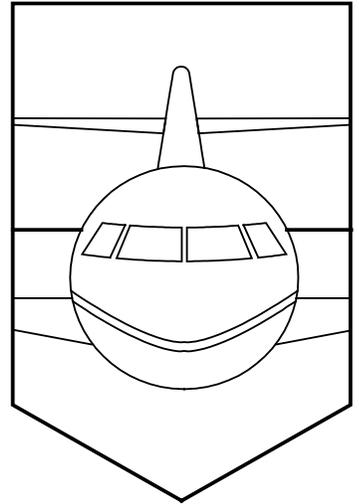
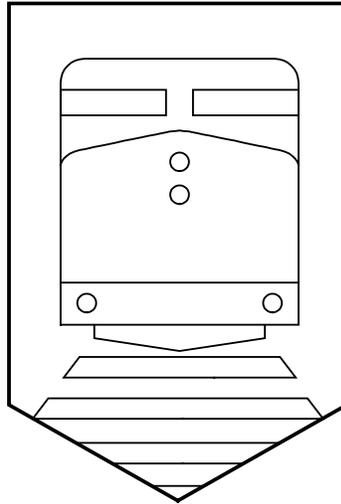
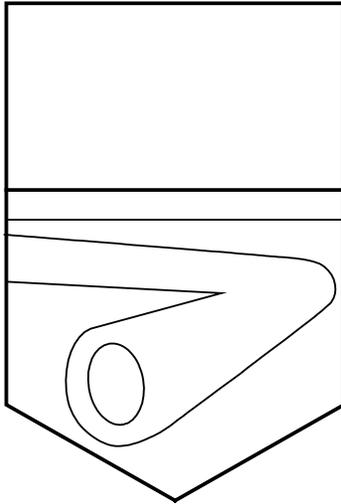
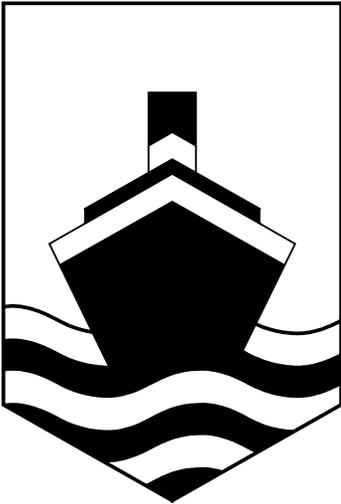




Transportation Safety Board
of Canada

Bureau de la sécurité des transports
du Canada



MARINE OCCURRENCE REPORT

**TAKING ON WATER, HEELING, DOWNFLOODING
AND SINKING**

**VESSEL "SHOWBOAT"
ONTARIO PLACE, TORONTO, ONTARIO
23 AUGUST 1995**

REPORT NUMBER M95C0045

Canada

MANDATE OF THE TSB

The *Canadian Transportation Accident Investigation and Safety Board Act* provides the legal framework governing the TSB's activities.

The TSB has a mandate to advance safety in the marine, pipeline, rail, and aviation modes of transportation by:

- conducting independent investigations and, if necessary, public inquiries into transportation occurrences in order to make findings as to their causes and contributing factors;
- reporting publicly on its investigations and public inquiries and on the related findings;
- identifying safety deficiencies as evidenced by transportation occurrences;
- making recommendations designed to eliminate or reduce any such safety deficiencies; and
- conducting special studies and special investigations on transportation safety matters.

It is not the function of the Board to assign fault or determine civil or criminal liability.

INDEPENDENCE

To encourage public confidence in transportation accident investigation, the investigating agency must be, and be seen to be, objective, independent and free from any conflicts of interest. The key feature of the TSB is its independence. It reports to Parliament through the President of the Queen's Privy Council for Canada and is separate from other government agencies and departments. Its independence enables it to be fully objective in arriving at its conclusions and recommendations. Its continuing independence rests on its competence, openness, and integrity, together with the fairness of its processes.

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Transportation Safety Board
of Canada

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du Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Marine Occurrence Report

Taking on Water, Heeling, Downflooding and Sinking

Vessel "SHOWBOAT"
Ontario Place, Toronto, Ontario
23 August 1995

Report Number M95C0045

Synopsis

On the evening of 23 August 1995, the twin-hulled "SHOWBOAT" departed the eastern end of Ontario Place with 39 persons aboard, 6 of whom were crew members. About 10 minutes later, both engines failed and the vessel started to list to starboard. While moving ahead at a slow speed, the "SHOWBOAT" struck a sea wall causing many of those on board to lose their footing. The vessel heeled to starboard, the starboard main deck edge became submerged, and all on board fell into the water. The vessel downflooded, sank and settled upright on the bottom in 1.8 metres of water. All on board were rescued and assisted to shore by the crew, the public and Ontario Place personnel.

The Board determined that the uninspected "SHOWBOAT" was heavily laden, downflooding and slowly sinking before it struck the sea wall. There was no life-saving equipment on the vessel, but all on board were rescued promptly because the vessel sank close to shore in relatively shallow water. Contributing to the accident was the absence of clearly defined responsibility for the management of safety and for maintenance, the lack of guidance to the operators regarding the weight the vessel could carry safely, and the modification to the vessel's transom through which water downflooded.

Ce rapport est également disponible en français.

1.0	Factual Information	1
1.1	Particulars of the Vessel	1
1.1.1	Description of the Vessel	1
1.2	History of the Voyage	2
1.2.1	Ontario Place Management Policy on Vessel Use	3
1.3	Injuries to Persons	4
1.3.1	Rescue of Those on Board	4
1.4	Damage to the Vessel	4
1.5	Certification	4
1.5.1	Vessel	4
1.5.2	Personnel	4
1.6	Personnel History	4
1.7	Weather Information	5
1.8	Radio Communication	5
1.9	Life-saving Equipment	5
1.10	Modification to the Transom	5
1.11	Railing – in Comparison to Passenger Vessels	5
1.12	Stability	6
1.12.1	Inclining Experiment	6
1.12.2	Quantity of Water Shipped	6
1.12.3	Small Vessel Capacity Plate	7
2.0	Analysis	9
2.1	Management and Vessel Operation	9
2.2	Safety Consciousness of Management and Crew	9
2.3	Vessel Maintenance	9
2.4	Vessel Construction and Ingress of Water	10
2.5	Rescue of Persons	10
2.6	Stability Overview	11
3.0	Conclusions	13
3.1	Findings	13
3.2	Causes	14
4.0	Safety Action	15
4.1	Action Taken	15
4.1.1	Buoyancy Foams for Marine Use	15
4.1.2	Operation and Seaworthiness	15
4.1.3	Measures Taken by Ontario Place	15
5.0	Appendices	
	Appendix A - Sketch of the Occurrence Area	17
	Appendix B - Photographs	19
	Appendix C - Glossary	25

1.0 Factual Information

1.1 Particulars of the Vessel

	"SHOWBOAT"
Licence Number	5OE57755
Port of Registry	Toronto, Ont.
Flag	Canada
Type	Twin-hull utility boat
Gross Tons	3.83
Length	9.53 m
Draught	0.81 m
Crew	6
Others on Board	33
Built	Aero-Marine Oakville, Ont.
Propulsion	Two 90 hp outboard gasoline motors
Owners	Ontario Place Inc. Toronto, Ont.

1.1.1 Description of the Vessel

The vessel was reportedly built for its present owners in 1973. The manufacturer is no longer in business.

The hull consists of two long semi-elliptical hulls spanned by a deck. Above this deck, a second, flat, main deck extends from bow to stern. The space between these decks forms a compartment which is open at the stern above the transom. The transom extends across both hulls and forms a deep well in each. Fibreglass was delaminating from the wood construction in the engine wells, port and starboard, and water was seeping into the vessel. In each well, there is an automatic bilge pump with a capacity of about 1.3 l/s. A 90 hp outboard engine is mounted on the transom in both the port and starboard deep wells. On the lower deck, between the hulls, is mounted a generator. The weight of the motors and generator caused a permanent trim by the stern.

At the bow, there is a small bulwark to deflect water and spray. The operator's control station is on the starboard side, immediately abaft this bulwark. A steel railing, with openings for boarding, encloses the main deck aft of the bulwark. Above the railing, there is a canopy supported by an aluminium framework. No seating is provided for those on board, with the exception of the operator.

In 1978, the two hulls were filled non-uniformly with aeromastic polyetherurethane foam. Under the lower of the two decks spanning the twin hulls, the foam compartments are about 33 cm in height. The foam extends from about 1 m from the after end (clear of the deep wells) to the bow. The volume of the foam was calculated to be about 3.6 m³. The foam type was identified by a chemical analysis performed by the TSB Engineering

¹ See Glossary for all abbreviations and acronyms.

² Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System (SI) of units.

Laboratory, and its dry density was established to be 0.22 g/cm³.

1.2 *History of the Voyage*

At 1900 on 23 August 1995, 33 gospel singers, who had been hired by Ontario Place for a performance, boarded the "SHOWBOAT" to be transported to the area where they were to perform. On board, there was also a crew of six, who worked for the "Entertainment" department of Ontario Place.

A quantity of musical equipment, speakers and amplifiers, the weight of which was unknown, was also brought aboard and located centrally on the main deck. All on board were situated within the area enclosed by the vessel's guard rail. The after main deck edge reportedly was approximately 3 cm above the waterline when boarding was completed.

The operators of the "SHOWBOAT" indicated that the method used to determine the vessel's maximum load was guesswork -- an indication of proper loading was whether the vessel "looked right". The "SHOWBOAT" reportedly had been loaded several times in the past to a condition similar to that existing at the time of departure on the day of the occurrence.

At 1915, the "SHOWBOAT" departed from a location adjacent to the eastern parking area of the Ontario Place main office for its destination about 1 km away. The depth in the channel for most of the projected journey was over 3 m. As the "SHOWBOAT" passed a finger dock of a marina facility, some people on shore observed that the stern was very low in the water, the exhaust ports of the two outboard engines were submerged and there was no freeboard aft. A minute later, they heard one of the engines stop and then the other. The operator attempted unsuccessfully to restart the engines.

The "SHOWBOAT" was now without power or steering and was drifting ahead at an estimated 3 to 3¹/₂ knots at an acute angle toward a sea wall on its starboard side. The vessel had developed a starboard list which was increasing. As the "SHOWBOAT" closed on the sea wall, one of the crew members attempted to cushion the impending impact by fending off with his legs. He was unable to do so, and the vessel's starboard shoulder struck the sea wall.

The impact with the sea wall caused most of the people on board to lose their footing and move rapidly toward the starboard side. The vessel heeled some 45 degrees to starboard. The majority of the persons on board, including one who was disabled, fell into the water as the starboard main deck edge became submerged. The vessel then settled upright on the bottom with the bow projecting slightly above the surface. In this area, the water is between 1.5 and 1.8 m deep.

1.2.1 *Ontario Place Management Policy on Vessel Use*

At the time of the occurrence, a number of Ontario Place departments, i.e. "Rides and Attractions", "Entertainment", or "Marine Activities", were using the "SHOWBOAT" for their own purposes on a first-come, first-served basis. The departments scheduled the activities of the "SHOWBOAT"; e.g. equipment and stage props could be transported throughout Ontario Place, or a band could play on the vessel while it proceeded through the park. Each department supplied its own operator and crew and was responsible for the operation and safety of the vessel while under its control.

Ontario Place did not provide an on-board emergency plan for the safety of persons carried aboard the "SHOWBOAT". Small fast boats, equipped with first aid equipment and radios are on patrol, but these may not necessarily be close in an emergency situation. There was no overall

s laboratory report (No. LP 120/95) is available from the TSB upon request.

times are EDT (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

documented contingency plan to respond to emergencies such as in this instance.

Hull and engine maintenance was performed by the "Rides and Attractions" section of the "Maintenance" department. There was no follow-up to ensure compliance with an Ontario Place directive that the individual departments using the vessel provide the necessary personal safety equipment on board the "SHOWBOAT".

There was no life-saving equipment of any type aboard the "SHOWBOAT". Other Ontario Place small licensed vessels which transport the public are equipped with fixed seating and carry sufficient lifejackets and other life-saving equipment for each person on board. These vessels also are not subject to inspection by Transport Canada as they are not classed as passenger vessels and do not trade between provinces.

Since the occurrence, all marine safety aspects of the operation of the "SHOWBOAT" and of Ontario Place passenger-carrying vessels have become the responsibility of the "Marine Operations" department.

1.3 Injuries to Persons

Eight persons were reported to have suffered injuries including bruised or injured hands, hips, lower backs and ankles.

1.3.1 Rescue of Those on Board

Most of the gospel singers were hampered by their gowns but were quickly assisted to shore by the crew, the public and Ontario Place personnel. They were attended to by a registered nurse, first aid and other Ontario Place personnel. Some of the gospel singers reported being hindered by crew who had remained on the vessel to attempt to remove sound equipment while the vessel was settling to the bottom. Other gospel singers were reported to have assisted in the recovery of the equipment.

No one donned a lifejacket; none was available.

1.4 Damage to the Vessel

The vessel sustained minor damage at the starboard bow at the same place where there had been previous minor damage. There was also minor water damage to the engines. Other damage occurred while the vessel was being salvaged.

After salvage, the vessel was withdrawn from service and sold for parts. The replacement "SHOWBOAT" is of different design.

1.5 Certification

1.5.1 Vessel

The vessel was licensed as a pleasure craft.

1.5.2 Personnel

The operator of the "SHOWBOAT" was required to and did hold a Toronto Harbour Operator's licence issued by the Toronto Harbour Commission. He did not have any level of Transport Canada certification, nor was such certification required for this operation.

1.6 Personnel History

The operator and crew of the "SHOWBOAT" had marine experience limited to seasonal employment with the Ontario Place administration. The

operator had worked as such for several summer seasons.

1.7 Weather Information

At the time of the occurrence, winds were light and visibility was good. Civil twilight commenced at 2008.

1.8 Radio Communication

The crew operating the boat was in radio contact with the Ontario Place main office by means of portable radios equipped with an ultra-high frequency (UHF) band and a very high frequency (VHF) band. The VHF band radio frequency in use was not a marine frequency. These portable radios performed satisfactorily.

1.9 Life-saving Equipment

The "SHOWBOAT" did not comply with the requirements respecting life-saving equipment as prescribed by the *Canada Shipping Act* for a vessel of its size and class.

At the after end of the vessel, directly beneath the canopy, is a screen grating designed for lifejacket storage. At the time of the occurrence, there was no lifejacket nor personal flotation device stowed there. The vessel did not carry a liferaft, any form of flotation device, a lifebuoy, an anchor or a sternlight, nor were there any emergency pyrotechnics aboard.

1.10 Modification to the Transom

An opening of some 18 cm in diameter had been cut in the transom to create an air flow to the generator. A coping designed to prevent water from downflooding to the generator space had been fitted over the hole. It is unknown when this modification had been carried out. The upper edge of this coping is 11 cm below the extension of the main deck edge. It was reported that the water was within approximately 3 cm of the deck edge at the time of departure. If the report is correct, the top of the coping was under water at this draught, and water was flooding into the vessel. This was not observed by the crew, but the inflow was countered to some extent by the two bilge pumps, one port and one starboard. The combined capacity of the pumps was about 2.6 l/s.

1.11 Railing -- in Comparison to Passenger Vessels

The railing on the vessel rises 737 mm above the deck with posts 305 mm apart without any strong netting. On a passenger vessel, rail posts must be no more than 229 mm apart, unless strong netting is provided, and the perpendicular height must not be less than 1,067 mm above the deck.

1.12 Stability

There is no regulatory requirement for the submission of stability data for a pleasure craft; however, the "SHOWBOAT" is generally used as a multi-function utility boat, depending on the needs of the departments using it. The vessel frequently carries more than 12 persons and varying amounts of cargo, but the people it transports do not fit the definition of "passenger" as found in the *Canada Shipping Act*.

For the purposes of the stability calculations in this report, STAB. 5, "Standard for the Intact Stability of Passenger Vessels Carrying More than 12 Passengers", of the *Stability, Subdivision, and Load Line Standards* (TP 7301) and the *Construction Standards for Small Vessels* (TP 1332) were used as references.

The calculation of the transverse stability characteristics of a vessel is based upon the "ideal" static sea state, and in actual dynamic sea conditions, angles of roll are usually greater than those calculated by the "static" methods. The interacting effects of wave-induced motion, wind, and vessel speed, subject the calculated reserve stability of small vessels to considerable fluctuation. In this instance, the simultaneous interaction of a number of separate dynamic effects, such as the shift of the vessel's centre of gravity due to people moving about the deck and the virtual rise of the centre of gravity due to the presence and movement of free surface water, overcame the vessel's remaining righting ability.

1.12.1 Inclining Experiment

The vessel was measured and inspected while out of the water. Once refloated, it was prepared for an inclining experiment to determine its basic stability characteristics. The experiment, conducted on 30 August 1995, consisted of shifting weights transversely across the deck of the vessel when it was free to heel. The angle of heel was measured by the shift of a plumb line along a graduated scale. For analysis purposes, the weight of 39 persons was used to approximate the vessel's loaded condition at the time of the accident. The inclining experiment determined that the lightship weight of the "SHOWBOAT" was 3,836 kg, with a vertical centre of gravity (VCG) of 0.72m.

1.12.2 Quantity of Water Shipped

The departure condition at 1915 is unknown, except that the stern freeboard was observed as being approximately 3 cm below the main deck edge.

The total displacement of the vessel when it struck the sea wall at 1925, as determined from information gathered and by calculation, was about 13,500 kg.

The average weight of the people involved in the occurrence was probably greater than the 63.5 kg per person used as a standard in STAB. 5. This extra weight and the weight of the sound and musical equipment aboard were estimated to have been about 250 kg. Thus, it is concluded that the vessel had taken on a total of about seven tonnes of water.

1.12.3 Small Vessel Capacity Plate

The tonnage of the "SHOWBOAT" was determined to be under five gross tons.

The Ontario Place administration had licensed the vessel as a pleasure craft under the Small Vessel Regulations. Since the vessel was over 5 m in length, Section 3 of Part I of the *Construction Standards for Small Vessels*, which deals with "Capacity Plates", did not apply. This plate, which gives the safe maximum load and recommended outboard motor size, is permanently attached to a vessel in a plainly visible position on board.

³ The naval architecture report, *Report of Stability and Capacity, "SHOWBOAT"*, is available from the TSB upon request.

2.0 Analysis

2.1 Management and Vessel Operation

The vessel was licensed as a pleasure craft and was operated by Ontario Place, a Province of Ontario Crown Corporation, as a utility craft/work-boat which transported both Ontario Place employees and others throughout the park.

Because the vessel was licensed as a pleasure craft, it was not required to be inspected by Transport Canada Marine Safety. However, whether it was inspected or not, it was required to carry safety equipment sufficient for the number of people on board.

The lack of on-board safety equipment may have been due to responsibility for the vessel's operation being shared between different departments of Ontario Place. The result of this division of responsibility was that no one department had a clear mandate to ensure that the vessel was properly maintained and equipped.

As a result of the occurrence, the "Marine Operations" department of Ontario Place has taken over responsibility for all life-saving and safety equipment for all vessels owned and operated by Ontario Place. Individual departments operate the vessels for which they are responsible.

2.2 Safety Consciousness of Management and Crew

Because the vessel had no safety equipment at all on board and there was no regime in place to ensure that there was, it is apparent that there was a lack of safety consciousness on the part of both management and the vessel's crew.

The fact that the vessel operated in protected waters may have contributed to a false sense of security and to a degree of complacency. The public may also have had a false sense of security while aboard the "SHOWBOAT" because a provincial Crown Corporation operated the park and its vessels.

The vessel's operators, who were seasonal employees, were unaware of the maximum cargo/persons which could be carried safely because no department supplied guidelines on the matter and there was no capacity plate posted on the vessel to give operators guidance.

2.3 Vessel Maintenance

As the need arose over the years, modifications to the "SHOWBOAT" were made, usually by the "Rides and Attractions" section, which also carried out the vessel's maintenance. The full extent to which these modifications altered the original builder's design characteristics and stability criteria is, in general, unknown. However, one modification, the hole cut in the transom to duct air to the vessel's retrofitted generator, was a major contributing factor to the occurrence.

Because the vessel did not have an assigned loadline, it could not have been overloaded, in the regulatory sense, on the day of the occurrence. However, the weight of the people and equipment on board was such that the vessel's effective freeboard aft was reduced to the point where water was free to flow at first through the hole in the modified transom and later over the transom. The bilge pumps were unable to cope with the volume of water, and the vessel slowly sank.

2.4 Vessel Construction and Ingress of Water

Although controlled by the automatic bilge pumps, water was seeping into the hulls where the fibreglass was delaminating from the wood construction in the engine wells, port and starboard. The foam in each hull essentially had deteriorated over the years to such an extent that it had, unnoticed, become hygroscopic.

Over time, it had absorbed an undetermined volume of water, and as it deteriorated, would progressively absorb more. The TSB Engineering

Laboratory report shows various ways in which this type of foam can deteriorate after a 10- to 15-year life cycle. It is unknown if this eventuality was known or considered before or since the foam had been injected some 15 years prior to the occurrence.

The space between the upper and lower decks was common with the generator and motor well open spaces at the transom. It was sub-divided into three compartments separated by two longitudinal non-watertight bulkheads. Consequently, once water flooded over the coping and through the hole cut in the transom for the generator air duct, it quickly flooded both the generator and motor deep wells, and these compartments no longer contributed to the vessel's buoyancy.

2.5 Rescue of Persons

The vessel heeled and sank in relatively shallow water, next to a sea wall and to a public walkway. Had the accident occurred at other locations along the vessel's projected route, the depth of water could have been greater and the location not as readily accessible to the public who, in this instance, was able to assist in the rescue. Without this assistance, swimmers and non-swimmers alike would have experienced considerable difficulty in reaching shore, hampered as they were by their gowns.

As it was, the crew of the "SHOWBOAT" and members of the public, who had seen the events unfolding, reacted quickly and, together, rescued those on board. Other Ontario Place personnel also assisted.

2.6 *Stability Overview*

Based on the vessel's loading condition of 23 August 1995, the investigation has shown clearly that the "SHOWBOAT" was heavily laden.

Flooding had commenced before departure at 1915 when the weight of the persons who had boarded was sufficient to load the "SHOWBOAT" to the point that the coping over the hole cut in the transom became submerged. Water then entered in volume through the generator air duct opening in the transom.

The automatic bilge pumps would have been running continuously at full capacity. It is most likely that the operator did not hear them because of the distance between the control position and the stern and of the ambient noise made by the people on board and by the outboard motors.

When both motors failed in quick succession, the dynamic lift provided by the forward momentum of the vessel was lost and the vessel's reserve buoyancy was at a minimum. By that time, water would have been covering the partitioned "tween-deck", and the detrimental effect of this large area of free surface water would have been significant.

With little reserve buoyancy and marginal transverse stability, the vessel struck the sea wall. The sudden jarring caused the people on board to lose their footing and move quickly to starboard, and the ensuing moment caused the vessel to heel and to start capsizing. A further indication that the vessel had virtually no reserve buoyancy left at that time is that it did not return to the upright when the people on board fell into the water. After the starboard deck edge hit the bottom, the vessel settled, almost totally submerged, and upright.

Whether or not the vessel had struck the sea wall, the "SHOWBOAT" undoubtedly soon would have sunk or capsized due to the loss of reserve buoyancy and to the effect of free surface water.

3.0 Conclusions

3.1 Findings

1. The Ontario Place administration did not have operational procedures in place to ensure that its departments and personnel operated the "SHOWBOAT" safely.
2. The uninspected "SHOWBOAT", which was used to transport equipment and people, was licensed as a pleasure craft.
3. There was no regime in place to ensure that life-saving equipment (i.e. lifejackets, personal flotation devices and lifebuoys) was available for the use of those on board the "SHOWBOAT" in an emergency.
4. There was no life-saving equipment of any type on board and the vessel did not meet the regulatory requirements in that respect.
5. No formal guidelines were established or provided to the crew to determine the maximum number of persons the vessel could carry safely.
6. The vessel was heavily laden and had a pronounced trim by the stern on departure. The "SHOWBOAT" had been similarly loaded on numerous occasions in the past.
7. No single Ontario Place department had clear responsibility to ensure that the vessel was efficiently maintained.
8. The foam in the twin hulls had deteriorated and become hygroscopic, such that it was less effective in providing reserve buoyancy.
9. Water was seeping into the vessel from the engine wells, port and starboard, where fibreglass was delaminating from the wooden construction.
10. The hole cut in the transom to duct air to the vessel's retrofitted generator was the primary route by which large volumes of water ingressed.
11. The vessel's trim by the stern submerged the engines' exhaust ports, and both engines failed.
12. The vessel's construction was such that water ingressed through the common spaces at the transom to the under-deck space, creating a large area of free surface water.
13. When the vessel struck the sea wall, the impact was such that the people on board lost their footing and moved quickly to the starboard side.
14. The ensuing moment caused the vessel to heel heavily and the people on board fell into the water as the vessel sank.
15. Those on board were rescued quickly because the location of the sinking was accessible, the water was relatively shallow, and the crew, the general public and other Ontario Place personnel responded quickly to rescue them.
16. The vessel's operator was the holder of a Toronto Harbour Operator's licence but had no formal training in emergency duties or life-saving equipment.

3.2 Causes

The uninspected "SHOWBOAT" was heavily laden, downflooding and slowly sinking before it struck the sea wall. There was no life-saving equipment on the vessel, but all on board were rescued promptly because the vessel sank close to shore in relatively shallow water. Contributing to the accident was the absence of clearly defined responsibility for the management of safety and for maintenance, the lack of guidance to the operators regarding the weight the vessel could carry safely, and the modification to the vessel's transom through which water downflooded.

4.0 Safety Action

4.1 Action Taken

4.1.1 Buoyancy Foams for Marine Use

The polyetherurethane foam found in the construction of the "SHOWBOAT" is commonly used as buoyancy material in small vessels. Following several tests conducted by the TSB and the National Research Council, the TSB forwarded Marine Safety Advisory No. 2/96 to Transport Canada (TC) to advise of the foam's susceptibility to degradation by oxidation. Subsequently, TC issued Ship Safety Bulletin No. 15/96, entitled *Buoyancy Foams for Marine Use*, on the application and care of polyetherurethane foam materials in the marine environment. In addition, TC Marine Safety undertook a major review of standards with respect to capacity, construction, etc., which is expected to be concluded in the fall of 1997.

4.1.2 Operation and Seaworthiness

Furthermore, the TSB issued Marine Safety Advisory No. 3/96 to apprise TC of several safety shortcomings with respect to the operation of the "SHOWBOAT", inter alia, the safe carrying capacity, training of operating personnel, vessel structure, and the provision of life-saving equipment. Subsequently, TC imposed requirements on the owners to take remedial actions in these areas of concern. However, Ontario Place has taken the vessel out of service permanently.

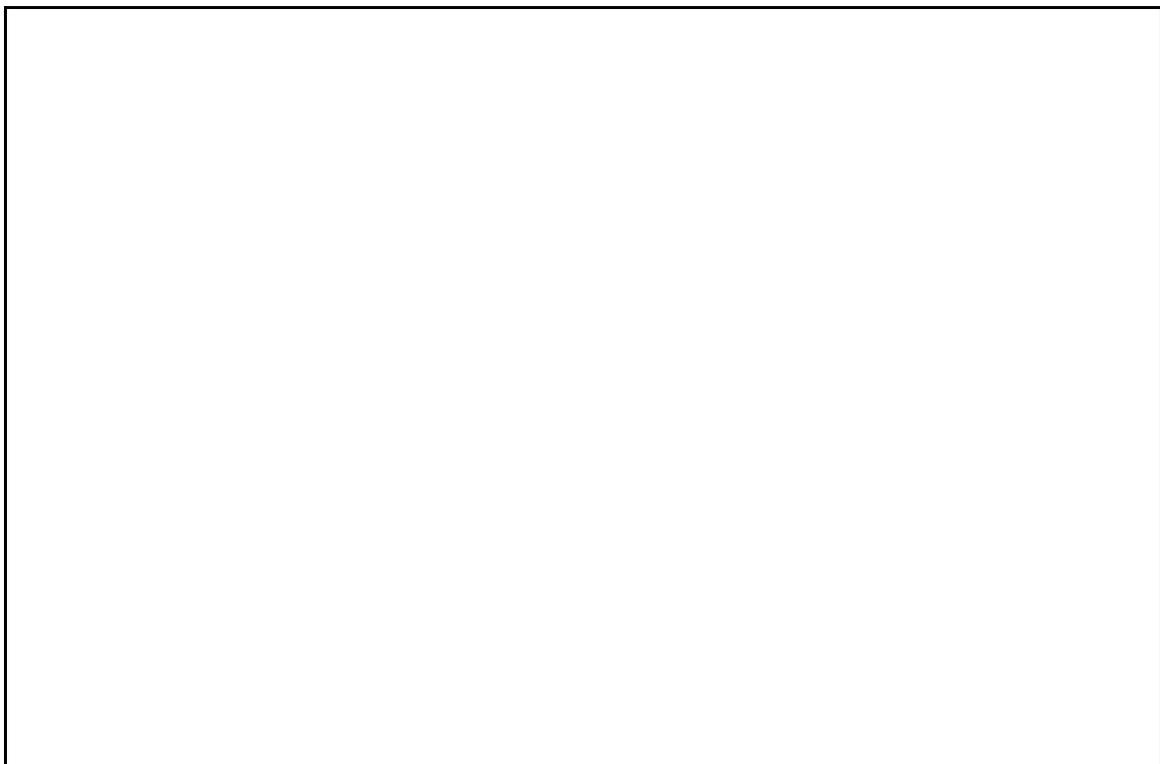
4.1.3 Measures Taken by Ontario Place

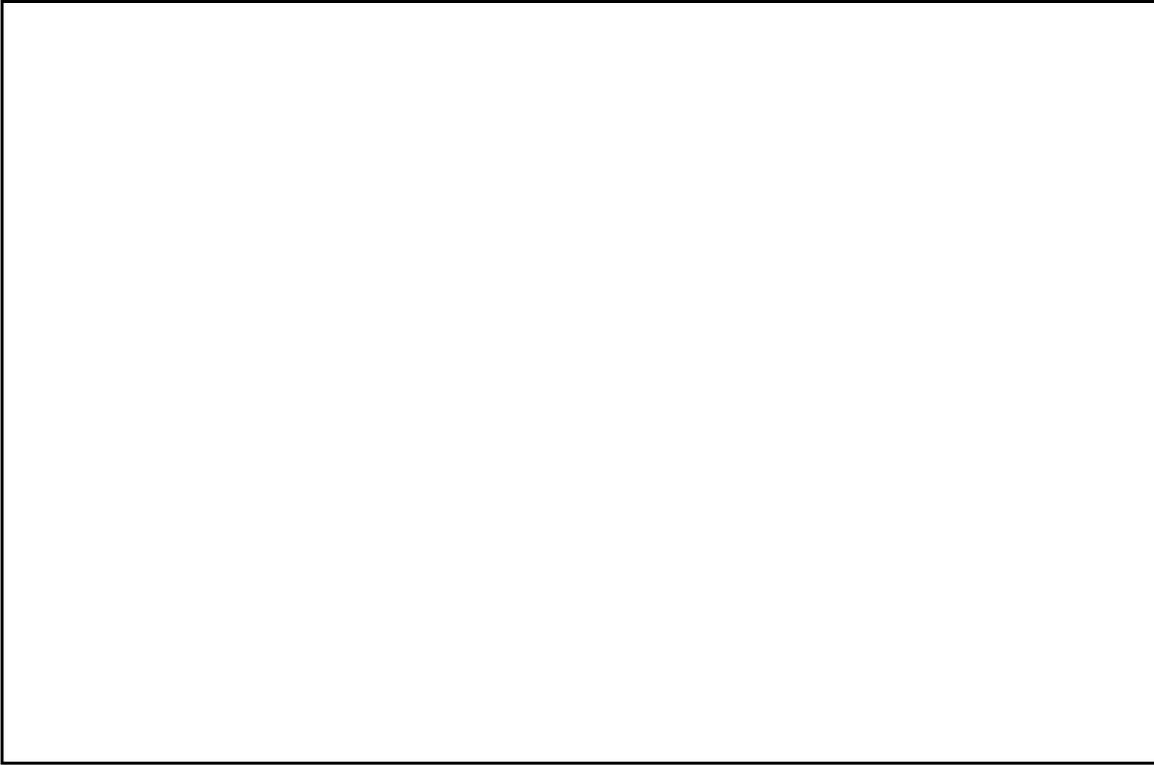
Since the occurrence, Ontario Place, inter alia, has had its vessels inspected by TC Marine Safety, instituted a weekly inspection regime, organized operating and emergency procedures, fitted all its vessels with capacity plates, maintained operating and maintenance logs for all its vessels, and implemented a training regime for vessel operators. In addition, sole responsibility for the marine program at Ontario Place, including the Crown Corporation's investigation of marine accidents involving its vessels, has been given to the Marine Operations department.

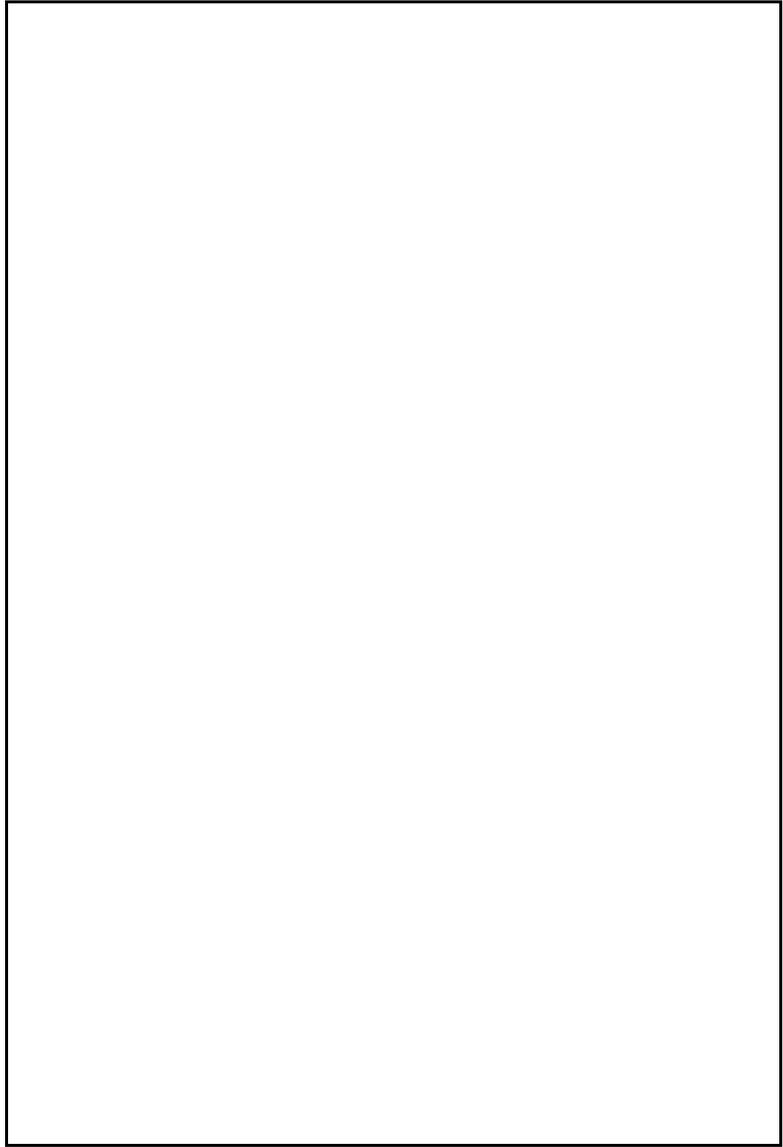
This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 07 August 1997.

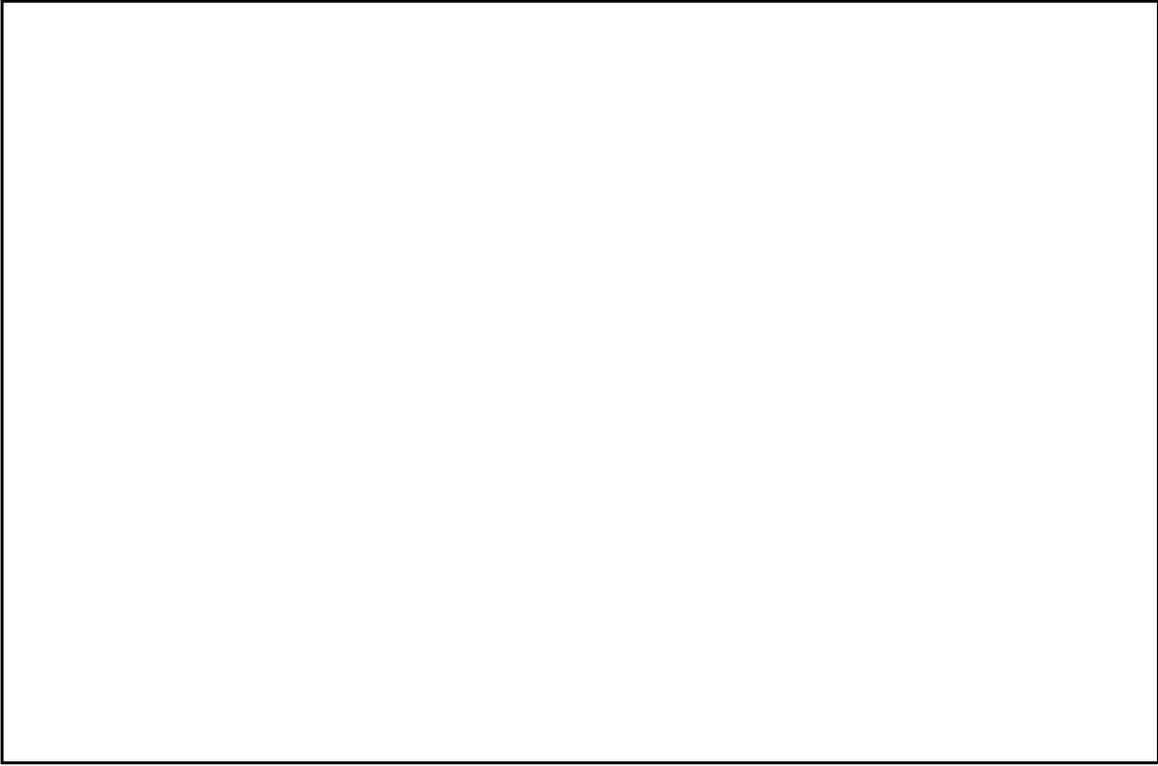
Appendix A - Sketch of the Occurrence Area

Appendix B - Photographs

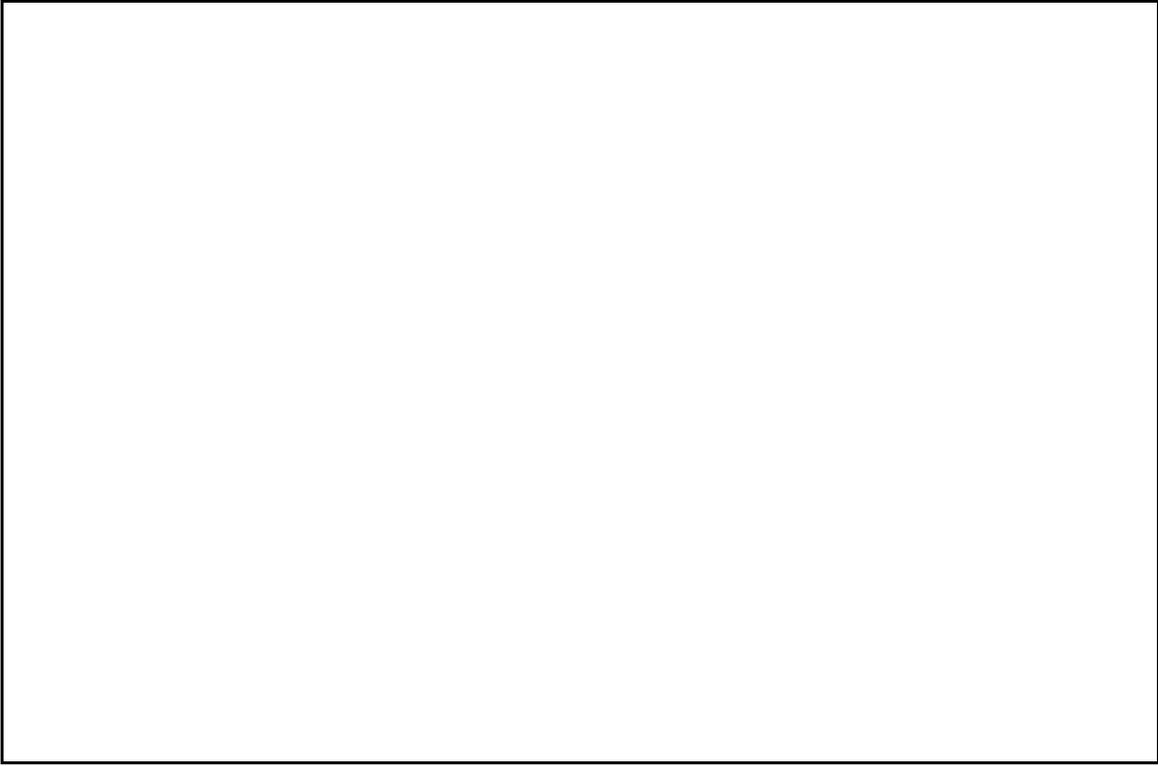












Appendix C - Glossary

cm	centimetre
EDT	eastern daylight time
g/cm^3	gram(s) per cubic centimetre
hp	horsepower
IMO	International Maritime Organization
kg	kilogram
km	kilometre
l/s	litre(s) per second
m	metre
m^3	cubic metre
mm	millimetre
Ont.	Ontario
SI	International System (of units)
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UHF	Ultra-high frequency
UTC	Coordinated Universal Time
VCG	vertical centre of gravity
VHF	Very high frequency