separate evaluation of general hydrodynamic capabilities in Chapter 5.3).

6.3 National Water Research Institute Tanks

On March 15, 1989 discussions were arranged with Drs. John Lawrence and Michael Skafel at the Canada Centre for Inland Waters in Burlington, Ontario to review possible testing of oil-spill control technologies at the Environment Canada research centre. An extensive tour of all hydraulics facilities was conducted by Dr. Skafel inclusive of the main wind-wave flume and towing tank used for the calibration of instrumentation.

Overall Findings

Neither tank is suitable for testing equipment with oil. The primary considerations taken into account in reaching this conclusion are summarized as follows:

Towing Tank

The tank has never been drained since there is apprehension that the removal of water could alter the position of the carriage rails (the carriage is used to support current meters and other sensitive instrumentation set-ups during calibration). Even a slight change of elevation of the rails due to removal of the tank water is significant.

The overall tank size is limited. The tank itself is very narrow and there is very limited associated space adjacent to it. The latter aspect will impede assessments if attention to the test device were required at any other point than the accessible end of the tank. Post-test cleaning will also be difficult as will other general access requirements. Underwater viewing is restricted to only one end of the tank.

There is no filtering capability for the tank. Lighting is minimal along its length to avoid algae growth (the present lighting levels are insufficient for equipment trials). Chlorination is not used out of concern for corrosion of exposed electrical lines located along one side of the tank. Introduction of oil into the tank is not favoured.

The single carriage system is relatively small and could not accommodate oil distribution, collection, instrumentation, and personnel, in a manner similar to OHMSETT. Costing of a second or more substantial bridge was not reviewed in detail since other factors precluded consideration of the tank for oil testing.

Wind-Wave Flume

The overall dimensions of the wind-wave flume are very limited for oil spill testing. Water depth is limited to about 1 m.

There is no carriage in the tank although a small, temporary structure is currently being constructed for a specific test set. There is no reason to design and fabricate a carriage to tow devices through the tank other than for the purpose of positioning instrumentation (wind and waves move naturally through the tank).

There is no filtering unit. It is conceivable that cleaning of the tank could be achieved by draining the tank.

Salt water use could be considered. The introduction of synthetic oil into the flume was reviewed; however, the overall structure, lack of carriage, restricted dimensions, and current commitments preclude any comprehensive spill control assessment program.

Consideration might be given to use of the wind-wave flume for the study of smaller devices in currents, and wind and mechanically-induced waves. Professional staff knowledgeable of hydraulics as well as shop facilities, analysis labs and other support facets of the Burlington centre comprise an appealing package relevant to equipment testing - **without oil.**

7.0 CONCLUSIONS

A review of 9 major test tank centres across Canada reveals that there is no single facility in Canada that duplicates the capabilities of OHMSETT in all respects. The most technically advanced facility (IMD) in St. John's will not accept oil in any tank or basin. Of the two outdoor facilities previously used for oil spill work in Canada, one suffers from the lack of any moving bridge from which to conduct advancing tests comparable to previous OHMSETT work. The IMD M-42 basin and the Esso basin lack the necessary length for high speed advancing tests. Only one facility in Canada is willing to accept oil burning as a practical test option (Esso's tank).

Esso's basin with the recent addition of a travelling bridge, is the only Canadian facility capable of conducting large scale advancing tests, and/or combustion experiments with real oil.

The B.C. Research facility offers extensive support services and is ready to commit to a long-term oil-spill research program. Unfortunately, the lack of burning capability and prohibition of real oil limits testing to hydraulics/seakeeping performance evaluations and small scale advancing tests in synthetic oil.

Remaining facilities are either too small or suffer from major technical deficiencies (e.g., lack of suitable wavemaker).

The following specific conclusions were derived from the evaluations conducted in this study:

1. Individual facilities, particularly the Esso Resources Canada Limited basin in Calgary and the outdoor maneuvering tank M-42 in Ottawa operated by the Institute for Marine Dynamics, offer the capability of extensive stationary tests involving relatively large spill-control devices with real oil (booms and skimmers).

   The B.C. Research Maneuvering Basin in Vancouver offers potential for stationary tests with large devices, and advancing tests of small components with synthetic oil. B.C. Research was the only facility outside of IMD (Ottawa) and Esso which showed a strong desire to cooperate in future oil-spill test programs - to the extent of considering substantial structural modifications.

Any advancing tests proposed for facilities lacking a moving bridge will require different test methods from those utilized in the past at OHMSETT.

Specific test protocols are needed to accommodate the physical setup, tank hardware and general capabilities available at each location.

2. The extent of future availability of both the Esso and IMD tanks for oil spill research is uncertain. Both facilities now have limited support capabilities including a reduced number of on-site permanent staff and lack of extensive workshops. In addition, the IMD Ottawa facility is undergoing a management re-appraisal of its future use.

   The B.C. Research basin has the advantage of a committed management staff, extensive analytical support services, and minimal time commitments over the next few years.

3. Tests undertaken at the Esso and IMD tanks will evaluate equipment in a less comprehensive manner than was possible at the OHMSETT facility. In particular, the absence of a carriage system at the IMD M-42 basin prevents the replication of a dynamic test series based on a precise repeatability of inputs for critical parameters such as relative velocity and slick thickness. Stationary tests at either Canadian facility should be comparable to the previous OHMSETT work.

4. Extensive modifications to the Esso and IMD basins should only be considered with assurances of continued availability of physical support services (needed to support a long term program), and clarification of the present uncertainty surrounding future commitments for internal use of both the Esso and NRC facilities. The cost of tank modifications (e.g., towing systems, filtration) is not justifiable for short-term tests of specific devices.

In conclusion, there is considerable potential for pure hydrodynamic testing of booms and skimmers at a number of Canadian facilities as the initial phase of an overall equipment evaluation or development program. The concentration of facilities in St John's such as the Institute for Marine Dynamics and the Institute of Fisheries recirculating flume would make it possible to perform even more extensive hydrodynamic testing than was possible at OHMSETT. The smaller facilities such as B.C. Research should not be overlooked as they can provide valuable and inexpensive information in the form of scale model tests.

8.0 RECOMMENDATIONS

Future spill-control equipment evaluations conducted in Canada and the United States should consider a staged approach to equipment development and testing.

The contractor recommends that oil-spill control equipment be evaluated according to three distinct assessment phases.

8.1 Recommended Future Approach to Spill Equipment Design & Testing

The **first** phase will encompass technical, and scientific studies of devices based on hydrodynamic principles and involving the use of dyes or other oil substitutes to determine collection, containment, loss mechanisms, and other aspects of machine design.

In the past, hardware manufacturers have presented their equipment for evaluation to government and industry representatives often without the benefit of detailed engineering analysis. Basic principles related to device performance have remained unknown so that, for example, various wave configurations, high relative velocities, interference from debris, cold temperatures, high oil viscosity, and inappropriate rotational speed and direction of collection mechanisms have seriously impeded the efficiency of equipment under *real-life* conditions. The study of basic hydrodynamic principles will provide insights into equipment design and development prior to undertaking costly prototype construction and testing with real oil. (Phases 2 and 3 below)

The **second** test phase will include the use of oil to measure oil removal, containment, detection, and other efficiency factors in a controlled tank or basin environment.

The **third** phase will encompass field trials of devices in realistic operating conditions. Oil releases will not necessarily be involved depending on the overall objectives (e.g. seakeeping). Among the factors to include are the type and utility of support vessels, safety, deployment, retrieval, operation, and maintenance.

8.2 Canadian Capabilities With Respect to the Proposed Approach

The **first phase** of testing outlined in 7.1 (above) will make full use of the excellent hydraulic/hydrodynamic test facilities in Canada . In particular, facilities operated by the Institute for Marine Dynamics, the Newfoundland & Labrador Institute of Fisheries and Marine Technology, the B.C. Research Ocean Engineering Centre, and the DME-NRC Hydraulics Laboratory provide world-class towing, maneuvering, and ice tanks and flumes that can be applied to fundamental engineering design of new devices and refinement of existing hardware.

Facilities exist in Canada to accomplish a significant number of the proposed **second phase** of equipment development and testing. For example, the Esso tank or NRC basin in Ottawa are both capable of carrying out a range of stationary tests with large devices and real oil in both ice and open water. Burning experiments are possible at the Calgary facility. The availability of Canadian facilities for specific tests will complement the proposed re-opening of the OHMSETT facility early in 1990.

Canada can contribute greatly to the **third phase** effort through extensive past experience in managing and implementing large-scale offshore field programs. (e.g., BIOS, 1987 Newfoundland boom trials, 1974 to 1981 Beaufort Sea oil spills).

8.3 Future Use of OHMSETT

Phase II testing of oil-spill clean-up technology should continue in a refurbished OHMSETT facility. Any new tank tests undertaken in the U.S. or Canada should reflect the new realities of spill clean-up priorities stemming from the Valdez catastrophe.

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Appendix A

OHMSETT Specifications

OHMSETT FEATURES

Technical criteria pertaining to OHMSETT are set out in the Introduction in E.P.A.'s January 1981 report by G.F. Smith and H.W. Lichte "Summary of U.S. Environmental Protection Agency's OHMSETT Testing, 1974-1979 and in E.P.A.'s undated report by R.A. Griffiths entitled "OHMSETT Capability". The data have been consolidated and reorganized into seven sections in this Appendix to form the basis for the selection of a Canadian facility:

*Overall Specifications
*Bridge Systems
*Wave Generating Capability
*Water Quality and Test Fluids
*Fabrication, Preparation and Test Set-up
*Recording Capability
*Analytical Capability
*Ancillary Needs

Overall Specifications

Construction: - concrete blocks, plexiglass viewing ports

Water: - brackish water from Sandy Hook Bay or fresh water

Dimensions:

- 203 m long x 20 m wide x 2.4 m deep

- distance between the main and auxilliary bridge is 20 m

- maximum size of skimmer tested at OHMSETT:

*length 17.7 m
*beam 4.3 m
*draft 1.6 m
*displacement 39 tonnes

- deck space for hardware deployment setup: 3 m each side accommodates vehicles etc..

Safety: - facility incorporated safety in its setup and design: guard rails, non-slip surfaces, warning lights and siren

Personnel: - 21 full-time & part-time staff, contractors as required

Purpose: - test off-the-shelf and equipment under development

- test systems designed for open water and ice infestations

Test Duration: - most programs required 10-14 days tank work

Bridge Systems

One permanent and three removable bridges ran on a pair of rails - cable driven by two 373 kW DC variable speed motors.

The bridges were analyzed for the following vertical structural load limits:

* main bridge
- supports 1.2 tonnes/m^2 static load
- tows test devices, houses instrumentation, gear and personnel

* auxiliary bridge
- 180 kg concentrated load limit (+ 72 kg/m)
- trails main bridge to hold skimmer stem and/or storage for recovered fluid; tows back to start

* video bridge (22.2 m)
(spanned, perpendicular to main, auxiliary bridges; normally allows for 19.2 m separation)
- 900 kg concentrated load limit

* vacuum bridge
(normally used to clean tank bottom; also attached to cable drive for use in testing; is self-propelled to 4 kts: can also be used for oil distribution ahead of main bridge)
- 4.3 tonnes concentrated load limit (+ 4.1 kg/m)

Purposes of Bridges:

- tow test devices
- support video, other observation equipment
- house instrumentation, personnel
- distribute, collect test fluids
- clean tank
- rearrange to allow various test configurations
- accommodate waves

Flexible connections for towing consisted of large ropes

Maximum towing speed was 6.5 kts with drag force to 151 KN

Deceleration: - 6.5 - 0 knots in 9.1 m (not including emergencies)

Acceleration: - usually 0-6.5 knots in 15.2 m in 8 seconds

Test Duration: -300 sec @ 1 kt to 46 sec @ 6.5 knots (data collected for half this time during steady state conditions)

Oil Retention: - booms follow skimmers after tests to retain oil

Wave Generating Capability

Wave Generator

Drive: variable speed hydrostatic unit - two variable speed DC motors, hydraulic pump, hydraulic motor, reduction gear and flywheel with adjustable eccentric (Scotch yoke).

Wave Makers: two rectangular flat flaps pivot at tank bottom on shafts and linkages coupled to the electrohydraulic drive system.

Controls: manual adjustment for wave height, frequency variation possible during operation with potentiometer.

Beach sections reduced regular wave pattern reflections.

* Wave generation hardware consistent with OHMSETT includes wave absorption (reflector preventor); regular waves with periods 1-6 seconds, lengths to 45 m and significant heights to 0.45 m; also confused sea, harbour chop capability

Regular Wave Pattern: wave flaps aligned with each other and beach used to dampen waves (20-50% reflection coefficient)

Period:	1 to 6 seconds
Lengths:	to 45 m
Significant heights:	to 0.45 m

Harbour Chop: wave reflection produces confused sea to .54 m high

Wave Height Measurements: acoustic transponder probe, recorded on magnetic tape and statistically analyzed. Selection of wave conditions made from predetermined data.

Time: 15 minutes required for steady-state waves, up to 30 minutes for wave dampening.

Water Quality and Test Fluids

Water Filter System:

A continuously circulating process was designed to achieve particulate removal down to 5 μ and water clarity for photo/video requirements using pressure-leaf filter & tank, 450 m^3/h pump, diatomaceous earth filter-aid handling system (provides coating of various pore sizes for filter), electrolytic chlorinator (controls biological activity), waste diatomaceous earth and tank particulate handling equipment. Oil content was reduced to <1 ppm prior to annual discharge.

Test Fluid Concerns:

- real oils versus circo oils
- use of chemicals as the test media
- space requirements (bridges, storage, proximity to other buildings)
- reprocessing (clients pay for reprocessing, makeup of oil)
- flammability

Note: OHMSETT stored 416 m^3 total test fluids (generally only 76 m^3 of any one fluid because of variety used).

Test fluids were also reprocessed for re-use to remove particulates and water. This involved various combinations of settling, heating, filtering, and vacuum distillation. The capability depended on oil type, ambient temperature and quantity/day used. <u>No test fluid was used that couldn't be effectively removed from the tank.</u>

Settling: - by gravity, overnight in tank

Filter/Coalescer: - liquid/liquid/solids for filtering & separating emulsified fluid into lighter components & water returned to tank; optional step depending on fluid properties.

Heating: - electrical coil heaters; water flashed off as vapour encourages separation of emulsions

Vacuum Distillation: - fluid filtered and fed to continuous cycle thin film heater and v vacuum unit; max reclamation rate = 1.13 m^3/h

Note: for estimation purposes, 0.75 m^3/h of No.2 fuel oil or 0.57 m^3/h heavier lube oil can be processed to <0.2% water content

Three Distribution Systems for Test Oils:

(1) weir/splash plate presents 4.6 m wide slick
(2) 20 spray nozzles in row give max 18 m (tank) wide slick
(3) overflow weir produces up to 9.1 m wide slick

All systems have capacity to deliver up to 230 m^3/h light oil (@ 160°C), powered by up to four pumps on main bridge, supplied by four 2.3 m^3 oil storage tanks. Flow meters were available for total flow volume and rate.

Fabrication, Preparation and Test Set-up

Materials, Tools:

- carbon and stainless steel
- fibreglass
- metal saws
- aluminum welders
- oxy-acetylene welder
- drill press
- 12 mm lathe
- 45 tonne press
- assorted wood-working equipment

Transportation, Lifting:

- two semi-tractors
- several flatbed trailers
- nine 19 m^3 tank trailers
- two 2.7 tonne forklifts
- two 18 tonne cranes (Naval Base equip)
- US Navy Cranes to 63 tonnes
- Contractor Cranes to 181 tonnes
- OHMSETT cranes 6.5 tonnes

Equipment >2.3 tonnes required engineering advice for setup.

Recording Capability

Video Cameras:

- eight video cameras (colour & black and white) above and below (to 2.1 m) water
- remote positioning & function controls
- four tape decks
- 12 monitors
- special effects generator (camera switcher, split screen, graphic aids)
- tape duplication
- multiplex video tape/16 mm film

Modes of Operation:

- high speed
- time lapse
- aerial
- underwater
- underwater through viewing ports
- fixed plane

Modes of Operation:

- micro
- macro
- large format
- remote triggering

Analytical Capability

Purpose:

(1) determination of physical properties of test fluids

(2) analysis of recovered fluids for oil content (RE)

(3) analysis of test tank water

Analyses: Test Fluids

- surface tension
- interfacial tension vs tank water
- specific gravity
- bottom solids
- viscosity vs temperature

Tank Water:

- pH
- salinity
- conductivity
- temperature
- suspended solids

Instrumentation:

Beckmann IR-33 centrifuge	oil in water /water in oil
DuNuoy Ring	oil surface tension Oil/Water interfacial tension
Brookfield LU & Saybolt hydrometer	viscosity specific gravity
Varian 1400 w/FID GC	HC composition
YSI-SCT meter	salinity, conductivity & temperature
Fisher 120 pH meter	

Ancillary Needs

*Firefighting Capability

*Outside Fabrication Needs

*Medical Assistance (First Aid, Hospital, Emergency)

*Transportation & Shipping

*Supplemental Lifting Hardware

Appendix B

Summary of Facility Descriptions and Selected Material Received from Canadian Facilities

DICKINS

Engineering & Environmental Research

D F Dickins Associates Ltd.
Suite 503A-21 Water Street
Vancouver, British Columbia
Canada V6B 1A1

Phone (604) 684-0516
FAX (604) 684-2357
Telex 04-54247 Telefax VCR

File 488-9

December 30, 1988

Mr. Gerry Stensgaard
B.C. Research
3650 Wesbrook Mall
Vancouver, B.C.
V6S 2L2

Dear Mr. Stensgaard:

We are considering your facility as a candidate for the tank testing of oil and chemical spill control equipment. This letter is a request for technical information describing your tank(s) and associated systems in order to assess the viability of performing the tests similar to those listed below.

Dickins Associates is under contract to Environment Canada to identify suitable Canadian testing facilities with the necessary resources to continue a program of oil & chemical spill equipment testing initiated in the United States. That program is now terminated with the closure of a facility known as OHMSETT located in New Jersey. Environment Canada and the United States Minerals Management Service wish to continue the OHMSETT program in Canada if an acceptable facility is found.

These agencies require that the selected facility be capable of conducting all or part of the following general types of tests:

Oil Boom Evaluations
Oil Sorbent Evaluations
Oil Treating Agents
Oil Combustion Experiments
Oil Recovery Skimmer Tests
Oil Slick Detection Devices
General Oil Behaviour Studies

The previous U.S. test program used so called "circo" oils as a substitute for real oil. These substitutes provide for ease of cleaning after an experiment and repeatability through controlled physical characteristics.

Example of the inquiry letter sent to the facilities.

Description of Canadian Tank and Basin Facilities

Facility	Water					
	Clarity	Viewing Windows	Temp. Range	Salt Water Possible	Ice Production	Filtering Capability
B.C. (Towing) Research	3 weeks of filtering for	Yes	Ambient	Yes	No	No oil filter. Basic pool filters.
B.C. (Man.) Research	clarity	No	Ambient to 20 °C	Yes	No	
Fleet Tech (Mod-ice)	Cleared for photography.	No	Ambient	Could be varied.	Yes (synthetic ice)	Subcontracted to specialized companies.
Fleet Tech (Ice)	Cleared for photography.	Yes	20 to -25 °C	Could be varied.	Yes	Basic pool filter in use
Esso (Man.)	No specs.	No	Ambient	30-60 ppt added in the past	2 refrigeration units plus ambient.	Tanks emptied into domestic and storm sewer
IMD (Ice) St. John's	Cleared for photography.	No specs.	-30 to 15 °C	Yes	Yes	No filter Cannot readily drain tanks.
IMD (Towing) St. John's	Cleared for photography.	No specs.	Ambient	No	No	
IMD St. John's (Man.)	Cleared for photography.	No specs.	Ambient	No	No	Filtering system
IMD Ottawa (Man. M-42)	Cleared for photography.	No	Ambient	No	Yes (Ambient)	None
IMD (Towing) Ottawa	Cleared for photography.	Yes	No data	No specs.	No	None
National Water Inst.	Cleared for photography.	Yes	Ambient	No	No	2 separate systems: 1 for clean water 1 for sediment/water No oil extraction
National Water Inst.	Cleared for photography.	No specs.	Ambient	Possible	No	
Institute of Fisheries	Cleared for photography	Yes (22.5x3 m)	Ambient	No	No	Basic filter Additives use
Memorial University	Cleared for photography.	Yes	Ambient	No	No	Simple filtration system.
DME-NRC (Coastal)	None	No	Ambient	No	No	No filter
DME-NRC (Multidir.)	Cleared for photography.	No	Ambient	No	No	4 ft. dia. sand filter with chlorinator.
DME-NRC (Ice Basin)	Cleared for photography.	No	-20 to 15° C	No	Yes	No filter.

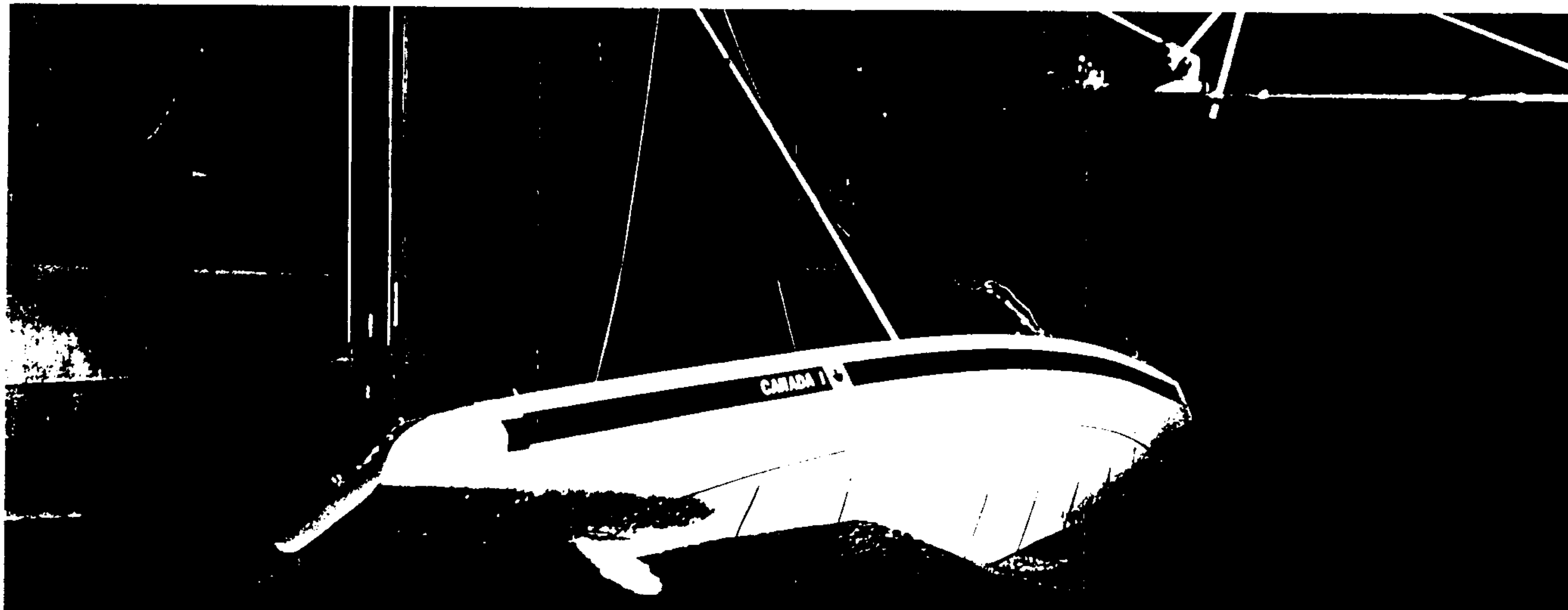
Description of Canadian Tank and Basin Facilities

Facility	Test Fluids				Support		
	Combustion tests?	Real oil use?	Synthetic oil use?	Solvents use?	Shop and Maintenance	Personnel	Cranes available?
B.C. (Towing) Research	No	No	Yes	No	Machine and woodwork shops	Technical staff	Chain hoist
B.C. (Man.) Research	No	No	Yes	Possible			
Fleet Tech (Mod-ice)	No	Yes	Yes	Possible	Repair and fabrication shops.	Technical staff of 25	Use contractors to lift equipment.
Fleet Tech (Ice)	No	Yes	Yes	Possible			
Esso (Man.)	Yes	Yes	Yes	Yes	Well-equipped workshops	120 technical staff	1.8 tonne boom with radius 30 m and 15 m tower
IMD (Ice) St. John's	No	No	No	No	Machine and woodwork shops N/C Milling available	43 professional staff combined with Memorial University staff.	Yes
IMD (Towing) St. John's	No	No	No	No			
IMD St. John's (Man.)	No	No	No	No			
IMD Ottawa (Man. M-42)	No	Yes	Yes	No specs.	Machine and woodwork shops	Limited	11 m high observation tower. 0.9 tonne jib crane.
IMD (Towing) Ottawa	No	No	No	No			
National Water Inst.	No	No	Possible	No	Machine and woodwork shops	20 Professional staff	Overhead hoist 1 tonne
National Water Inst.	No	No	No	No specs.			
Institute of Fisheries	No	No	No	No	Machine and woodwork shops	100 support staff	Overhead 4.3 tonne
Memorial University	No	No	Possible	No specs.	Machine and woodwork shops	Combine staff with IMD	Yes
DME-NRC (Coastal)	No	No	No	No	Machine and woodwork shops	Lab research staff of 32.	1 tonne gantry (travelling)
DME-NRC (Multidir.)	No	No	No	No	Machine and woodwork shops	Lab research staff of 32.	1 tonne overhead monorail.
DME-NRC (Ice Basin)	No	No	No	No	Machine and woodwork shops	Lab research staff of 32.	2 tonne gib

Description of Canadian Tank and Basin Facilities

Facility	Data Collection				Availability
	Cameras	Computers	Wave height measuring devices	Chemical Analysis	
B.C. (Towing) Research B.C. (Man.) Research	16 mm and annotated video	VAX 11/780	No specialized equipment	Full range of services.	Towing tank for hydrodynamic use only. Man. basin available for extended periods.
Fleet Tech (Mod-ice) Fleet Tech (Ice)	Underwater carriage and equipment available.	Yes	No specialized equipment	None	Available on contract.
Esso (Man.)	Colour videos 35 mm Underwater camera	Personal computers	Use capacitance wave probes	Have some equipment	Available with adequate lead-time.
IMD (Ice) St. John's IMD (Towing) St. John's IMD St. John's (Man.)	All types Underwater carriage	Mini-computers VAX systems	Capacitance wave probes.	Use equipment at Memorial University	Limited.
IMD Ottawa (Man. M-42) IMD (Towing) Ottawa	New data aquisition system installed to indoor tank.		No specs.	Share with NRC	M-42 available with advance planning. Towing tank not available.
National Water Inst.	No specs.	Personal computers available	Stream guaging and wave measuring available.	No specs.	Both tanks have limited availability.
Institute of Fisheries	0.75 inch video (3 chip) Underwater	Yes	N/A	No specs.	Available for specific projects.
Memorial University	No specs.	Personal computers attached to carriage	Use capacitance wave probes	Use university equipment.	Available for extended time periods.
DME-NRC (Coastal) DME-NRC (Multidir.) DME-NRC (Ice Basin)	16 mm, video, and underwater video.	20 microVAX II, PC, HP1000F	NIC data aquisition hardware, capacitance wave probes, wind anemometers, and accelerometers.	Full range of services.	Available for limited periods for specific projects.

British Columbia Research Corporation



FACILITIES

Towing Tank

This tank is used primarily for ship model studies including resistance tests, self-propulsion tests, flow visualization, wake surveys and seakeeping experiments.

Shallow Water Tank

Ship performance in restricted channels may be studied in this tank. The facility also has many other applications, notably in coastal and hydraulic engineering.

Towing Carriage

The maximum speed of the carriage is 4.5m/s (14.75 ft/sec) allowing, for example, 1:12 scale models to be tested at the scale equivalent of 30 knots.

Wave-Maker

A hydraulically-operated, computer-controlled wave-maker is installed in the towing tank. Waves up to 25cm in height can be generated in either regular (sinusoidal) or irregular profile.

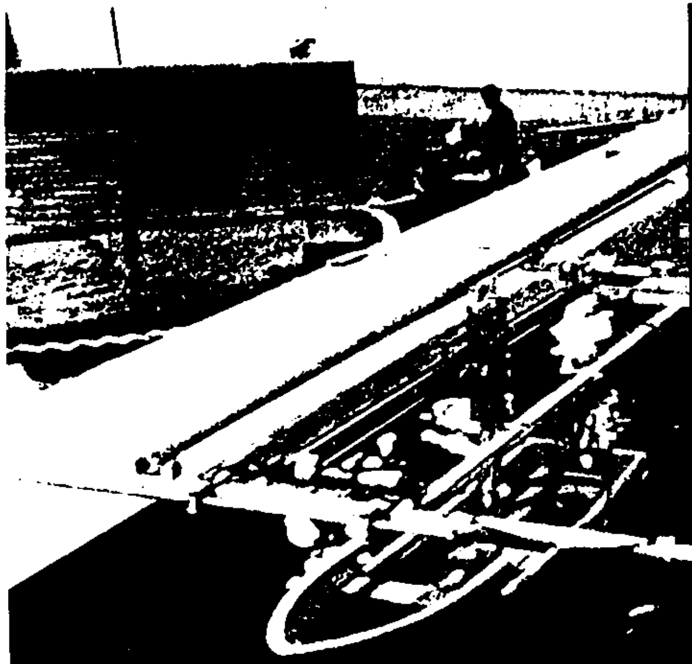
Wave Basin

The wave basin is used primarily for coastal and hydraulic studies and may be used for tests of radio-controlled models. A removable rotating arm is used for high-speed model tests.

RESOURCES

A range of instrumentation is available for measuring forces, motions, accelerations, wakes, etc. Underwater observation windows in the towing tank facilitate flow visualization experiments which have proven to be of great assistance in interpreting hydrodynamic phenomena. An in-house photographic section offers complete service including colour video and high-speed film recording.

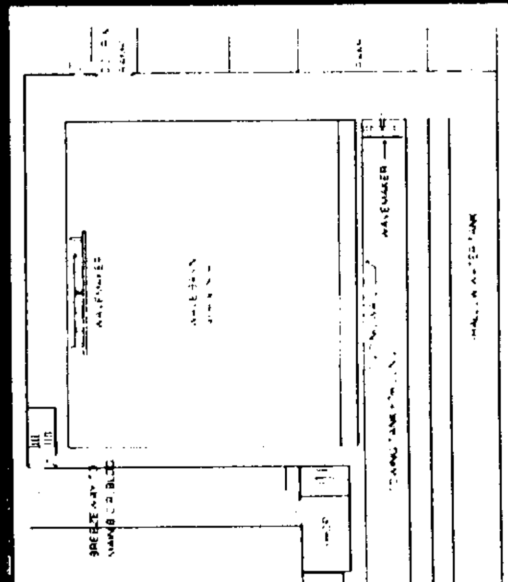
Work is carried out by experienced researchers who are committed to client satisfaction.



The Ocean Engineering Centre is ideal for cost-effective research and development studies on small to medium size vessels of all types.

Opened in 1978, the Centre is the only major North American ship model basin west of Michigan and north of San Francisco. The O.E.C. is operated under an Agreement between B.C. Research, the University of British Columbia and National Research Council Canada. Work conducted at the Centre ranges from fundamental hydrodynamic research through to extensive R&D programs on specific vehicles. Model studies of civil engineering works such as harbours, breakwaters, spillways, etc., are also undertaken.

Client-sponsored model tests have been executed on a wide variety of craft such as tugs, barges, planing hulls, sailboats, offshore supply boats, hydrofoils, ferries, surface effect ships, submarines and catamarans.



PRINCIPAL SPECIFICATIONS

Towing Tank
- Length 67m (220 ft)
- Width 3.7m (12 ft)
- Depth 2.4m (8 ft)

Maximum carriage speed
- 4.5 meters sec

Wavemaker
- Hydraulically controlled flat type
- Max. wave height 0.25m

Wave Tank
- Length 30m (100 ft)
- Width 26m (88 ft)
- Depth 2.4m (8 ft)

Shallow Water Tank
- Length 67m (220 ft)
- Width 4.0m (13 ft)
- Depth .75m (2.5 ft)

The Ocean Engineering Centre facilities

BC RESEARCH
BRITISH COLUMBIA RESEARCH CORPORATION

For further information contact:

Ocean Engineering Centre
British Columbia Research Corporation
3650 Wesbrook Mall
Vancouver, B.C. Canada V6S 2L2
Fax: (604) 224-0540
Phone: (604) 224-4331

OCEAN ENGINEERING CENTRE

Operated jointly by:
British Columbia Research Corpora[tion]
University of British Columbia
National Research Council Canada

BC RESEARCH
BRITISH COLUMBIA RESEARCH CORPORATION

Fleet Technology Limited

LIST OF FLEET TECHNOLOGY FACILITIES
USED FOR TESTING OF OIL SPILL RECOVERY DEVICES

	FACILITY OPERATOR	CITY	FACILITY CHARACTERISTICS: BASIN DIMENSIONS LENGTH (m)	WIDTH (m)	DEPTH (m)	TEMP. CONTROL (C)	MAIN FEATURES AND CAPABILITIES: UNDERWATER PHOTOGRAPHY WINDOW	CARRIAGE	WAVE GENERATION CAPABILITY	FACILITY FITTED WITH CARRIAGE(S)	ABLE TO PRODUCE TRUE CURRENTS	OIL PREVIOUSLY SPILLED?
SUBJECT TANK	OHMSET TANK	LEONARDO	203.0	20.0	2.4	N/A	YES	YES	YES	YES(4)	NO	YES
UNCOVERED OUTDOOR TANKS	FLEET TECHNOLOGY(1)	KANATA	30.0	20.0	0.5	N/A	NO	NO	AVAILABLE	NO	NO	YES
INDOOR TANKS (AT ROOM TEMPERATURE)	FLEET TECHNOLOGY(2)	CALGARY	30.5	7.3	1.4	AMBIENT	NO	YES	AVAILABLE	YES(2)	NO	YES
TEMPERATURE CONTROLLED TANKS	FLEET TECHNOLOGY(3)	KANATA	15.6	4.9	1.5	20 TO -18	YES	YES	AVAILABLE	YES(1)	NO	YES

NOTE

CONSTRUCTION MATERIALS: CONCRETE FOR 2&3 AND SILTY CLAY FOR THE OUTDOOR TANK.
DECK SPACE: SEE ATTACHED FIGURES
TOWING CARRIAGES: SPEED IS VARIABLE DEPENDING ON REDUCER USED(0.001 TO 1.25 m/sec). THE MOTORS ARE ABOUT 10HP EACH.
TOWING CARRIAGES ARE DESIGNED FOR 2.5 TONS VERTICAL LOADING.
OBSERVATION TOWER: OBSERVATION WINDOWS ARE AVAILABLE FROM THE CONTROL ROOMS FOR TANK 2 AND 3.
SALINITY: COULD BE VARIED DEPEND ON TEST REQUIREMENT.
LIFTING CAPACITY: USE OF CONTRACTORS TO LIFT EQUIPMENT. NO PRACTICAL LIMITATIONS OTHER THAN BASIN DOOR LIMITATIONS.
MAXIMUM DEVICE TESTED: 4m x 6m x 1m DEEP. THE SIZE LIMITATION DEPEND ON THE TYPE OF THE TEST.
OIL CLEANING AND FLUID PROCESSING: IT IS USUALLY SUBCONTRACTED TO SPECIALIZED COMPANIES FOR BEST RESULTS.
STORAGE: LARGE STORAGE AREA IS AVAILABLE.

TEST DOCUMENTATION CITED ARE ALL AVAILABLE FOR THE TESTS AND MUCH MORE.
SUPPORT: FLEET TECHNOLOGY IS EQUIPPED WITH A SHOP REPAIR AND FABRICATION IN KANATA AND CALGARY.
DATA PROCESSING: COMPUTERS FOR DATA PROCESSING AND A TECHNICAL AND ENGINEERING STAFF OF MORE THAN 25 FAMILIAR WITH THEIR USE.

(See also attached information on Fleet Technology's Cold Room)

Facilities and Capabilities

Cold Room

Length ....7.75 m
Width ....7.75 m
Height ....3.70 m

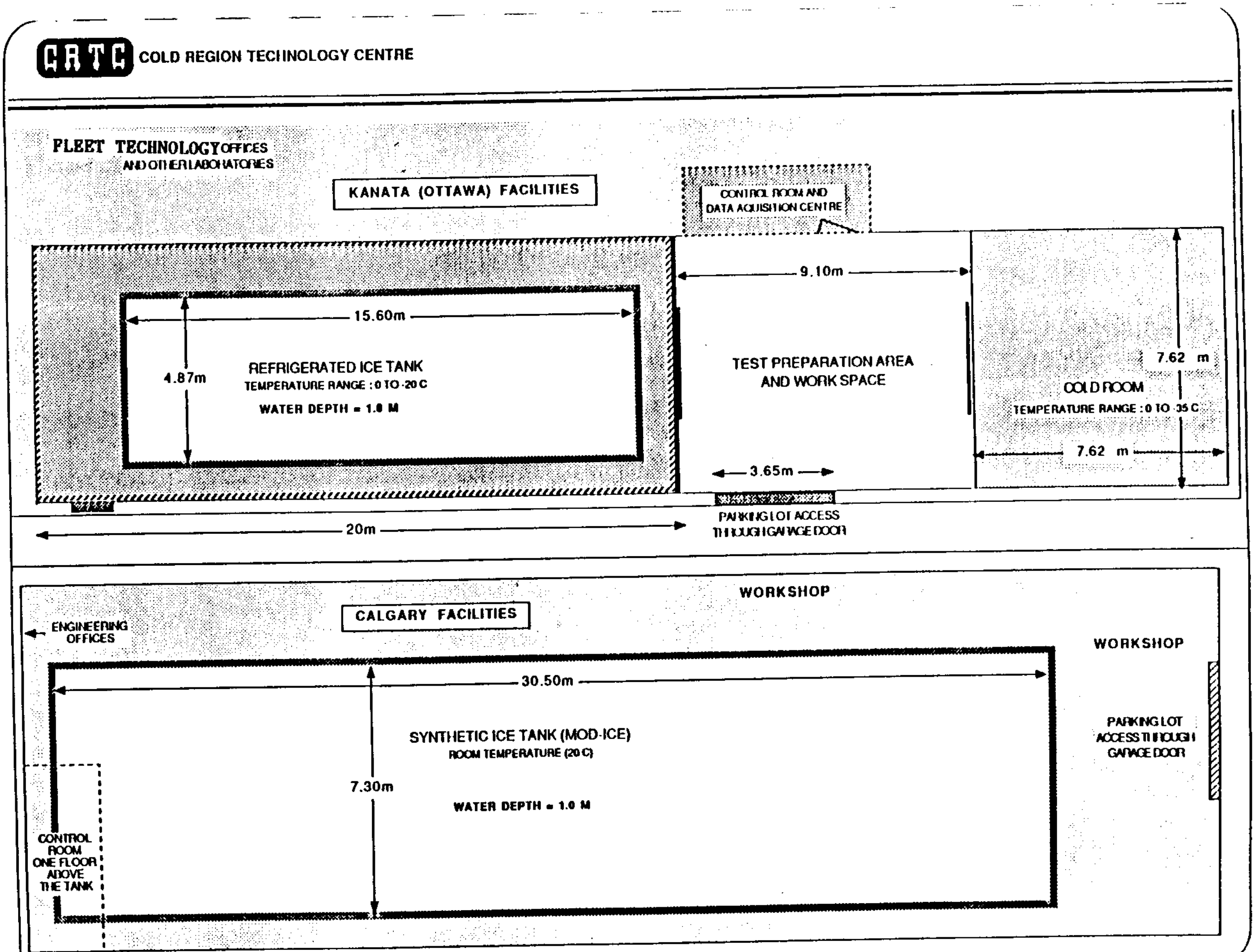
Min. Temp. -35°C

Equipment:

Closed Loop Press (1MN)
Ice/Concrete Abrasion Machine
Ice Tribometer *(Friction Apparatus)*
Ice Cutting and Machining
Ice Crystallography Analysis
Two Ton Crane
Photography and Video
Ice Growing Tank 1.8m x 4 m

Towing Tanks

	Refrigerated Ice Tank	Mod-Ice Model Basin
Basin		
Length	16.5 m	30.5 m
Width	4.9 m	7.3 m
Depth	1.8 m	1.1 m
Towing Carriage		
Drive System	3 hp	10 hp
Maximum Load	0.3 tons	1 ton
Speed Range	.01 to 1.5 m/sec	.01 to 1.0 m/sec
Wavemaker	Plunger Type	Plunger Type
Ice Preparation		
Method	Refrigeration	Synthetic Ice
Capability	3 mm/hour	6 m^3/day
Temperature		
During Preparation	-25°C	Ambient
During Testing	+20 to -25°C	Ambient



A DIVISION OF FLEET TECHNOLOGY LIMITED

Esso Resources Canada Limited

ESSO RESOURCES CANADA LIMITED
Research Department

R H G MILLAR
Manager

339 - 50th AVENUE S.E.
CALGARY, ALBERTA T2G 2B3
(403) 259-0671
PANAFAX (403) 259-0649

January 17, 1989

D.F. Dickens Associates Ltd.
Suite 503A
21 Water Street
Vancouver V6B 1A1

Dear Mr Dickens,

In response to your request of December 30 for details of our wave basin facility, I will try to outline below as much information as is readily available. As I mentioned to you this morning by telephone, I will also send off some 35mm slides which show various aspects of the facility, but these will be delayed for a short time while copies are made. As you are aware we have done similar experiments to many of those which have been carried out in the OHMSETT basin and in some respects the two facilities have similar capabilities. It is unfortunate that the U.S. agencies have chosen to close OHMSETT but there is the possibility that some of the work previously handled there can be done here in Calgary.

ESSO RESEARCH WAVE BASIN

Physical Layout

The wave basin is an outdoor concrete pool originally built for ice studies but now also fitted with wave making equipment. It is situated in a light industrial area of southeast Calgary adjacent to the Esso Resources laboratory on about 1 hectare of land. The pool is 56m long by 30m wide and has a variable depth as shown on the accompanying diagram. The pool end behind the wave boards is 30cm lower than the other sides and has a sloping backside leading down to a asphalted catchment basin. This is intended to hold broken ice pushed over the back wall during ice sheet experiments.

Basin water capacity is $2000m^3$ and this is supplied from the city mains through a metering station. The basin is normally emptied via a pumped sump into the domestic sewer system although if necessary it can be emptied into the storm sewer system. We inform the city sanitation department when the basin is to be dumped and take samples for them. This has not posed any problem in the past and they have routinely accepted 30ppt salt (NaCl) water with 100ppm of dispersed oil for treatment in the sewage plant. Filling or emptying the basin usually takes about 30 hours per task. There is no provision for filtering and recirculating the water. The basin has been used with an NaCl concentration of up to 60ppt (double ocean salinity).

A Heede Model 100 Tower crane is permanently mounted at the southwest corner of the basin. This has a capacity of 2 tons and a boom radius of 30m. It currently has a 15m tower and provides an excellent camera platform for viewing basin activity from directly overhead.

Adjacent to the pool are three small buildings housing respectively the water pumps and metering equipment, a small shop and tool shed, and the control equipment and data gathering devices. As the basin is part of a large research laboratory and is used by a variety of groups, the data gathering and measurement equipment will change depending on the nature of the experimental program. Most groups set up their own equipment in the control building then remove it when their tests are completed.

Field Simulation

The wave generator consists of four independently actuated wave boards spanning the west end of the basin and supported on stands bolted to the floor. These are removable for winter ice studies. The boards are driven by an hydraulic pump rated at 6000psi at a flowrate of 225l/minute. The pump is electrically driven. The whole system is controlled by a computer which can be programmed for any of the usual wave spectra (JONSWAP, Pierson-Moskowitz, etc.) or for regular waves. Waves of > 40cm height can be generated but these begin to break in the shallow end of the pool and wave heights are usually kept to 30cm or below. Capacitance wave probes are used to gather data for frequency analysis by the wave generator computer. Wave energy is dissipated at the east end of the pool on a corrugated metal beach with a 1 in 10 slope. This is removable for winter ice studies.

The hydraulic supply which powers the wave boards is also used to power two trolleys which are mounted on tracks along the top of the basin sidewalls. These are controlled by another computer and can be run separately or in unison at speeds from 0.01m/sec to 0.3m/sec. The trolleys are intended to be used in pulling ice sheets against structures in the deep end of the basin and have a capacity of 60 tons force (530,000 Newtons) each. They have an effective track length of about 40m. To aid in ice sheet formation, there are two refrigeration units which circulate glycol through cooling mats placed on the ice surface. These have a startup capacity of 200,000 BTU/hour each and a running capacity of 115,000 BTU/hour each at -15°C.

Data Acquisition

Esso's Calgary research staff currently numbers about 120 people in a variety of disciplines and research fields. Consequently, there is a wide variety of measurement devices and data handling equipment on site. During those experiments involving oil spills, for example, we have typically used fluorometers, thermocouple arrays, load cells, met instruments, etc. and interfaced these via digitizers directly to personal computers. We usually keep a visual record of our experiments with colour videos and remotely triggered 35mm cameras. We have an underwater video camera and monitor but the pool has no underwater viewing port.

The laboratory has a well equipped workshop and two machinists on staff although contractors are normally used for large scale fabrication.

Recent Studies

Some studies which the environmental group has carried out illustrate the scope of work which has been done in the wave basin. Civil engineering groups also use the facilities extensively.

Dispersant Effectiveness:

During the recent past we have conducted over 40 oil spills in the basin to measure dispersant properties. These have usually involved dumping 75 litres of an oil into a boomed area and then spraying the slick with a dispersant chemical. Oil in the water beneath the slick was measured with fluorometers and surface phenomena were recorded on video. A review of this work was given at the 1988 AMOP Seminar (Brown and Goodman (1988)).

Skimmer Tests:

We have just completed a series of tests of skimmers in conjunction with Alaska Clean Seas and the PROSCARAC committee of the Canadian Petroleum Association. These involved determining the effect on skimmer pickup rate of adding Elastol (an elasticity modifier) to various oils. The Oilwoolf heavy oil skimmer was tried with Cold Lake oil when the viscosity was > 10^6 cSt.

Net Tests:

This year fish netting was tested as a containment device for viscous crude oil such as Cold Lake oil. Leak rates were determined as a function of towing speed for various mesh sizes. This work will be reported at the 1989 Oil Spill Conference.

Oil Burning:

About two years ago experiments were carried out to determine if burning was a viable disposal technique for oil trapped in ice leads (Brown and Goodman(1986)). Artificial leads were cut in the basin ice sheet and about 40 burns conducted in various wind conditions. Permission for this work had to be obtained from the Air Quality branch of

Alberta Environment and from the Calgary Fire Department. Primary concerns were the extent and duration of smoke from the experiments but we were allowed to proceed if only crude oil was burnt. The location of the lab. in a light industrial area well away from residences was also a consideration.

Oil Emulsions:

A test has been scheduled on behalf of the Cook Inlet Response Organization to study the rate of emulsion formation in weathered Alaskan crude. This will involve using the wave basin to mimic sea conditions to determine the effect of dispersants on emulsion formation. Oil will be spilled into containment booms and weathered with wave action.

Generally, we have been able to carry out tests in which a substantial amount of oil must be spilled and then measured in some fashion. Cleanup is always a time consuming job but we maintain a small skimmer for that purpose and various absorbents. Recovered oil is sent to a used oil refiner. Vapours and smells from the experiments have not caused problems with neighboring businesses to date.

Copies of a few papers reporting studies conducted in the basin have been included. Some of the work is in internal reports which are not available, however.

Wave Basin Pictures

We have included a few 35mm slides of the facilities taken during various experiments and these are described below.

1.Filling the basin with water and salt prior to a dispersant test.

2.Overhead view of dispersant experiment from temporary tower. Rotating boom is the dispersant spraying apparatus.

3.Typical instrumentation at basin edge. Often such equipment is placed in the basin control building.

4.Wave boards at west end of pool.

5.A series of small containment booms in use during skimmer tests.

6.A rope mop skimmer under test at basin edge.

7.A fish net under tow during tests with Cold Lake heavy oil.

8.A burning test in an artificial lead in the basin ice sheet.

9.Test conditions during cold water tests of the Vikoma Oilwoolf skimmer.

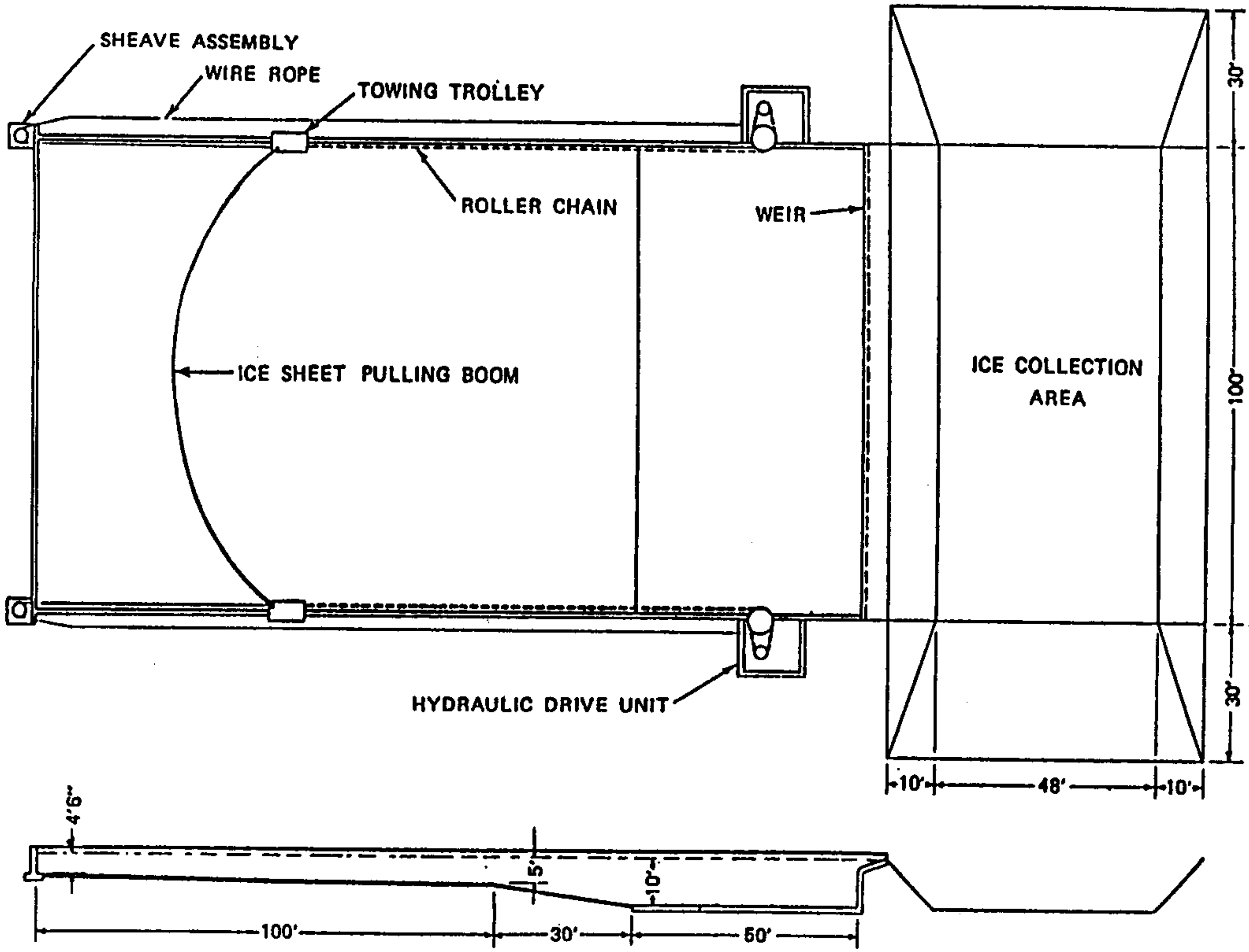
Yours truly,

H. M. Brown

Hugh Brown

HMB/mar

PLAN VIEW AND CROSS-SECTION OF THE ICE TEST BASIN



Institute for Marine Dynamics - St. John's

Canada's New Institute for Marine Dynamics, Opportunity for Improved Polar Transportation

N. E. Jeffrey, S. J. Jones
Institute for Marine Dynamics
National Research Council of Canada
St. John's, Newfoundland, Canada

International Polar Transportation Conference Vancouver 4–8 May 1986

ABSTRACT

The National Research Council of Canada's new Institute for Marine Dynamics (IMD) is described. The major facilities are:

1. Refrigerated model basin (ice tank) 93m x 12m x 3m deep.
2. Clearwater towing tank 200m x 12m x 7m deep.
3. Seakeeping tank 75m x 32m x variable depth.
4. Cavitation tunnel.
5. Model preparation workshops.
6. Computing facilities and library.

The research program and examples of industry collaboration are outlined with emphasis on those aspects relevant to Polar Transportation.

1.0 INTRODUCTION

On 5 November 1985 the National Research Council of Canada inaugurated its new Institute for Marine Dynamics (IMD) in St. John's, Newfoundland, approximately 5000 kilometers from the site of this conference. While this event marked the beginning of a new era of research into marine dynamics in Canada, the Institute itself is not new, but rather it is an outgrowth of the Marine Dynamics and Ship Laboratory which had existed in Ottawa since

1933. The new IMD facilities bring the opportunity to carry out, in Canada, the research required for the development of ships and offshore systems with superior performance, not only in water and waves, but of particular importance to Polar Transportation, in ice. This paper, while describing the whole Institute, will emphasize the refrigerated model basin, or ice tank, and the work of the Arctic Vessel Research Section . A companion paper (Jeffrey & Murdey, 1986) gives greater emphasis to other aspects of IMD.

The start of the expansion of the IMD capability can be traced to an element of the Government's oceans policy announced in July 1973 which was the declaration that Canada would develop an internationally recognized excellence in operating in or below ice covered waters. Following this announcement, various processes of consultation were set up and, to cut a long story short, the end result was the present facility in its location on the campus of Memorial University of Newfoundland (MUN). The expanded facility was to include not only an ice tank, but also a seakeeping tank to best meet the increasing needs of the offshore industry, and a new, larger towing tank. Subsequently, it was decided to move the cavitation tunnel and some additional items of equipment from Ottawa to St. John's.

IMD is a division of the National Research Council of Canada, and the role of IMD reflects the mandate of the Council as a whole which, in part, can be summarized as follows:

- to operate national facilities
- to carry out research in direct support of industrial innovation and development.
- to carry out research on problems of economic and social importance (such as marine transportation and safety).
- to develop a national competence in the natural sciences and engineering.

The Institute itself is, under the Director, divided into three Sections: the Arctic Vessel Research Section; the Hydrodynamics Research Section and the Research and Development Services Section. The Arctic Vessel Research Section has responsibility for the operation of the ice tank and cold rooms, essential for carrying out research on the properties of ice and its interaction with ships and offshore structures. The operation of the towing tank, seakeeping tank and cavitation tunnel are the responsibility of the Hydrodynamics Research Section. The research carried out by this section is concentrated in three main areas: ship performance (including resistance and propulsion); dynamics of ships and underwater vehicles (including seakeeping and manoeuvring) and offshore engineering hydrodynamics. The third Section in the Institute provides the essential support to the Research Sections in the areas of model design and construction, data processing and instrumentation, as well as in the administrative services related to finance, personnel and supply.

2.0 IMD FACILITIES

2.1 Towing Tank

The Towing Tank in St. John's is 200m long and 12m wide with a water depth of 7m. The size of this facility is consistent with the size of the ice tank and will enable large models (up to 12m in length) to be tested. It is much larger than the Institute's tank in Ottawa and in addition, being fitted with the very latest designs of carriage and wavemaker, has in all respects an enhanced capability compared with the older facility.

A key element in the towing tank is the towing carriage, which is illustrated in Fig. 1. The carriage spans the full width of the tank and is 14m long, and weighs approximately 80 tonnes. This massive structure is of particular importance for experiments with captive models. The carriage is powered by eight electric motors with a total power of 1500Kw, which gives a maximum speed of 10.0 m/s with accelerations available in six steps from 0.2 to 1.2 m/s^2. A computer controlled drive system enables the optimum duration of runs to be obtained for any test.

Another major feature of this tank is the dual flap wavemaker which was designed by MTS in the United States and built in Canada by Davis Engineering. It is hydraulically driven and is of dry back design. The

Fig. 1 Clearwater towing tank carriage and the beach in the background.

latter feature enables maximum flexibility in the positions of the actuators and has a reduced power requirement compared with a wet back design. The phasing of the movement of one flap with respect to the other may be selected to minimize distortion in the waves. The flaps can be controlled to oscillate over a range ± 16 degrees, and to accurately follow the characteristics of any driven signal (the harmonic distortion of the wave board motions is less than 2 percent). The wavemaker can produce regular or irregular waves. The maximum waveheight for regular waves is 1m, and the range of wavelengths which can be produced varies from 0.5 to 40 metres.

The tank is equipped for carrying out the full range of ship model tests. Resistance and propulsion dynamometers suitable for models of all sizes and and speeds are available as well as apparatus for wake surveys, propeller open water tests and flow visualization.

2.2 Seakeeping Tank

This tank, which is sometimes referred to as a stability or manoeuvring basin, is designed to provide the most realistic representation of the ocean wave environment for testing models of ships and offshore structures. With a length of 75m and a width of 32m, it is more square in proportion than the ice or towing tanks. The depth of water is variable from 0.5 to 3.5m, and a 4m square pit 5m deep, provides a maximum depth of 8.5m for testing some types of bottom founded structures in the centre of the tank. The IMD seakeeping tank is one of the largest in the world, and belongs to a new generation of such facilities which are characterized by their large size and the sophistication of the wave generating equipment installed in them.

The superior wave generation capability, for which installation remains to be completed, will consist of approximately 170 individually controlled, hydraulically driven wave boards developed by NRC and Davis Engineering. By suitably controlling the amplitude of oscillation of each wave board and the phasing of the motion of one board with respect to the next, regular or irregular waves can be produced with wave crests running obliquely to the tank walls. Superposition, within the drive computer, of such control signals yields waves which run simultaneously in a range of directions, and are, in the case of irregular waves, reproductions of the short crested waves found in nature. Regular wave trains up to breaking height will be produced for wavelengths from 0.4m to approximately 7.5m, and the maximum waveheight in regular waves will be 1m.

2.3 Ice Tank

The third major facility, and the one of most interest to this conference, is the ice tank. With a usable ice sheet length of 76m, width of 12m and a depth of 3m, the IMD ice model basin is the largest in the world, see Fig. 2. The 12m width allows large scale models to be tested and also permits limited manoeuvring studies on smaller models. Typical model lengths will be 6 to 8m, but models up to 12m in length can be accommodated.

A 15m long setting up area is located at one end of the towing tank and is separated from it by a thermal barrier gate, as shown in Fig. 3. The opposite end of the tank has a sloped ramp leading into a melt pit (Fig. 4) which has an insulated cover to enable the next ice sheet to be grown while the remains of the previous one are melting.

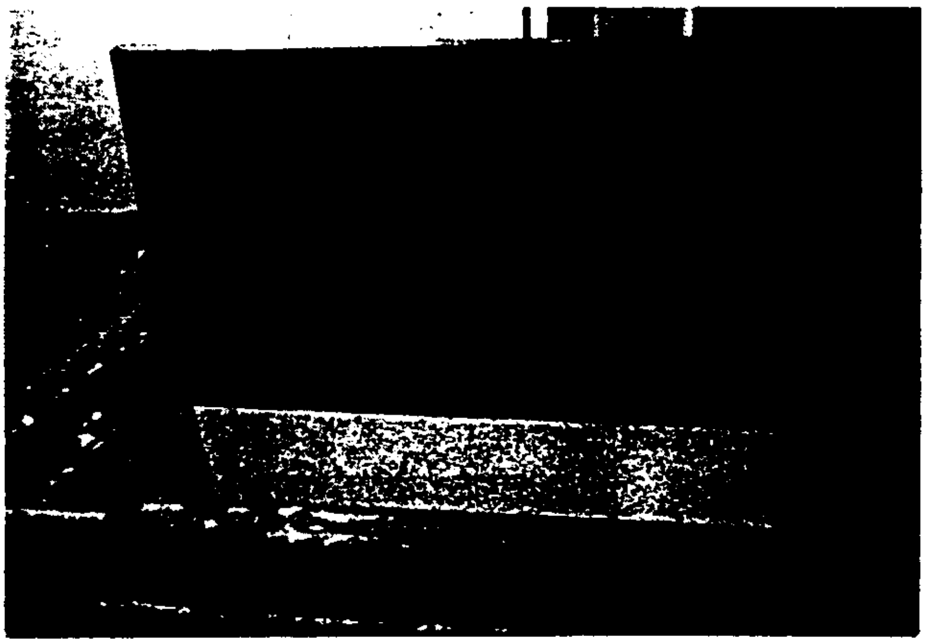


Fig. 4 The melt pit with its lid open, into which a used ice sheet is pushed.

The tank is constructed of steel reinforced concrete with a glass fibre reinforced epoxy liner and external polythurethane foam insulation. The tank is supported on four rows of concrete columns with teflon pads to allow for thermal expansion. The basin has sufficient corrosion resistance to handle saline ice but other dopants, such as the new EGADS ice, (Timco, 1986) will be used, since studies at NRC have shown that this provides more accurately scaled model ice properties. Section 1.4 below describes this ice in more detail. The laboratory in which the tank is housed is 105 metres long by [illegible] metres wide by [illegible] metres high. The walls and ceiling of the room are constructed with prefabricated, steel-clad, urethane foam panels, and with special techniques to reduce air infiltration from the outside.

The refrigeration system uses two-stage mechanical compression and utilizes ammonia as the working fluid. The rejected heat is reclaimed for ice melting, domestic water preheat, and tank wall perimeter heating, via embedded pipes fed with glycol, for ice sheet release. The ammonia refrigerant is delivered to 24 ceiling hung evaporators in the main tank plus two similar units in the setting up area. Compressor capacity, evaporating pressure and fan speed are computer controlled in order to obtain a uniform temperature distribution near the water surface. The aim is to provide a cold air supply over the upper part of the basin with heat transfer near the ice sheet/air interface by natural convection, and this is achieved because of the height of 10m between the ice surface and the evaporators. The air temperature can be controlled from -30°C to +15°C and

Fig. 5 The main carriage in the ice tank pushing a cylindrical structure through ice.

ice growth rates of 3.5mm/h [illegible] have been obtained with a maximum thickness of 15cm. A separate chiller system is used initially to cool the water.

The towing carriage, which was built in Japan by Mitsui Limited, and is shown in Fig. 5, is 14m long and weighs approximately 80 tonnes and has a natural frequency of 12 Hz. There are two speed ranges: 0.0002 to 0.04m/s and 0.02 to 4m/s. The carriage can be operated in either friction drive or rack drive. The maximum thrust available on the low speed range for testing fixed structures is 60kN on the centreline and 30kN on the quarter points. The model test bay is spanned by an adjustable test frame. This frame can be adjusted vertically and horizontally to accommodate the fitting of a wide variety of test instrumentation and model configurations. In addition, it provides the capability to move the model across the tank from one-quarter point to the other. This would enable two test runs to be made

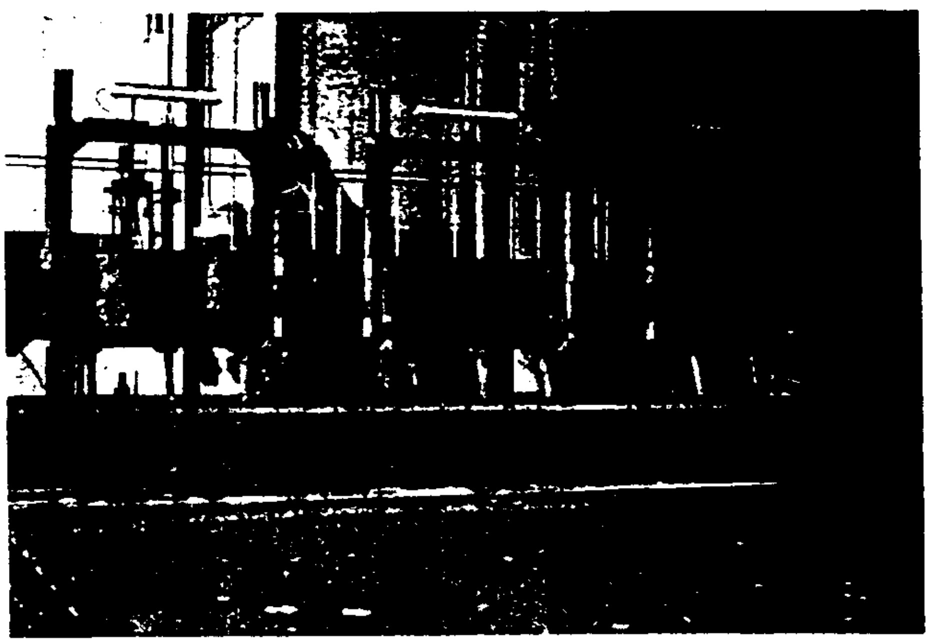


Fig. 6 The service carriage shown parked above the melt pit.

through one ice sheet, a procedure, which if it can be validated, would greatly improve the cost efficiency of the facility. A Micro Vax I Computer on the carriage provides for data collection and reduction.

A separate service carriage is used for ice control and measurement work. It is a 4 wheel, 24 ton, hydraulically driven carriage and is shown in Fig. 6. Manual control permits speeds of up to .4 m/s in either direction. The carriage is fitted with a 3 section working platform which can be raised or lowered to any convenient height from the ice. The sections can be operated individually or in unison. A 3 section ice boom is installed in front of the carriage and these sections can also be raised or lowered together or separately. The boom can be tilted from horizontal to vertical for ice pushing and cleaning operations. The combined tilting and lifting effects are used to build pressure ridges, and the boom is capable of lifting 1800 kg. The boom can withstand thrust forces of 60 kN, though for such work the carriage is attached to the main towing carriage. The service carriage is fitted with a hydraulically operated, folding, sea crane and winch, to aid in the installation of bottom mounted test structures. A bucket extension is provided for maintenance of ceiling mounted fixtures in the laboratory.

An underwater carriage is being constructed to carry video, and high speed ciné, cameras for making visual records of, for example, the interaction of ice pieces with a model and its propellers.

Standard test equipment is installed in the facility for carrying out resistance and self-propulsion tests on ship models in ice, and for measuring forces generated on a model of an offshore structure by the ice.

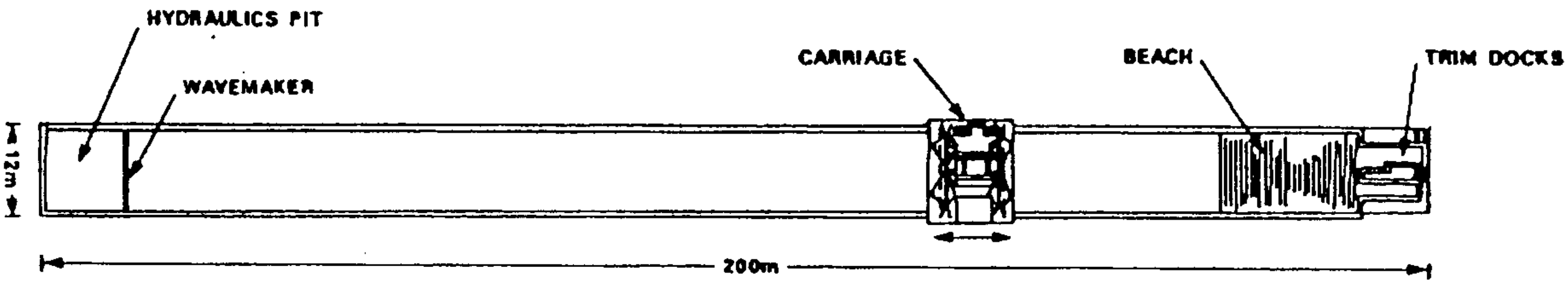
2.4 The EG/AD/S Ice

This model ice has been described in detail by Timco (1986). It is a dilute aqueous solution of ethylene glycol (EG), aliphatic detergent (AD) and sugar(S) in the approximate ratio 0.4/0.03/0.04%.

CLEARWATER TANK

1 : 1000

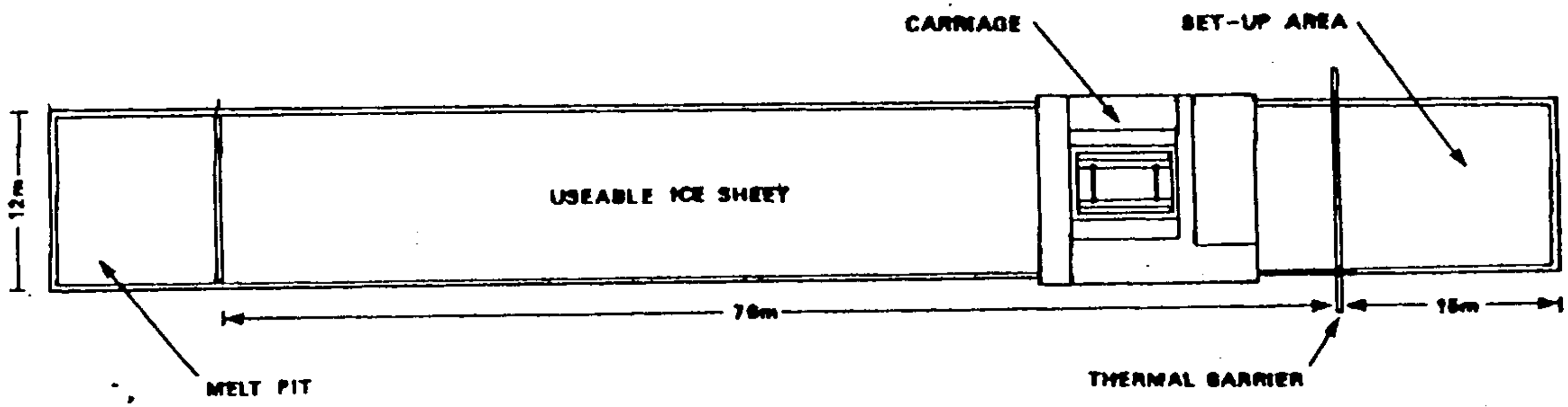
7.0 METRES DEEP



ICE TANK

1 : 600

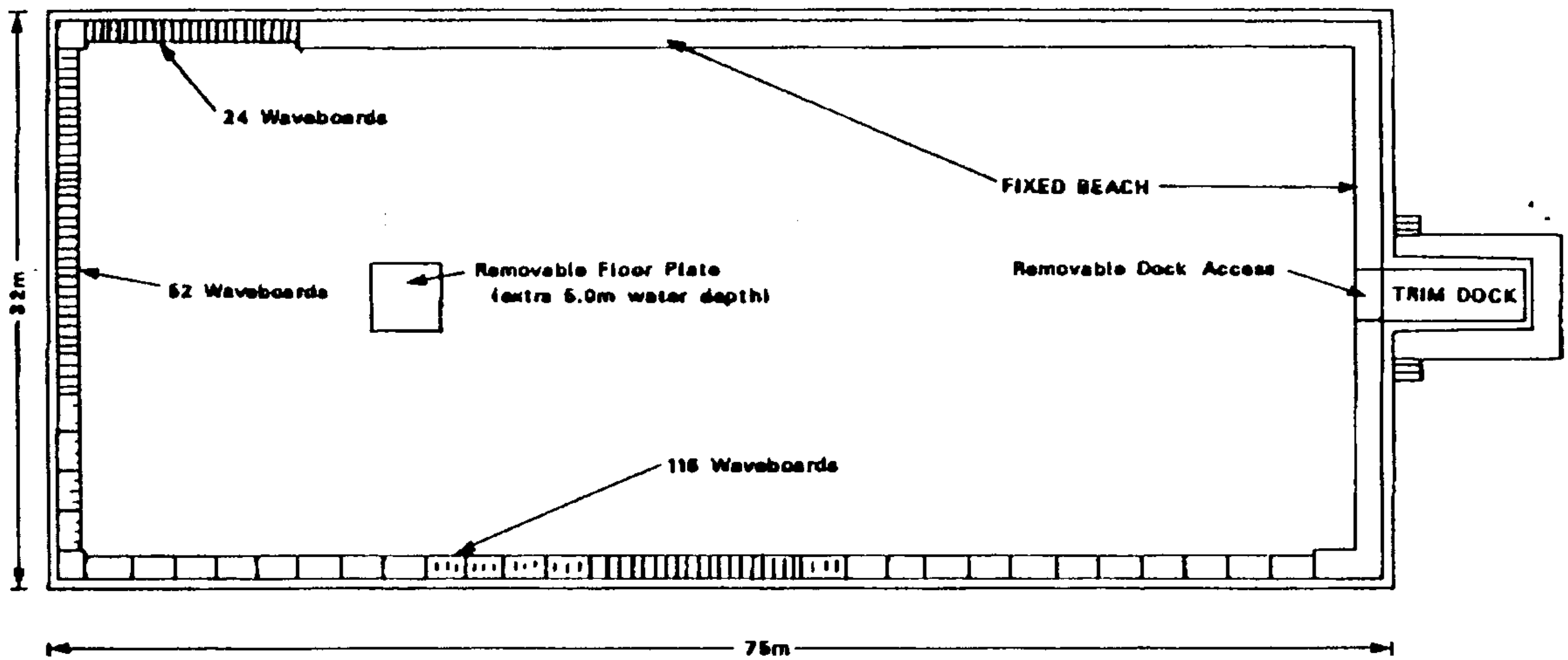
3.0 METRES DEEP



SEAKEEPING TANK

1 : 400

3.5 METRES DEEP



Institute for Marine Dynamics - Ottawa

The Institute for Marine Dynamics Ottawa Laboratory has two tanks hereafter referred to as M-22 and M-42.

M-22 - Indoor Tank

Concrete shallow water towing tank 137m long x 7.6m wide x 2m deep equipped with an electrically driven towing carriage capable of speeds up to 12 m/sec, a flap-type wavemaker and a wave absorber. A new data acquisition system is presently being installed.

Portholes in a viewing room beside the tank permit underwater observation or photography.

M-42 - Outdoor Tank

Concrete sides, fibreglass reinforced asphalt bottom - 122m long x 61m wide x 3.7m deep equipped with a bank of eight pneumatic wavemakers at one end, capable of generating regular waves of up to approximately 0.6m in height and lengths of about 2 - 15m and with a wave absorber situated at the other end. There is a paved walkway on the two long sides. The facilities include an 11m high observation tower, a 1 ton jib crane and an enclosed work/storage area.

National Water Research Institute

FACILITIES AND EQUIPMENT

WIND-WAVE FLUME

This combination wind tunnel and wave flume can produce wind-generated and/or programmable paddle-generated waves. Wave action of any type can be produced by supplying the appropriate time series to the wave maker. Depending on the water depth, wind velocities can be controlled over a range of 0.15 to 15 m/s. In addition, a circulating pump can produce mean water velocities in either longitudinal direction of up to 15 cm/s at a water depth of 1.25 m.

> ***Specifications:*** length 103 m, width 4.5 m, height of flume walls 1.48 m, height to ceiling 3.03 m; maximum water depth 1.25 m; overhead hoist capacity 1 tonne; paddle-generated wave frequency range 0 to 2.0 Hertz; paddle-generated wave height range 0 to 60 cm; maximum fan discharge 104 m^3/s; fan power 261 kW; accuracy of fan speed control +/-1%

PUMPING AND WATER DISTRIBUTION

Two separate pumping systems are available; one system is used for clear water experiments, the other is designed for sediment-water experiments. Each system has three pumps and can generate flows up to 0.5 m^3/s. The pumps have nominal ratings of 0.142, 0.283 and 0.425 m^3/s and can be run individually or in combination. The water in each system is pumped from a sump to a constant head tank having an overflow crest 6 m above the laboratory floor.

TOWING TANK

The towing tank and carriage are used to calibrate all types of current meters and can be used for drag and other hydrodynamic tests. The full depth of the tank is 3 m, of which 1.5 m is below ground level. Subsurface observations are possible at observation windows in the sidewall at the head and at the midpoint of the tank.

> ***Specifications:*** length 122 m, width 5 m, depth 3 m; normal water depth 2.7 m; carriage length is 3 m, width 5 m; carriage controlled speed range 0.5 to 600 cm/s +/-1%, maximum speed can be maintained for 12 sec; overhead hoist capacity 1 tonne.

SEDIMENT TRANSPORT FLUME

The flume's primary purpose is for fluvial sediment transport studies. Features of this facility include a sediment feed system, a self-powered instrument carriage, a tail-gate system, sediment traps and a sediment processing system.

> ***Specifications:*** length 26.5 m, width 2.0 m, height of walls 0.75 m; working section length 21.9 m; maximum flow rate 0.5 m^3/s; slope range of -1% to +1%; maximum sediment feed rate 3.25 kg/s (sand); accuracy of feed rate +/-1%; 3 sediment traps, each with length 11 m, width 1.5 m, height of walls 2.1 m, capacity 2.0 m^3.

— continued

Memorial University of Newfoundland

construction, while the waveboard is fabricated from aluminum with a watertight teflon seal along its sides and bottom. Several large viewing windows are conveniently located in one of the tank's walls, enabling visual and photographic analysis of a model's response at surface and subsurface elevations.

Both regular and irregular wave spectra can be generated by the waveboard's translatory motion, in a frequency range between 0.3 and 1.3 Hz. The force capability of the hydraulic actuator, shown in figure 2 and which drives the board over a 0.25 m stroke, is specified to be 48.8 kN and limits the actual operating depth of the tank to about 2.13 m or less. Electronic control for the waveboard is provided from the control room through an MTS closed-loop, servo-controlled system with error detection and compensation being applied through an LVDT feedback loop (refer to figure 3).

A previous calibration of the tank revealed that a maximum wave height of 0.7 m could be achieved at a frequency of 0.3 Hz. and a design water depth of 1.8 m (Muggeridge and Murray, 1981). Control signals for random wave spectra are provided by an on-line microcomputer, which allows quick and efficient implementation of any theoretical spectrum (ie; JONSWAP, Pierson-Moskowitz, Neumann, etc.). Muggeridge and Murray, 1981, found that for a Pierson-Moskowitz spectrum with prototype wind speeds up to 25 m/s, a maximum significant wave height of 20 cm could be achieved for a 1 m water depth. Experimental results from their tests also indicated good agreement with design curves presented by Gilbert, Thompson, and Brewer, 1971.

Located at the far end of the wave tank is a parabolic beach, consisting of an aluminum frame covered by wooden slats, which was installed in 1985 (see figure 4). This construction is intended to absorb and dissipate the energy contained in the incident wave and maintain a minimum reflection coefficient. Wave filter plates affixed directly to the front of the wave generator are employed to reduce the presence of cross tank oscillations in the tank (see figure 5).

A towing carriage, installed in 1983, is available for use in towing tests, resistance tests, current probe calibrations, and self propulsion experiments. The carriage has a net weight of 3.9 tonnes and can attain a maximum speed of 5 m/s. A dynamometer is also available for use in conjunction with the carriage and it can measure horizontal forces of +/- 20 kg, vertical translations over a 0.4 m range, and rotations within a +/- 30 degree arc.

In the years since the tank was commissioned, a variety of experiments have been carried out on both floating and fixed bottom structures, and with the installation of the carriage came the capability to perform an even wider range of research (refer to figures 6 to 8). Semisubmersible models have been most prevalent in the tank with many of the investigations centering around the body's six degrees of freedom motion response in regular and irregular seas. A number of experiments have also involved the interaction of a floating drilling platform with modelled icebergs, bergy bits, and pack ice. Tests have been performed on a hydroelastic model as well, with an interest in the internal stresses and strains which develop in the columns, cross braces, pontoons, and deck.

Apart from semisubmersible models, experiments have been carried out

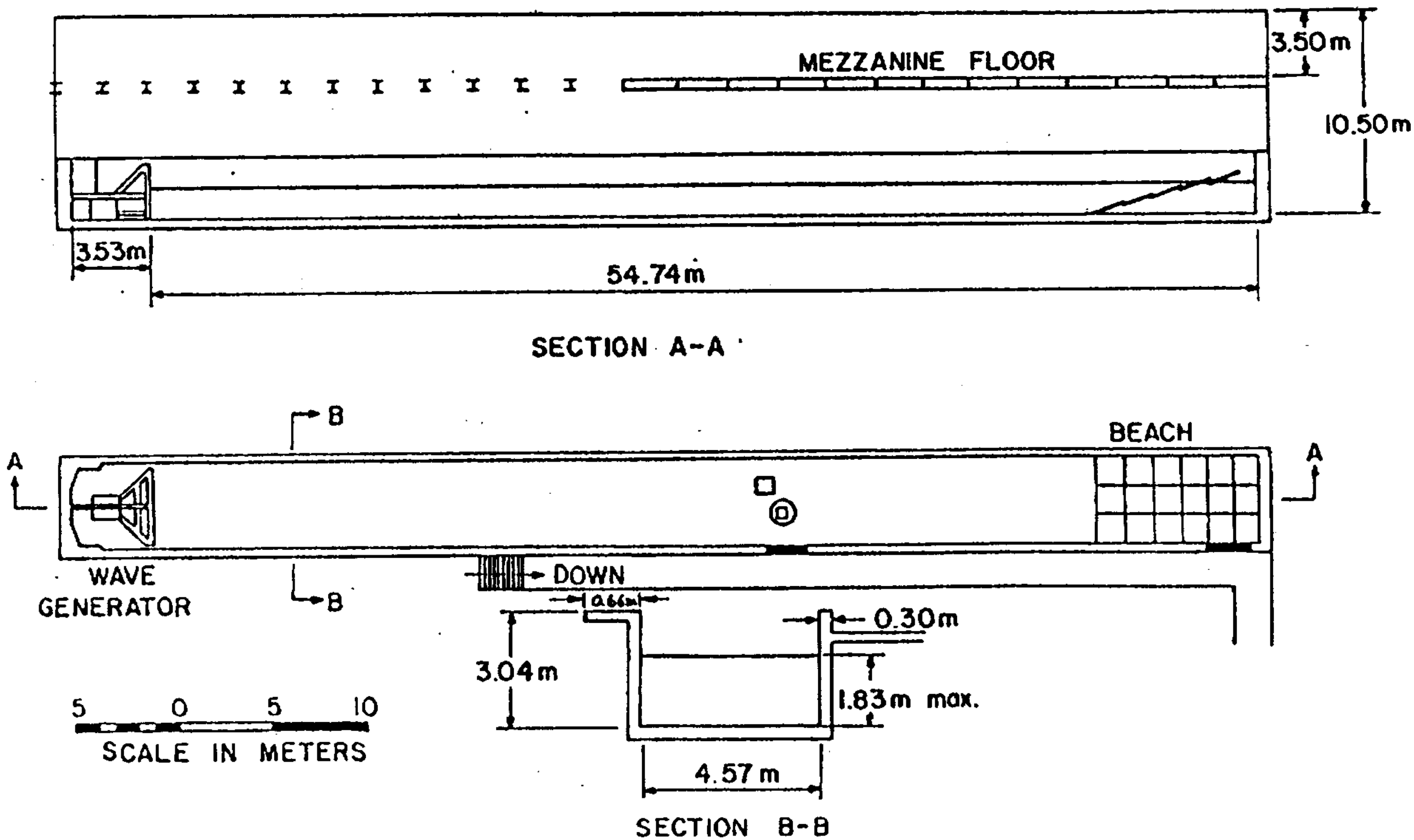
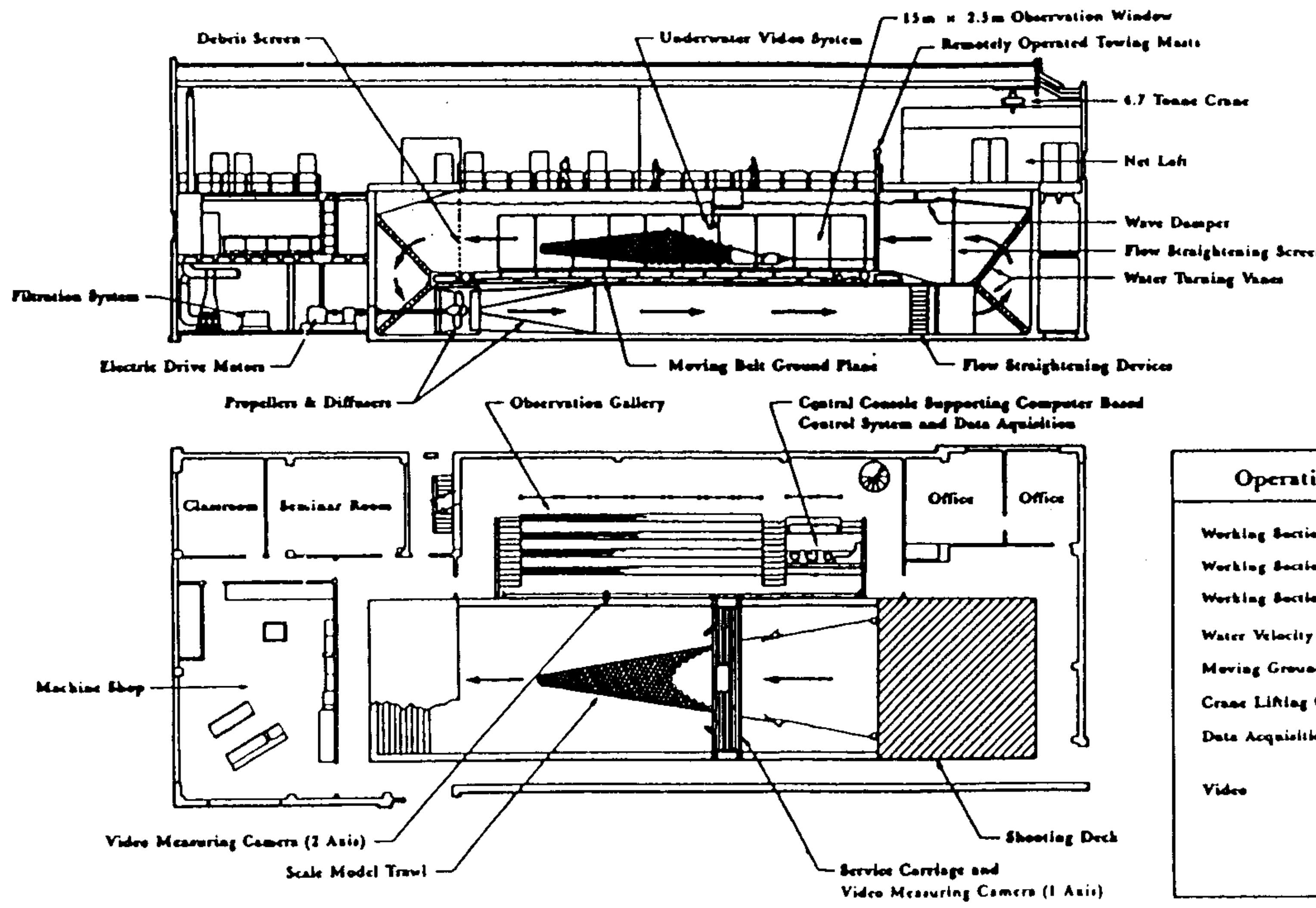


Fig. 1 Elevation, and Plan Views of Wave Tank

Newfoundland & Labrador Institute of Fisheries and Marine Technology

Marine Institute
Fisheries Flume Tank



Operating Characteristics

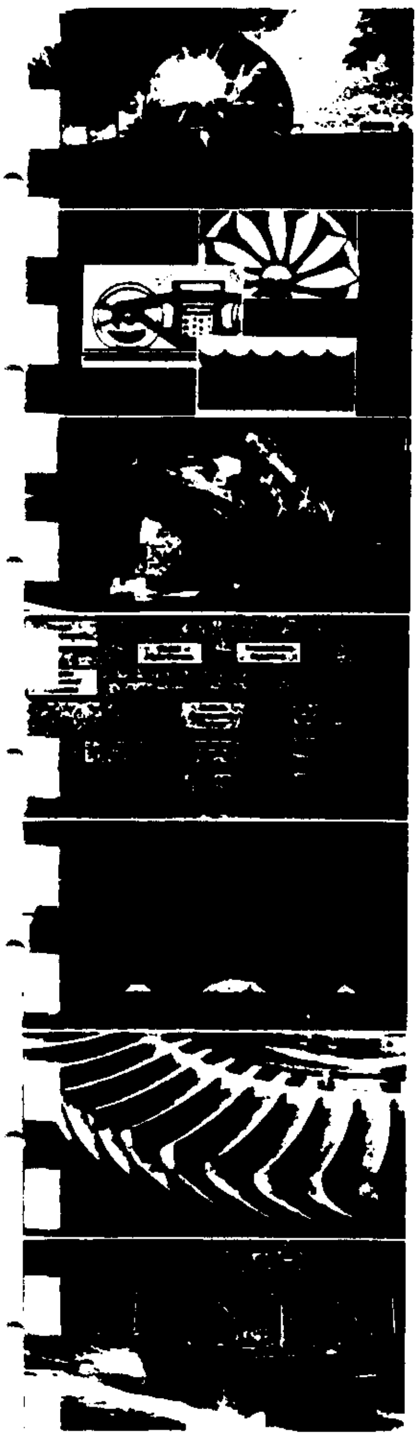
Working Section Length	21.5 metres
Working Section Width	8.0 metres
Working Section Depth	3 or 4 metres
Water Velocity	0 — 1 m/s
Moving Ground Plane	± 0 — 1 m/s
Crane Lifting Capacity	4.7 tonnes
Data Acquisition	32 Channel analog/digital
Video	High quality underwater/ surface video with editing capability.

Department of Mechanical Engineering
National Research Council
Hydraulics Laboratory

National Research Council Canada
Conseil national de recherches Canada

Division of
Mechanical Engineering
National Facilities

Multidirectional Wave Basin



Dimensions

Basin: 50 x 30 x 3.0 m
Centre pit: 5.3 m diameter x 12 m deep

Wave Generator

Segmented

- Total of 60 segments
- Each segment has a 0.5-m-wide, 2.0-m-high wave board
- Sixty hydraulic actuators, driven by 450-kW power pack
- Can be operated as hinged paddle, piston, or intermediate mode
- Maximum wave height: 0.75 m
- Segments can be moved vertically along frame to accommodate variable water depths up to 2.5 m
- Generates directional sea states, normal or obliquely to wave boards, or regular or irregular long-crested waves, normal or obliquely to wave boards

Computing and Data Aquisition Systems

- DECnet network of Digital MicroVAX computers (two MicroVAX IIs and one MicroVAX 3500), a VAXserver 3400, and workstations (VAXstation 2000s, 3100s, and 3200s)
- Four gigabytes of disc drive storage
- Two 9-track tape drive systems: one of 1600 bits/inch and one of 1600 or 6250 bits/inch
- Two TK50 and two TK70 cartridge tape drive systems
- Printers and plotters (both draft and report quality)
- Central data switch linking terminals, graphics terminals, personal computers, and modems
- Data acquisition and control systems 480 and 620 (Neff Instrument Corporation):

System 480

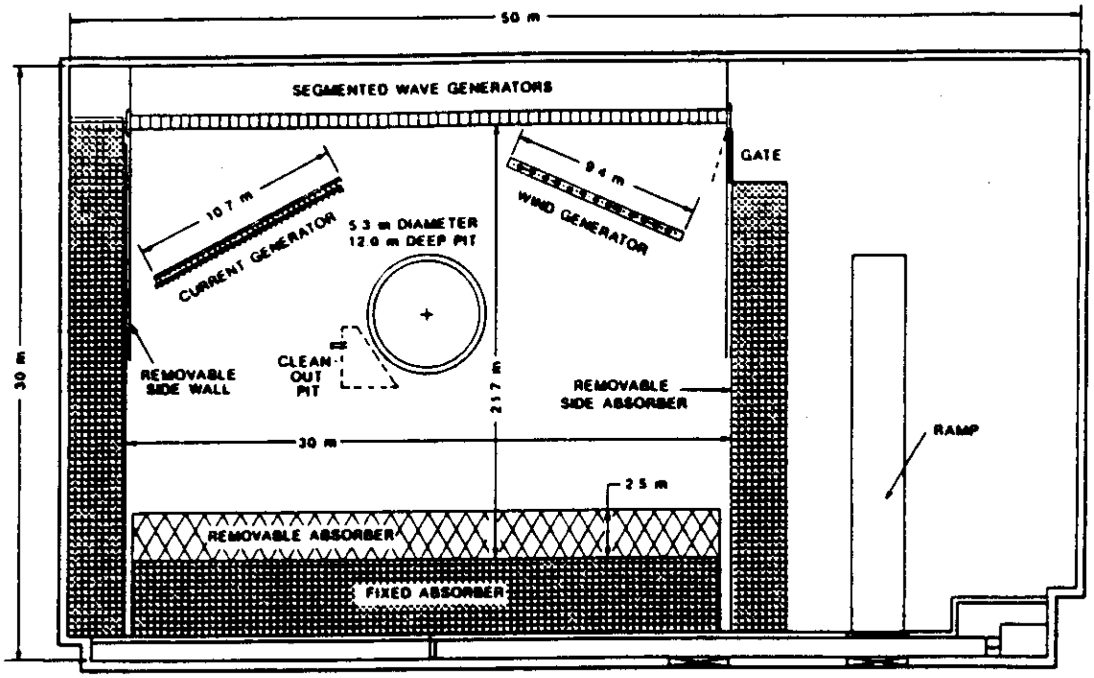
- Differential amplifier and analog-to-digital converter per channel
- One-megaword data storage per channel
- Fifty-kilohertz channel sampling (12-bit resolution)

System 620

- Series 100 amplifier/multiplexer units (15-bit resolution)
- Series 300 signal conditioners
- Series 400 differential multiplexer (14-bit resolution)
- Series 500 measurement and control systems
  - local and remote systems
  - digital-to-analog converter output cards (12-bit resolution)
  - nonbuffered operation (low speed, 20 Hz)
  - dual-buffered operation (medium speed, 100-500 Hz)

Instrumentation and Equipment

- Pumps for generating currents
- Variable speed fans for modelling wind effects; up to 24 groups of 6 each
- Outdoor water reservoir of 5 x 10^6 L, pumping capacity of 0.5 m^3/s
- Capacitance wave probes (accuracy, 0.1% of range or 0.001 m)
- Arrays to measure directional spectra
- Bidirectional and multidirectional current meters
- Wind anemometers
- Load and pressure cells; dynamometers to measure with six degrees of freedom
- Accelerometers and Selspot system to measure motions with six degrees of freedom
- Fibre optic system to transmit 30 measurement channels to computer and 6 control signals from computer
- On-line computer control and data acquisition system
- Enclosed control room above basin
- Access to basin for construction equipment
- Filtering system
- Photographic, cinematographic, and video equipment



PLAN

Further Information

Dr. B.D. Pratte, Head
Hydraulics Laboratory
Division of Mechanical Engineering
National Research Council Canada
Montreal Road
Ottawa, Ont., Canada
K1A 0R6

Telephone: (613) 993-2417
Telex: 053-3386 (NRC ME OTT)
Telefax: (613) 952-7679

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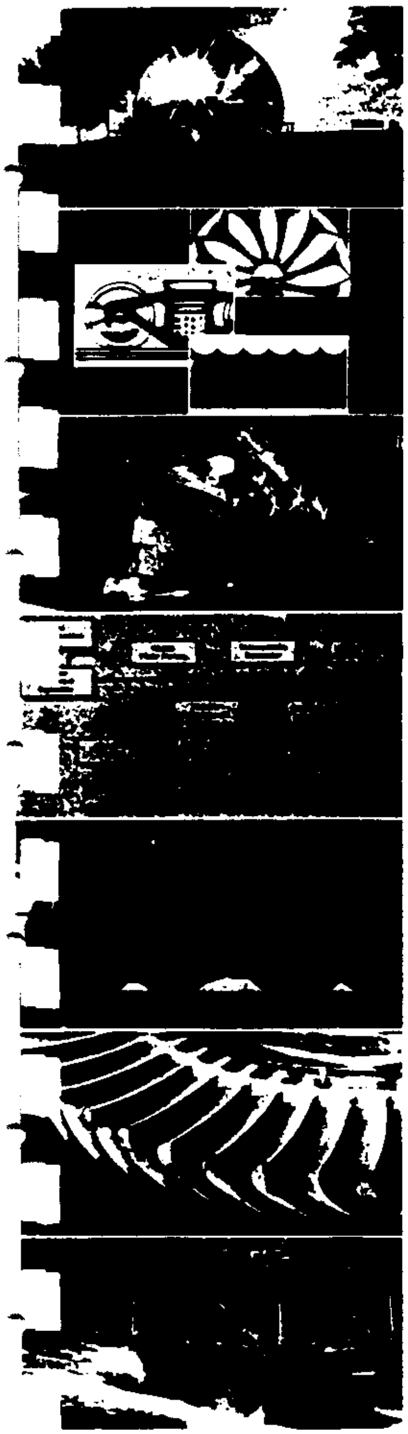
National Research Council Canada

Conseil national de recherches Canada

Division of Mechanical Engineering National Facilities

Coastal Wave Basin



Dimensions

Basin: 14 x 63 x 1.5 m
Two instrumentation pits: 2.4 x 2.4 x 0.3 m

Wave Generators

WM-14

- Width: 14 m
- Height: 1.8 m
- Can be operated as hinged paddle, piston, or intermediate mode
- One or two 40-kW hydraulic actuators
- Maximum wave height: 0.5 m

WM-7

- Portable for use in shallow basins
- Width: up to 14 modules of 3.5 m available
- Height: 0.6 m
- Can be operated as hinged paddle, piston, or intermediate mode
- One 15-kW hydraulic actuator
- Maximum wave height: 0.2 m

Computing and Data Acquisition Systems

- DECnet network of Digital MicroVAX computers (two MicroVAX IIs and one MicroVAX 3500), a VAXserver 3400, and workstations(VAXstation 2000s, 3100s, and 3200s)
- Four gigabytes of disc drive storage
- Two 9-track tape drive systems: one of 1600 bits/inch and one of 1600 or 6250 bits/inch
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- Bidirectional and multidirectional current meters
- Wind anemometers
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- Accelerometers and Selspot system to measure motion with six degrees of freedom
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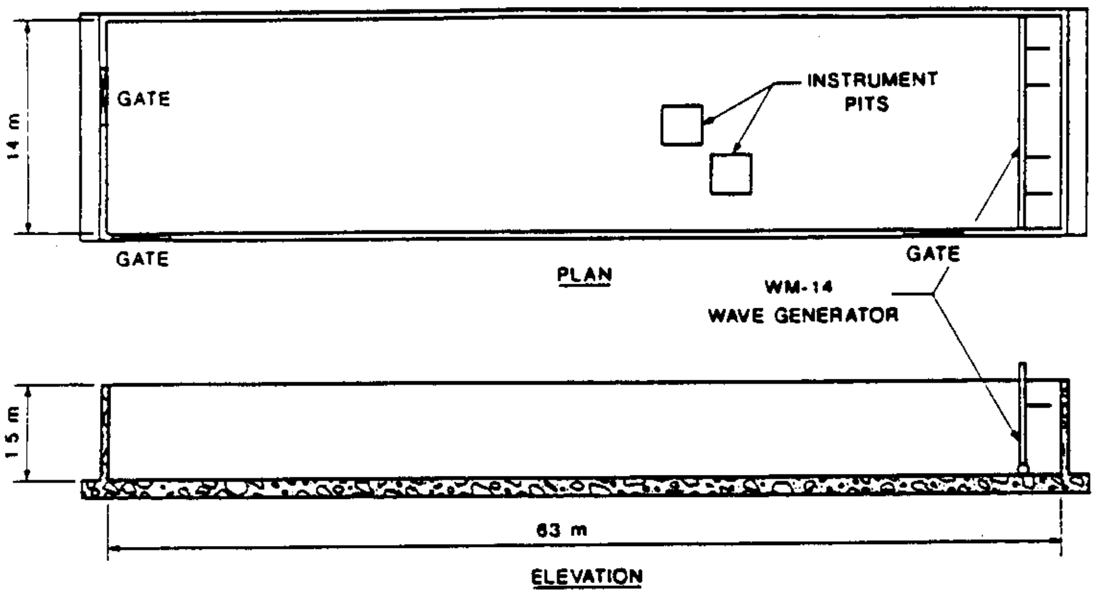
- On-line computer control and data acquisition system
- Enclosed control room above basin
- One tonne gantry crane and mobile service bridge
- Access to basin for construction equipment
- Photographic, cinematographic, and video equipment

Canada



Further Information

Dr. B.D. Pratte
Hydraulics Laboratory
Division of Mechanical Engineering
National Research Council Canada
Montreal Road
Ottawa, Ont., Canada
K1A 0R6

Telephone: (613) 993-2417
Telex: 053-3386 (NRC ME OTT)
Telefax: (613) 952-7679

DME-CWB-E (89.8)

National Research Council Canada
Conseil national de recherches Canada

Division of Mechanical Engineering
Division de génie mécanique

Hydraulics Laboratory
Laboratoire d'hydraulique

Ottawa, Canada
K1A 0R6

File Référence 3700-2

1990-01-17

Mr. Martin Poulin
D.F. Dickins Associates Ltd.
503A, 21 Water Street
Vancouver, British Columbia
V6B 1A1

Dear Martin:

Thank you for your call requesting the enclosed information on the facilities of the Hydraulics Laboratory of the Division of Mechanical Engineering, here in Ottawa at the National Research Council. As you know, we were concerned why our major facilities did not appear in your draft report to Environment Canada "An Evaluation of Canadian Towing Tanks and Manoeuvring Basins as Substitute Test Facilities for OHMSETT", by D. Dickens and L. Solsberg, 31 March 1989. Many other facilities appeared in the report even though they too are unwilling to have actual oil spill testing carried out. I think it a good idea to complete the survey by including DME Hydraulics Laboratory. We are happy to provide our facilities for testing oil spill recovery or containment devices for their hydrodynamic performance in waves, winds and currents, using tracers or dyed water layers. However, we cannot allow oil to be used in the basins since cleanup is difficult and costly, and our other experiments and instruments such as wave probes, require a clean water surface. The Multidirectional Wave Basin can be drained or filled in 3 hours, from a large outdoor reservoir. This gives access to construction equipment such as a loader or forklift, to install and remove test structures. The Basin is used for studies on fixed offshore platforms, caissons, guyed towers, and for shallow water coastal studies such as harbours, breakwaters, shore protection. A new pit, 12 m deep, 6 m diameter, permits testing structures in very deep water. For example, a tension-leg drill platform in 800 m water has just been tested at a scale of 1:70. In total, we can have a depth of 14.7 m by using the pit. Thirty feet above the pit, in the roof trusses, we have walkways and a 1 tonne hoist on a monorail, capable of placing models in the pit, or moving equipment in and out of the basin. Special NRC-designed wave generators (60) and variable porosity wave absorbers surround the basin to produce realistic directional sea states, and to efficiently absorb them (reflections are less than 5%). This basin is presently the most sophisticated in the world in terms of wave size and control. IMD's new larger Offshore Engineering and Seakeeping Basin is almost operational (due by June 1990), and incorporates all the advances made here over the years. Our Multidirectional Wave Basin has no windows; it uses underwater video. Its water is chlorinated and filtered.

Besides three other shallow (0.6 m deep) large basins for coastal engineering work and three narrow wave flumes, we also have another National Facility, the Coastal Wave Basin. Generally we test models of coastal breakwaters or harbours in this tank, constructing the bathymetry in concrete. A WM14 long

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Telex 053-3386
Telefax: 613-952-7679
Télex 053-3386
Télétax 613 952-7679

crested wave machine is used. There is no towing carriage, although a light service carriage on rails is used to mount cameras, carry 10-15 people, etc., to view the tests. An overhead crane spanning the basin has a 1 tonne capacity for moving equipment anywhere in the tank.

We also have a cold room ice tank in which we study how to model arctic ice covers, and ice-structure interaction effects. All the major studies to develop NRC's model ice material, urea (carbamide) ice, and now, EGADS ice, were developed by Dr. Garry Timco here in our laboratory. This 7 x 21 m tank, 1 m deep, is equipped with a powerful carriage capable of 5 tonnes horizontal force. It too should be included in your report.

I've attached pages from your report on which I've penned in DME-NRC Hydraulics Laboratory basins.

Note that the NRC Institute for Research in Construction has a Fire Research Laboratory, and a field site outside Ottawa. They may be interested in construction of a test basin to meet your OHMSETT type needs. Please contact Mr. J.K. Richardson at (613) 993-2204 or (613) 993-9775 to explore the possibilities.

If you should require more information, please give me a call. I appreciate your making the effort to include Canada's major coastal engineering laboratory in your survey report.

Sincerely,

B Pratte

Bruce Pratte, Ph.D.
Head

c.c. R. Dennison

BDP:ch

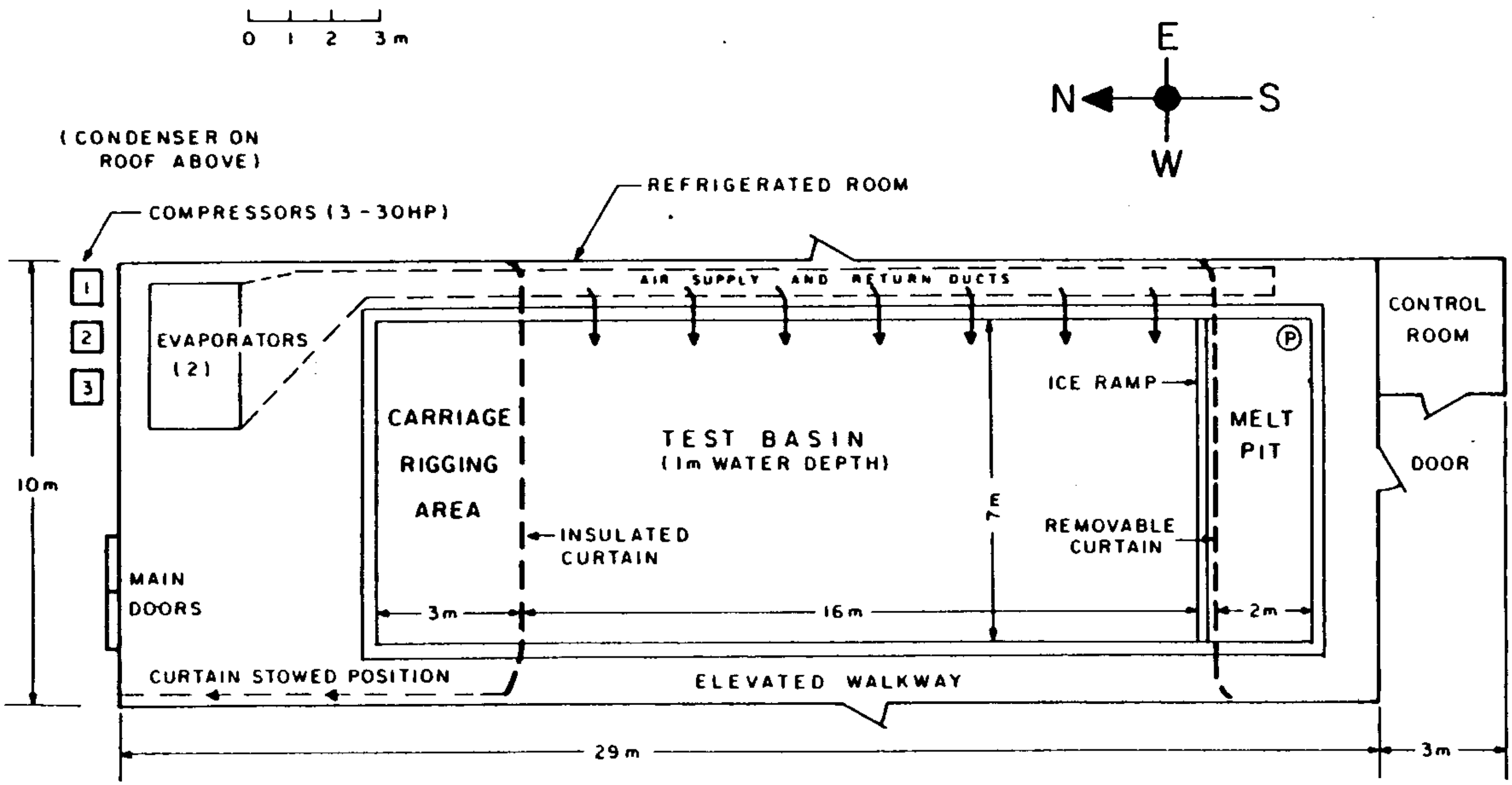

FIG. I PLAN OF NRC MODEL BASIN FOR TESTING ICE—STRUCTURE INTERACTIONS

Appendix C

Engineering Assessment of Canadian Facilities

B.C. Research Towing Tank
Vancouver, B.C.

Configuration	- advancing tests limited to a 1 minute duration at 1-2 knots - stationary testing is limited - dispersant/burning work not feasible
Bridges	- speed is adequate but towing capacity limited
Test Setup	- adequate deck space - unable to collect oil on bridge for advancing tests - a second bridge is needed - tank is too narrow for a comprehensive program
Waves	- wave generation is adequate for all testing
Ice	- no capability for natural or artificial ice
Saline Water	- fresh water is used now - salt water is possible
Test Fluids	- no real oil or chemicals are allowed in the tank - management are willing to accept synthetic oil with adequate safeguards to ensure clean-up
Water Quality	- slow filtering capability may be adequate for discontinuous testing schedule
Data Gathering	- bridge configuration limits advancing tests - carriage and viewing ports allow video recording
Analysis	- full analysis capability is available including GC physical chemistry test instrumentation.
Ancillaries	- adequate workshop - chain hoist has limited capacity - trained personnel are available for test programs

Summary - B.C. Research Towing Tank

The BC Research towing tank has a bridge that could conceivably allow 1 minute tests of advancing skimmers and booms at maximum relative velocities of 1.5 - 2.0 knots. However, bridge space and carrying capacity are lacking insofar as setup for oil collection and the stationing of personnel and instrumentation are concerned. The lack of a second bridge would limit testing.

The narrow width of the tank at less than 5 metres restricts use of this facility to smaller devices only. Modifying the bridge system is not warranted given the dimensional limitations.

The towing tank requires more substantial filtering capability if synthetic oil were to be introduced. (academic since management is not in favour of introducing any fluid other than water into the towing tank - see maneuvering basin).

Restricted lifting capability could be improved by the incorporation of an overhead track/hoist/jib assembly.

Burning is obviously not possible in this indoor facility.

Theoretically, the B.C. Research towing tank could be utilized for the evaluation of advancing and smaller stationary systems conditional on:

* improved water filtration
* incorporation of new two-bridge system
* management's agreement to use synthetic oil
* investigation of use of saline water
* confirmation of adequate lifting capability

The tank offers insufficient technical capacity to provide a replacement for the OHMSETT facility.

The most positive features of B.C. Research are its excellent staffing, analytical and support facilities which could be used to advantage for small scale test programs where the use of real oil is not essential.

The Ocean Engineering Centre at B.C. Research submitted a proposal for B.C. government funding which would involve synthetic oil testing in the towing tank.

Note: an adjacent shallow flume with 0.8 m concrete walls will be fitted with a wavemaker in 1990.

B.C. Research Maneuvering Basin
Vancouver, B.C.

Configuration	- testing restricted to runs of 30 seconds at 1-2 knots - dimensions allow for full range of stationary tests - burning is not feasible - dispersion experiments possible but no underwater viewing
Bridges	- none at present - bridge could be constructed at high cost (not justified given the short duration of advancing tests)
Test Setup	- deck space is adequate for large devices - lifting capacity is limited.
Waves	- production of irregular waves is adequate - wave generation satisfactory for stationary tests - plans for improved wavemaker in near future - 12 capacitance wave probes
Ice	- this is an indoor facility without ice production
Saline Water	- basin is filled with fresh water - sea water replacement is possible.
Test Fluids	- facility will accept synthetic not real oils (e.g. Circo) - filtering system requires improvement
Water Quality	- filtering capability is an unknown factor - may limit utility of underwater video - no underwater viewing ports - with application of floculants, the wave basin can be clarified to a depth of 2.4 m in one day
Data Gathering	- adequate for stationary testing.
Analysis	- excellent range of analytical services - MicroVAX 3800 with PC's using EtherNet
Ancillaries	- 5 ton gantry crane - technical support staff and workshop facilities

Summary - B.C Research Maneuvering Basin

Based on its dimensions, this tank has potential application for stationary equipment tests using synthetic oils (may require modified filtering system)

While the dimensions of the BC maneuvering tank are suited to stationary testing, they are less ideal for advancing trials. No bridges are incorporated into the tank; the available length will severely restrict relative velocity test runs. This indoor facility is not suitable for conducting burning experiments.

Overall, the tank has the capability of conducting a limited range of OHMSETT type tests.

A significant advantage of this facility is afforded by a cooperative management who actively support the use of this facility for oil spill related work. They are willing to discuss any reasonable modification which could make the facility more suitable for this type of research. B.C. Research has a technology sharing agreement with the National Research Council and is able to share specialized instrumentation and equipment with other Canadian facilities.

The Ocean Engineering Centre at B.C. Research is planning to significantly upgrade the wavemaking equipment in the Maneuvering Basin in 1990.

Fleet Technology Ltd. Ice Modelling Tank
Calgary, Alberta

Configuration	- restricted testing of 30 seconds duration at 1-2 knots - burning is not possible.
Bridges	- the single carriage system has limited capacity. - feasibility of advancing tests is questionable.
Test Setup	- deck space is adequate for smaller devices - single bridge
Waves	- waves are generated by a simple plunger mechanism - no indication of size, frequency of waves.
Ice	- this is an indoor facility using synthetic ice
Saline Water	- saline water is not used but may be possible.
Test Fluids	- tank operator will accept synthetic and real oils.
Water Quality	- limited filtering capability
Data Gathering	- adequate for stationary testing - requires review for advancing trials - viewing ports are built-in.
Analysis	- available services is limited to ice analysis - chemical analysis by outside contract
Ancillaries	- lifting capability is not indicated; - technical staff and workshops on site.

Summary - Fleet Technology Ltd. Ice Modelling Tank

Fleet Technology's ice modelling tank in Calgary is relatively small. It could only be used for the limited testing of advancing systems if the single bridge (or other means) allows adequate data collection (the towing and carrying capacity are limited). Stationary device testing is possible as well as the limited investigation of dispersants. Wavemakers require improvement for open water testing.

The main advantages of this facility are the experienced staff, willingness to use oil in testing, and past experience with oil spill test procedures. These attributes are outweighed by the small dimensions and lack of substantial carriage which severely limit the scale of possible tests.

Fleet Technology Ltd. Ice Tank
Kanata, Ontario

Configuration	- mobile skimmer testing, dispersant work and burning are not possible - the evaluation of stationary devices is restricted to smaller units.
Bridges	- there is one bridge of limited capacity.
Test Setup	- adequate deck space - bridge limitations allow stationary testing only
Waves	- limited capability is achieved via a simple mechanical plunger
Ice	- refrigeration produces natural ice.
Saline Water	- the water salinity is variable
Test Fluids	- operator will allow synthetic and real oils.
Water Quality	- limited filtering capability - outside contractors employed for residue disposal following oil tests
Data Gathering	- space allows good data collection for stationary testing of small devices - video capability is unknown
Analysis	- available services is limited to ice analysis - chemical analysis by outside contract
Ancillaries	- shops on site - lifting capability unknown - staff has oil spill experience.

Summary - Fleet Technology Ice Tank

Dimensions of Fleet Technology's ice tank will limit its application to tests of smaller stationary oil spill control devices. Although there is a single bridge system, the evaluation of advancing systems is not be possible; the tank is too small to produce steady-state data. Wave data/recording capability is not available.

Technical staff are experienced in spill matters, and oils are permitted in the tank. This facility will not provide an alternative to OHMSETT. The tank should be considered for the assessment of small stationary skimmers, pumps, hoses, separators, etc. in the case of specific test programs requiring cold climate conditions.

Esso Resources Canada Ltd. Test Basin
Calgary, Alberta

Configuration	- dynamic testing is limited to 60 second runs at 1-2 knots - stationary testing, dispersant work, and burning experiments are possible - restricted water depths prevent the evaluation of large advancing devices
Bridges	- One travelling bridge with a vertically adjustable platform - bridge capacity of 10,000 lbs vertically and 5000 lbs horizontally - variable speed up to 0.3 m/s - also available is a motorized trolley system consisting of two trolleys, one on each side of the tank.
Test Setup	- adequate deck space and lifting capacity allows large devices
Waves	- small but adequate computer-controlled hydraulic generator produces medium height waves
Ice	- this is an outdoor facility with ice testing as a primary function - refrigeration units are available to enhance ice growth
Saline Water	- salt water was used in past work
Test Fluids	- operator will accept synthetic and real oils
Water Quality	- no filtering capability is present - expanded oil spill test program could increase oily discharges to the municipal sewer
Data Gathering	- adequate for stationary testing but limited for advancing tests - no viewing ports or underwater cameras.
Analysis	- services are likely to be limited in the future due to recent sale of part of the property surrounding the facility
Ancillaries	- lifting capability is adequate - workshops will be limited in the future - capable technical staff but upcoming move to a new research facility away from the tank may reduce their availability in the future (requires confirmation)

Summary - Esso Resources Canada Ltd. Basin

The Esso tank is suitable for the evaluation of smaller stationary and advancing spill control devices and other countermeasures techniques, inclusive of burning, which call for the use of real or synthetic oils. The removable wave generation capability is a noteworthy feature.

An equipment evaluation program expanded to include mobile tests must consider additional features (see below). The discharge of hydrocarbons to the domestic sewerage system will require further assessment. It is difficult to foresee this practice continuing to be allowed by the City of Calgary.

Presently the carriage is capable of towing at speeds up to 0.3 m/s. The carriage speed could be increased at moderate expense. The bridge is intended for viewing and equipment mounting but of course could be used for towing. The original trolley system is also still in place. It has a maximum speed of 0.3 /s as which can be increased at moderate expense by changing the drive cog wheels.

Factors to consider in an overall assessment of this facility include:

* the lack of viewing ports (may be unimportant given the poor water clarity)
* lack of filtration capability (oily water is discharged to Calgary sewers)
* the limited nature of analytical instrumentation
* conflict with existing Esso priorities in offshore engineering
* potential conflict of interest in using an oil industry facility
* necessity for saline water
* potential for spilling real oil, including burning and chemical dispersion
* recent sale of property and buildings along with relocation of staff

The recent (1989) sale of buildings and relocation of staff to facilities at the University of Calgary could influence the extent to which the tank (which will remain the property of Esso) might be used for spill technology studies by outside user groups. Regardless of the property transaction, Esso's engineering research needs will continue to dictate future use of the tank.

The Esso tank is the only Canadian facility with the potential for a comprehensive spill technology evaluation program including both stationary and advancing tests and using real oil in open water and ice.

Institute for Marine Dynamics Ice Tank
St. John's, Newfoundland

Configuration	- advancing trials are limited to 70 second runs at 1-2 knots - dispersant and burning tests are not possible - the size allows stationary evaluations of spill devices **(without oil)**
Bridges	- one only available at present
Test Setup	- deck space and lifting are adequate for large devices - limitations of a single bridge space - limited availability (require long lead time advance planning)
Waves	- there is no capability to generate waves in the ice tank
Ice	- this is an indoor facility with refrigeration
Saline Water	- saline water is not used at present but may be possible (given compatibility with rubber seals and/or tank coatings)
Test Fluids	- operator will not accept synthetic or real oils.
Water Quality	- there is no filtering capability - tank cannot be drained (a major problem)
Data Gathering	- underwater video cameras are available but small carriage will limit data gathering for advancing tests
Analysis	- no analytical services are available at present.
Ancillaries	- lifting capability is adequate - wood and metal shops - technical staff (no previous experience with spill testing)

Summary - Institute for Marine Dynamics Ice Tank

The NRC ice tank in St. John's is not suitable for testing spill control equipment. There is no hope of either real or synthetic oil ever being allowed in the tank, no filtering capability, limited bridge capacity, no analytical services, no possibility of burning experiments, and limited scheduling opportunities.

No further consideration of the IMD ice tank is recommended insofar as an OHMSETT program is concerned. Note: the tank has considerable potential for engineering tests which do not require the presence of oil. This facility is a world class ice tank.

Institute for Marine Dynamics Towing Tank
St. John's, Newfoundland

Configuration	- three minute trials at 1-2 knots are possible. - dispersant and burning trials are not feasible. - the tank size allows a range of tests
Bridges	- one bridge only
Setup	- deck space is unknown
Waves	- good wave generation capability with beach in place
Ice	- this is an indoor facility with no ice production
Saline Water	- saline water is not used now and is unlikely.
Test Fluids	- operator will not accept synthetic nor real oils.
Water Quality	- no filtering capability
Data Gathering	- video and underwater capability
Analysis	- no analytical services are indicated.
Ancillaries	- lifting capability is adequate - range of shop services and technical support staff

Summary - Institute for Marine Dynamics Towing Tank

The dimensions of this facility are suited to advanced and stationary testing programs exclusive of burning. However, the present policy of no testing with oil precludes the tank from further consideration.

The width of the tank is somewhat narrow but still allows the testing of most commercial skimming devices. The towing tank is a world class modern facility with considerable potential for basic research into fundamental fluid dynamics problems affecting the design of booms and skimmers.

Institute for Marine Dynamics Maneuvering Basin
St. John's, Newfoundland

Configuration	- limited advancing trials of 70 seconds are possible at 1-2 knots - tank size is ideal for large scale stationary tests - dispersant application and burning not feasible.
Bridges	- none at present (unlikely in the future due to 32 m width)
Test Setup	- adequate space allowing testing of large devices
Waves	- computer-controlled hydraulic system with a beach
Ice	- not available
Saline Water	- not used
Test Fluids	- operator will not accept synthetic or real oils
Water Quality	- no filtering capability and tank cannot be drained
Data Gathering	- adequate for stationary testing incl. underwater video & cameras.
Analysis	- as per other IMD facilities
Ancillaries	- as per other IMD facilities

Summary - Institute for Marine Dynamics Maneuvering Basin

Dimensionally, this tank is suited for the comprehensive testing of stationary spill control devices and techniques. There is also no filtering capability nor intention of draining the tank. Limited testing of advanced systems may be possible if the oil and filtering problems were solved. The width of the tank prevents the incorporation of a practical bridge system to allow oil distribution, collection and data gathering. This facility is not yet commissioned for use at time of writing.

The overall conclusions with regard to the Maneuvering Basin is the same as those reached for the other IMD facilities. Regardless of their advanced technical capabilities for hydrodynamic testing, neither the tanks or basin are potential candidates for an OHMSETT type program (without a complete reversal in management's policy towards oil spill research).

Institute for Marine Dynamics Maneuvering Basin (M-42)
Ottawa, Ontario

Configuration	- tank size allows two minute tests at 1-2 knots - stationary trials, dispersant work, burning are all feasible
Bridges	- the basin has no bridge (size precludes a conventional bridge) - a simple advancing system with pulleys or rails is possible for a limited range of tests
Setup	- deck space is satisfactory - observation tower for cameras or remote sensing systems
Waves	- pneumatic-controlled generator is adequate (regular waves are produced and there is a wave absorber
Ice	- ice tests are possible during the winter months
Saline Water	- use of saline water is possible (not normal)
Test Fluids	- operator has accepted usage of real oils in recent tests (the future continuation of this policy is uncertain)
Water Quality	- there is no filtering capability (tank drains to sewer or river)
Data Gathering	- adequate for stationary testing - observation tower is extremely useful
Analysis	- full range of services available through NRC.
Ancillaries	- moderate on-site lifting capacity - limited staffing - simple shop facilities and storage on site

Summary - Institute for Marine Dynamics Maneuvering Basin (M-42)

The NRC outdoor tank has been used in the testing of stationary spill control devices with oil. At 61 m, this is the widest tank in Canada; the incorporation of a bridge system would require innovative concepts. The lack of a bridge will preclude the evaluation of advancing systems in a manner similar to OHMSETT.

In spite of previous indications burning may be possible, NRC officials maintain that combustion experiments are extremely unlikely regardless of wind direction (sensitivity to local residents). Management are considering whether or not to implement a new program of ship testing in the tank which would preclude its use for oil spill experiments.

Institute for Marine Dynamics Towing Tank (M-22)
Ottawa, Ontario

Configuration	- 130 second tests at 1-2 knots are possible. - stationary trials, burning experiments, and dispersant applications are not possible
Bridges	- single carriage
Test Setup	- limited deck space
Waves	- flap-type unit with adequate wave-generating characteristics
Ice	- this indoor facility does not utilize ice (see IMD St. Johns)
Saline Water	- saline water is not used
Test Fluids	- operator will not accept synthetic nor real oils
Water Quality	- there is no filtering capability.
Data Gathering	- viewing ports; - new data acquisition system being installed (1989)
Analysis	- analytical services are available through NRC
Ancillaries	- lifting capability is adequate - both workshops and staffing are now limited

Summary - Institute for Marine Dynamics Towing Tank (M-22)

The current policy for this tank calls for no oil use. Otherwise, its physical dimensions would allow a moderate amount of towed testing. The evaluation of smaller devices would be limited in the stationary mode by the narrow tank width. Burning experiments could not be undertaken.

Other limiting factors which preclude this tank as a replacement for OHMSETT include:

*no filtration
*limited permanent staff
*90% commitment to existing programs
*one carriage system

National Water Research Institute - Towing Tank
Burlington, Ontario

Configuration	- tests of 2 minutes duration at 1-2 knots are possible. - stationary trials are limited by size - dispersant application and/or burning are not feasible.
Bridges	- single bridge at present
Test Setup	- limited deck space - moderate lifting capability.
Waves	- there is no wave-generating equipment.
Ice	- no ice production capability
Saline Water	- saline water is not possible (the tank cannot be drained)
Test Fluids	- the use of synthetic oil is highly unlikely (given lack of drainage) - the use of real oil is not possible
Water Quality	- sediment filtering capability
Data Gathering	- single carriage
Analysis	- full range of services available in the associated facilities.
Ancillaries	- satisfactory lifting capability - shops and technical staff

Summary - National Water Research Institute Towing Tank

The narrow width of this tank, limited filtering system, lack of wave generator, no opportunity for burning tests and limited availability eliminate this facility as a replacement

However, management indicated its willingness to consider the use of synthetic oils in tank tests. The National Water Research Institute houses excellent technical staff and ancillary services related to hydraulic testing.

Newfoundland & Labrador Institute of Fisheries & Marine Technology Recirculating Flume, St. John's, Newfoundland

Dimensions	- tests to 2 knots are possible for a range of advancing systems and boom sections
Bridges	- not applicable to a flume configuration (water is already moving)
Test Setup	- adequate associated space
Waves	- no wave-generating capability is present.
Ice	- no production capability
Saline Water	- salt water is not used at present nor desired
Test Fluids	- operator indicates possible synthetic oil use
Water Quality	- "basic" filtering capability (requires further evaluation)
Data Gathering	- excellent opportunities for underwater viewing and video
Analysis	- likely available in St. John's or through the University
Ancillaries	- adequate lifting capability - excellent shops - technical support staff

Summary - Newfoundland & Labrador Institute of Fisheries & Marine Technology Recirculating Flume

This flume facility presents an intriguing alternative to the OHMSETT tank. Its size would preclude the testing of the largest skimming units but would otherwise allow the evaluation of many small-to-mid size advancing systems. Further examination of the filter's ability to process oil is required. The bottom moves to eliminate its hydraulic influence.

The flume should be viewed as a possible means to conduct design work and preliminary hydrodynamic testing of prototype devices, and model development.

Mr. R. Griffiths of E.P.A. expressed his interest in this type of facility mainly because relative velocities can be quickly and infinitely adjusted (within the limits of available capabilities) to study behavioural phenomena. Carefully controlled flume testing can be utilized to precisely determine hydraulic interactions between devices and moving water past them.

Additional discussion of the hydrodynamic test potential of this unique Canadian facility is included as Chapter 4.3.

Memorial University Towing Tank
St. John's, Newfoundland

Dimensions	- advancing tests of 60 seconds at 1-2 knots are possible - limited opportunity for stationary assessments - burning, dispersant work not feasible
Bridges	- one only
Setup	- limited deck space
Waves	- wave generation covers regular/irregular waves to <0.4 m.
Ice	- no ice capability
Saline Water	- no saline water is not used at present nor possible
Test Fluids	- operator will consider synthetic not real oils
Water Quality	- limited filtration capability
Data Gathering	- unknown capability
Analysis	- full range of services likely available through Memorial University.

Summary - Memorial University Towing Tank

The narrow width of the Memorial University tank will restrict any testing to smaller devices only. Advancing systems studied will require the incorporation of a bridge system to accommodate oil distribution and collection as well as instrumentation.

The negative aspects of this facility include the simple filtration system, inability to test large devices, lack of ice, inability to conduct burning experiments, and unknown nature of ancillaries (shop, available personnel, video, etc.).

Positive attributes include low cost and availability for extended periods.

DME-NRC Coastal Wave Basin
Ottawa, Ontario

Dimensions	- basin size allows one minute tests at 1-2 knots - burning, dispersant work not feasible
Bridges	- one manually propelled service bridge (1 tonne capacity)
Setup	- sufficient deck space
Waves	- wave generation covers regular/irregular waves to <0.5 m.
Ice	- no ice capability
Saline Water	- use of saline water is possible (not normal)
Test Fluids	- operator will not accept synthetic nor real oils
Water Quality	- there is no filtering capability
Data Gathering	- no viewing ports; full range of computers and collection equipment
Analysis	- full range of services

Summary - DME-NRC Coastal Wave Basin

The Coastal Wave Basin offers no advantages over the adjacent M-42 tank operated by IMD. In particular, the wave basin is smaller, will not accept real or synthetic oil, and will not allow burning.

DME-NRC Multidirectional Wave Basin
Ottawa, Ontario

Dimensions	- basin size allows 50 second tests at 1-2 knots - burning, dispersant work not feasible
Bridges	- the basin has no bridge
Setup	- 3 m all round
Waves	- wave generation covers regular/irregular waves to <0.75 m. - short crested waves possible
Ice	- no ice capability
Saline Water	- use of saline water is possible (not normal)
Test Fluids	- operator will not accept synthetic nor real oils
Water Quality	- there is a 4 ft diameter sand filter with chlorinator
Data Gathering	- no viewing ports; full range of computers and collection equipment
Analysis	- full range of services

Summary - DME-NRC Multidirectional Wave Basin

The Multidirectional Wave Basin offers no advantages over the adjacent M-42 tank operated by IMD. In particular, the wave basin is smaller, will not accept real or synthetic oil, and will not allow burning.

The wave making capabilities of the DME-NRC wave basin are currently the best in Canada (this situation may change once the IMD Maneuvering Basin becomes fully operational). Multi-directional seas can be produced as well as regular or irregular long-crested waves. The test pit can be used for testing of deeper draft equipment. The Multidirectional Wave Basin is suitable for stationary testing of equipment behaviour in waves.

DME-NRC Cold Room Ice Tank
Ottawa, Ontario

Configuration	- restricted testing of 40 seconds duration at 1 knot - burning is not possible
Bridges	- one bridge capable of towing 5 tonnes at a maximum speed of 0.5 m/s
Test Setup	- one meter walkways all round
Waves	- there is no wavemaker
Ice	- ice capability (temperature range: -20 to 15 °C) - use EGADS ice
Saline Water	- use of saline water is not possible
Test Fluids	- operator will not accept synthetic or real oils
Water Quality	- there is no filtering capability
Data Gathering	- no viewing ports; full range of computers and collection equipment
Analysis	- full range of services

Summary - DME-NRC Ice Basin

The dimensions of the ice basin at DME-NRC and the policy against spilling oil limit its use to hydrodynamic tests of smaller, stationary, oil spill control devices. At only 21 m, the ice basin is not long enough to produce steady state data during advancing tests.

Technical staff are experienced with testing in ice.