Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT
M02C0030

SINKING AND LOSS OF LIFE

AMPHIBIOUS PASSENGER VEHICLE *LADY DUCK*
OTTAWA RIVER
NEAR THE HULL MARINA
GATINEAU, QUEBEC
23 JUNE 2002

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 Investigation Report

Sinking and Loss of Life

Amphibious Passenger Vehicle *Lady Duck*
Ottawa River
Near the Hull Marina
Gatineau, Quebec
23 June 2002

Report Number M02C0030

Synopsis

At about 1610 on 23 June 2002, the amphibious vehicle *Lady Duck* took on water while on the Ottawa River during a combined land and water-borne sightseeing tour of the National Capital Region. The vehicle sank rapidly by the bow in eight metres of water when near the Hull Marina. Of the 12 people on board, 6 passengers, the driver, and the tour guide escaped from the vehicle and were recovered by private craft on the scene at the time of the sinking. Four passengers, trapped within the sinking vehicle, drowned. There was no environmental damage.

Ce rapport est également disponible en français.

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5.0 Appendices

Photos

Figures

Tables

1.0 Factual Information

1.1 Particulars of the Vehicle

	Lady Duck
Registry/Licence Number	BP2 110 (Ontario road licence)
Port of Registry	Exempted from registry (amphibious vehicle)
Flag	Not applicable
Type	Amphibious passenger vehicle
Gross Tonnage[1]	Not assigned, less than 5.0
Length[2]	8.46 m
Draught	0.84 m
Built	2001
Propulsion	Mercruiser inboard/outboard drive, Alpha One, 100 kW, single propeller
Number of Crew	2
Number of Passengers	10 (12 maximum)
Registered Owner	Amphibus Lady Dive Inc., St. Isidore, Ontario

1.1.1 Description of the Vehicle

The *Lady Duck* was an amphibious vehicle arranged to carry up to 12 passengers on combined road and water-borne tours in the National Capital Region (NCR)[3] and on the Ottawa River. The vehicle was developed and built by the owner and entered commercial service at the start of the tourist season in June 2001.

The vehicle was based on the conversion of a Ford F-350 truck chassis (see Photo 1). The original gasoline engine was used for on-road operation. A gasoline-powered Mercruiser inboard/outboard (I/O) motor at the rear was used for water-borne propulsion. Figure 1 shows the basic layout of the vehicle.

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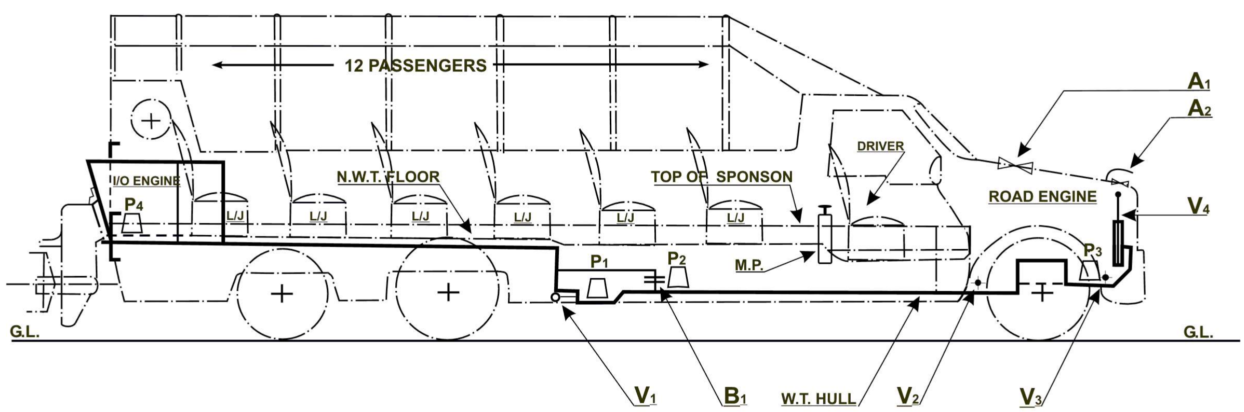
1 Tonnage and tonnage length as determined by Transport Canada after the occurrence.

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

3 See Glossary at Appendix H for all abbreviations and acronyms.

Photo 1. *Lady Duck* after recovery at the Hull Marina



G.L.	GROUND LEVEL	V_1	2 BILGE DRAIN VALVES (19 mm dia)
I/O	INBOARD/OUTBOARD	V_2	2 BILGE DRAIN VALVES (19 mm dia)
L/J	LIFEJACKET	V_3	1 BILGE DRAIN VALVE (12 mm dia)
W.T.	WATERTIGHT	V_4	FIXED W.T. VISOR
N.W.T.	NON-WATERTIGHT	P_2	2 EMERGENCY BILGE PUMPS IN HULL
P_1	2 MAIN BILGE PUMPS IN WELLS	P_3	BILGE PUMP IN ROAD ENGINE COMPARTMENT
P_4	BILGE PUMP IN I/O ENGINE COMPARTMENT	A_1	2 VENTILATION OPENINGS IN HOOD TOP
B_1	DRIVE SHAFT BEARING	A_2	2 COWL VENTILATORS IN HOOD TOP
		M.P.	MANUAL BILGE PUMP

Figure 1. Construction profile outline

The bottom of the chassis was enclosed with welded and bolted steel plating and the sides were extended upward to enclose a buoyant structure. The original truck wheels and suspension were fitted outside the watertight hull. The effective breadth of the chassis was increased by the addition of extensions (sponsons) on each side. These sponsons were partially filled with rigid foam plastic to enhance transverse stability and buoyancy and to ensure appropriate forward and after trim when water-borne.

A passenger boarding ramp, located at the rear left corner of the vehicle, hinged up to a steel sill and a flexible gasket to ensure the watertight boundary of the passenger deck. The ramp was lifted to the closed position by an electrically driven winch and secured in place with hasps on each side of the ramp.

Eleven single-passenger seats were arranged along the sides of the open passenger deck, with five on the port side and six on the starboard side. There were two seats in the vehicle cab, the left one for the driver and the right one for the tour guide. In the event of a full payload, the tour guide's seat acted as the 12th passenger seat; the tour guide would assume a standing or crouching position in the middle of the cabin aisle.

A fabric awning provided overhead protection from inclement weather. Roll-down transparent weather screens were arranged on each side of the passenger area for additional protection.

Approved lifejackets were stowed in lockers under each of the passenger seats and, at the time of the occurrence, three children's lifejackets were located at the after end of the vehicle. Twelve additional adult-approved personal flotation devices (PFDs), located adjacent to the seats in the passenger area, were readily available.

A steel visor plate was fitted at the front of the forward engine compartment and was intended to prevent the entry of water at the front of the vehicle when water-borne and underway.

Combustion and cooling air supply to the road engine were provided by two triangular ventilation openings in the top of the hood and also by a pair of 76 mm-diameter (3-inch) cowl-shaped ventilators fitted at the forward end, above the top of the visor.

The vehicle was fitted with five drainage points, each comprised of a hand-operated, ball check valve (seacock) with a swing-check, non-return valve immediately inboard, both of which were mounted on a common pipe spigot and closed with a screwed steel plug. Four of the drainage points were 19 mm (¾ inch) in diameter; the fifth was 12 mm (½ inch) in diameter. Once on shore, the drainage points could be used to release accumulated water from the bilges (see Figure 1).

The vehicle was equipped with six electrically driven submersible bilge pumps. One pump of 1250 US gal/h (78.8 L/min) maximum rated capacity and another of 630 US gal/h (39.7 L/min) maximum rated capacity were located in port and starboard bilge drain wells that extended below the hull bottom near the mid-length of the vehicle. These two pumps were referred to as the main bilge pumps. Two other pumps, each of 1250 US gal/h (78.8 L/min) maximum rated capacity, were located in the hull, slightly forward of the bilge wells, and were referred to as emergency bilge pumps.[4]

A submersible bilge pump of 1100 US gal/h (69.4 L/min) maximum rated capacity, incorporating an automatic float switch, was located at the forward end of the forward engine compartment. Another submersible bilge pump of 630 US gal/h (39.7 L/min) maximum rated capacity, also with an automatic float switch, was located in the Mercruiser I/O engine compartment at the after end of the vehicle.

A manual bilge pump was installed on the port side of the vehicle abaft the driver's seat, with a flexible overboard discharge hose. All electrically driven bilge pumps, except that in the I/O engine compartment, were operable from the steering position. No automatic bilge high level alarms were fitted.

The vehicle's communication aids included a very high frequency (VHF) radio, a public address system, and a two-way radio, all adjacent to the driving position.

1.2 History of the Voyage

1.2.1 On-land Operation of Vehicle

On Sunday, 23 June 2002, the driver went to the company's yard and, in accordance with standing instructions, conducted an inspection and other preparatory procedures to prepare the *Lady Duck* for tour operation. He then drove the vehicle to the Hull Marina where, at about 0820, he conducted the water-borne operational test. On completion of the test at 0835, the vehicle was driven to the company kiosk on Sparks Street in Ottawa.

At about 1030, having completed an all on-land tour, the driver was informed that another company vehicle (*Lady Dive III*) had broken down and that the *Lady Duck* would carry out the next amphibious tour.

1.2.2 First Amphibious Tour of the Day

The water-borne part of the tour commenced at approximately 1100. During routine operation of the main bilge pumps, no water was seen to be discharging from the bilge outlets near midships. The driver switched on the emergency bilge pumps and observed water intermittently discharging on each side of the vehicle near midships.

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[4] The term "emergency pump" was used by the owner and is retained throughout the report.

The driver notified the company's mechanic of the situation by two-way radio. It was suggested that the bilge pumps be switched "off " for a few minutes, then restarted. This action was unsuccessful and the water-borne tour continued with the emergency bilge pumps in continuous operation.

Upon returning to the kiosk, the driver called the mechanic again for further instructions. He was directed to inspect the fuse box, where it was found that both main bilge pump fuses were burned out. These fuses were then replaced with two new 20-ampere fuses.

1.2.3 Second Amphibious Tour of the Day

Before departing on the second amphibious tour of the day, the driver was instructed by the company manager to include more on-land and less water-borne time due to increased traffic on the river, such that approximately 15 minutes would be added to the on-land portion of the tour and the water-borne portion would be reduced proportionately. The water-borne part of the tour was to take the vehicle slightly upstream of the Alexandra Bridge, then downstream of the Macdonald-Cartier Bridge close enough to the Rideau Falls for the passengers to see them, before returning to the Hull Marina ramp.

The *Lady Duck* started the amphibious tour at about 1500, with the driver, 10 passengers, and a tour guide on board. At the beginning of the tour, the guide briefed the passengers, in French and English, on safety procedures related to the on-land part of the tour. Before the vehicle entered the water at the Hull Marina ramp at approximately 1540, the tour guide provided a safety briefing to the passengers for the water-borne part of the tour.

When the vehicle entered the water, the main bilge pumps were switched on to clear the hull of any shipped water. Because no water was seen to be discharging from the outlets near midships, the emergency bilge pumps were also activated to discharge the accumulation of floodwater. Water was then seen discharging intermittently from outlets on both sides of the vehicle near midships.

The bilge pump, located in the forward engine compartment, was also switched on manually and a red light adjacent to the steering position indicated that the pump was supplied with electrical power. The switch was then placed in the automatic operating position and the pump was considered to be active.

Once the vehicle was afloat, the front engine was kept running in neutral, the I/O motor was started, and the water-borne part of the tour commenced. The vehicle was driven to the Ottawa side of the river at approximately eight kilometres per hour (km/h) and then at slower speeds to various points of interest so that passengers could take photographs.

The weather was fine and clear with little wind. The river was relatively calm, with waves caused by wakes from boats and other watercraft in the tour area. On occasion, the vehicle encountered waves that washed over the hood and up to the windshield. Some spray also came in through the opened windows in way of the driver and tour guide seats.

Toward the end of the tour, at about 1608, while returning to the Hull Marina at approximately 8 km/h, the driver noted that the front end of the vehicle was floating lower than normal and that water was being continuously discharged from both sides of the vehicle near midships. The driver then ordered the four foremost passengers and the tour guide to move to the back of the vehicle to try to decrease the forward trim.

The forward trim continued to increase and, realizing that the safety of the passengers was at risk, the driver instructed the tour guide to tell the passengers to don PFDs. At this time, he diverted the vehicle toward the nearest point on the Quebec shore. The driver then broadcast a MAYDAY on emergency VHF channel 16, identifying the *Lady Duck*, giving its position and the number of passengers on board. At about 1610, the situation deteriorated rapidly as more floodwater accumulated in the forward end of the vehicle. The driver then called on the passengers to abandon the sinking vehicle. The driver left the steering position, made his way aft and, with seven other persons, managed to get free of the sinking vehicle. The remaining four passengers became trapped under the fabric awning and sank with the vehicle in 8 m of water.

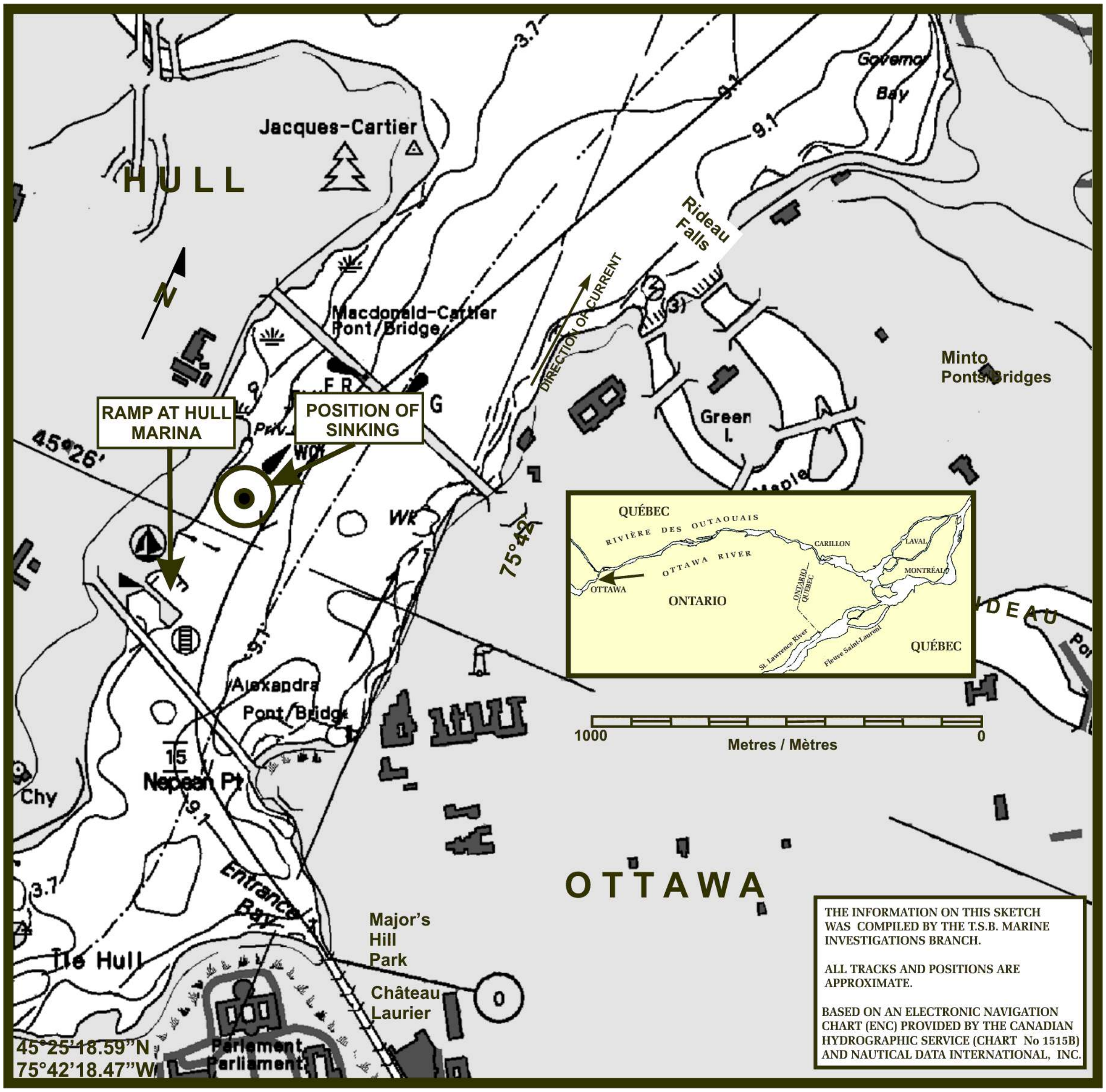

Figure 2. Chart of the occurrence area

The driver, the tour guide, and four of the passengers who escaped as the vehicle was sinking were quickly recovered by the pontoon boat *Le Pirr'eau*, which happened to be near the *Lady Duck* as it sank. Two more passengers were recovered by the pleasure craft *Marina de Hull*, which had responded promptly after witnessing the sinking. The bodies of the four passengers who sank with the vehicle were recovered later and were subsequently examined by the coroner. The coroner determined the cause of death to be drowning associated with hypothermia.

Following recovery from the water, the survivors were taken to the Hull Marina office for first-aid medical attention; those with no apparent injuries were subsequently released. The driver and two passengers, requiring further medical attention, were transported to the Ottawa Hospital and released later that day.

1.3 Injuries to Persons

	Crew	Passengers	Others	Total
Fatalities	-	4	-	4
Missing Persons	-	-	-	-
Seriously Injured	-	-	-	-
Minor/No Injuries	2	6	-	8
Total	2	10	-	12

1.4 Search and Rescue Response

The driver's radio distress call on emergency VHF channel 16 was received by some of the pleasure craft in the area. However, the driver of the *Lady Duck* had no time to acknowledge any of their responses before abandoning the vehicle.

Several bystanders with cellular telephones called the 911 emergency telephone service and informed emergency services in Hull[5] and Ottawa of the occurrence. Ottawa and Hull fire and police emergency response services were alerted between 1612 and 1615, and were on site by 1620.

At 1635, Marine Communications and Traffic Services (MCTS) Prescott were advised of the occurrence by the pleasure craft *Catch the Sun*. MCTS Prescott relayed this information to MCTS Québec.

The Hull police and fire departments launched their rescue craft shortly after 1620 and the Hull police chief of operations assumed the duty of on-scene commander.

As Hull fire department divers were not equipped to descend 8 m to the sunken vehicle, the services of the Ottawa Underwater Recovery Team Unit were requested. At approximately 1800, the Underwater Recovery Team Unit recovered the bodies of four passengers from the sunken

5 The City of Hull was officially designated as the City of Gatineau on 21 July 2003

vehicle. All the victims were found at the rear of the *Lady Duck*, floating against the underside of the awning. Two adult victims were recovered wearing adult PFDs. Before the sinking, the two younger victims were wearing adult PFDs; however, on recovery, one was found wearing a partially donned adult PFD and the other was recovered without a PFD.

1.5 Vehicle Recovery

1.5.1 Recovery Operations

The sunken vehicle was located in 8 m of water, approximately 90 m from the Quebec shore and 120 m east of the Hull Marina ramp in approximate position 45°26.1' N latitude, 75°42.3' W longitude. The *Lady Duck* was facing in a westerly direction, in an upright condition with its front wheels and propeller drive unit turned to the right. Divers subsequently straightened the front wheels to facilitate ramp haul out. Following extensive underwater videotape recording of the vehicle, including its fittings and the positions of all bilge pump energizing switches, the *Lady Duck* was recovered on 27 June 2002 and transported to the TSB Engineering Laboratory in Ottawa for further inspection.

1.5.2 Vehicle Condition on Recovery

The propeller drive unit of the I/O motor was found to be in the raised position.

The boarding ramp at the after end of the open passenger space was found to be in the raised and fully secured position on the watertight gasket surrounding the access opening.

The five bilge drainage valves were found in the fully closed position with their steel screwed plugs in place.

The fabric awning over the open passenger space was in place and secured to its metal frame. One roll-down transparent weather screen on the starboard side near midships and the foremost weather screen on the port side were securely zipped in the lowered position. The foremost weather screen on the starboard side and two other weather screens on the port side were undone and hanging loose. The remaining roll-down transparent weather screens were secured in the raised position.

1.5.3 Vehicle Examination after Recovery

After recovery, the partially flooded vehicle leaked freely from several hull penetrations, and was more rapidly cleared of floodwater by removing the screwed plugs from the bilge drains and opening all five seacocks.

On boarding the vehicle, the following items were noted:

- The main ignition key was turned “on” and the front engine, which had been running when the vehicle sank, had incurred extensive mechanical and electrical damage due to water ingestion.
- The transmission shifter of the Mercruiser I/O motor was in the neutral position, the ignition key was turned on, and the engine had incurred extensive mechanical and electrical damage.
- The switches located in the overhead panel adjacent to the driving position, which activated the main bilge pumps and the emergency bilge pumps, were all in the “on” position.
- The switch in the panel below the steering column, which activated the bilge pump in the forward engine compartment, was in the “automatic” position.
- The switch in the local control for the bilge pump in the after engine compartment was in the “off” position.
- One starboard side passenger seat had broken free from its fastenings.
- Rubber mats covering the floor in the passenger space had lifted and wooden panels under the rubber mats, giving access to the bilge pumps, were dislodged.
- An approved 610 mm-diameter lifebuoy and heaving line, located at the after end of the open passenger space, was found secured in place by a bungy cord.
- Two decorative non-standard lifebuoys were found permanently attached to the outside of the vehicle at the after end of the passenger space. These lifebuoys incorporated a moulded-in notice stating: “Attention parents. Not a life-saving device. Do not leave child unatended” (sic).
- Ten approved adult lifejackets were found stowed in boxes under the passenger seats, and two other adult lifejackets and three children’s size lifejackets were recovered separately.
- Of the PFDs reportedly stowed adjacent to each of the passenger seats, eight were recovered.

- A comprehensive outfit of safety-related equipment and other gear was found on board the vehicle, including:
    - flare gun, flares, and portable air horn,
    - first-aid kit and flashlight,
    - boating safety kit,
    - emergency steering gear handle for I/O motor,
    - three fire extinguishers,
    - one Danforth anchor and anchor rope,
    - mechanic tool kit,
    - mooring lines,
    - two paddles,
    - spare motor oil,
    - booster cables,
    - logbook,
    - pre-departure vehicle checklists, and
    - spare fuses (30 and 15 amperes).

1.6 Passenger Seating

Passenger seats were arranged on the port and starboard sides of the vehicle, with a centre aisle giving access fore and aft. Metal lockers, forming the base of each seat, were fastened to the 12 mm-thick (½-inch) plywood floor by 3 mm-diameter (C -inch) screws. The original Ford truck driver and passenger seats were retained in the steering cabin. The number of screws securing the tour passenger seat bases varied from a minimum of three up to a maximum of six. The plywood flooring and metal seatings in way of some of the screwed connections were in a deteriorated condition.

Transport Canada's (TC) *Motor Vehicle Safety Regulations*, Standard 207, requires seat anchorages to withstand a force 20 times the weight of the empty seat (20 g[6]), applied in a longitudinal direction through the centre of gravity of the seat. TSB tests and calculations indicate that a seat from the *Lady Duck* anchored with four fastenings would require a force of 9.7 g to separate from the flooring (see Appendix G—List of Supporting Reports).

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6 "g" unit of measurement used to express force as a proportion of the object's weight. A force of 1 g equals the weight of the object. A force of "n" g equals "n" times the weight of the object.

1.7 Bilge Pumping Arrangements

1.7.1 Bilge Pumps Installation

Post-sinking inspections by the TSB showed that the port-side electrically driven submersible main bilge pump (Attwood V625), located and secured in a bilge drain well near the mid-length of the vehicle, was fitted with a fine wire gauze strainer. A 20 mm-diameter (¾-inch) flexible discharge pipe led to an 11 mm-diameter (7/16-inch) overboard discharge fitting, located 100 mm (4 inches) below the gunwale, creating an operating pressure head of some 1100 mm (43 inches) at the pump. The location of the overboard fitting was such that any water discharged by the pump could be seen from the driving position in the left-hand side rearview mirror. The on/off switch that energized the pump was located in an overhead panel adjacent to the driving position.

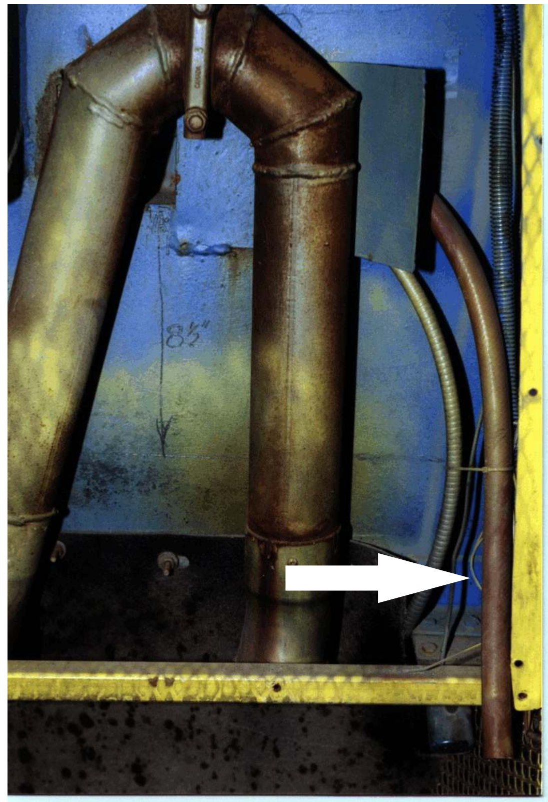

Photo 2. After end of the starboard-side main bilge pump discharge pipe

The starboard-side electrically driven submersible main bilge pump (Attwood V1250), located and secured in a bilge well near the mid-length of the vehicle, was fitted with a fine wire gauze strainer. The discharge piping was comprised of various lengths of flexible 25 mm-diameter (1-inch) concertina-type plastic hose, 20 mm-diameter and 16 mm-diameter (¾-inch and e-inch) rubber hoses, and 12 mm-diameter (½-inch) metal ferrule joining pieces. The discharge piping led aft along the starboard side of the passenger area and passed through the transom some 240 mm (9½ inches) above the load waterline, creating an operating pressure head of some 900 mm (35½ inches) at the pump. The after end of the flexible discharge pipe protruded outside the transom, extended some 305 mm (12 inches) below the load waterline, and was out of sight of the driver (see Photo 2).

An overboard discharge fitting, adjacent to the pump and some 100 mm (4 inches) below the gunwale, was blanked off, having become redundant when the original bilge pump discharge hose was re-directed aft and through the transom. The on/off switch that energized the pump was located in an overhead panel adjacent to the driving position.

The port- and starboard-side electrically driven submersible emergency bilge pumps (both Attwood V1250), each located approximately 610 mm (24 inches) forward of the bilge wells, were not fitted with wire mesh strainers nor were they secured to the bottom hull structure.

Each pump was fitted with a 25 mm-diameter (1-inch) flexible discharge hose, led to an 11 mm-diameter (7/16-inch) discharge fitting located 150 mm (6 inches) below the gunwale, creating an operating pressure head of some 1070 mm (42 inches) at the pump. The locations of the overboard fittings on each side near the mid-length of the vehicle were such that they could be seen from the driver's position in the left- and right-hand side rearview mirrors. The on/off energizing switches were located in an overhead panel adjacent to the driving position.

The electrically driven submersible bilge pump (Attwood V625), located in the after engine compartment, was equipped with a float switch. The pump was energized locally by a switch arranged for manual and automatic setting. A 20 mm-diameter (¾-inch) flexible hose, some 610 mm (24 inches) long, was attached to the pump discharge but was not led overboard, so that any bilge or floodwater issuing from the pump would be retained inside the vehicle.

An electrically driven submersible bilge pump (Rule Mate 1100), incorporating a float switch, was located at the forward end of the forward engine compartment. The pump was actuated from a panel located below the steering column by a switch arranged with "automatic," "off" and "manual" settings. The manual switch was spring-loaded and must be held in that position by the driver for the pump to continue operating. A 25 mm-diameter (1-inch) flexible concertina-type discharge hose led up over the top and forward of the visor plate and the hood flexible gasket, some 460 mm (18 inches) above the load waterline. The hose extended some 200 mm (8 inches) below the load waterline at the front of the vehicle and was out of sight of the driver (see Photo 3). When the hood was closed, the discharge hose was compressed where it passed over the top of the forward sealing gasket, partially restricting the flow of any water issuing from the pump.

A 38 mm-diameter (1½-inch) manual piston pump (Beckson "Thirsty Mate" 136PF6), located on the port side abaft the driver's seat, was supplied with a flexible discharge hose capable of being led overboard over the top of the gunwale. The pump suction extended to within 12 mm (½ inch) of the bottom shell plating. The pump barrel below the plywood flooring was locally compressed; however, the pump operated freely, and the discharge rate was dependent on the arm strength and stamina of the operator.

Photo 3. Discharge hose from the forward engine compartment

A pump suction hose, with a 20 mm-diameter (¾-inch) end connection flange, elbow and attached strainer, was located in way of the foremost passenger seat base on the port side of the vehicle. The suction hose penetrated the plywood flooring and extended down into the hull to within 12 mm (½ inch) of the bottom shell plating. This suction became redundant when a small gasoline-driven bilge pump, to which it had been connected, was removed from the vehicle some time before the occurrence.

Figure 3 shows the location of the bilge pumps. Table 1 gives a summary description of the bilge pumps and outlines their status. See Appendix A for results of bilge pump examination and testing.

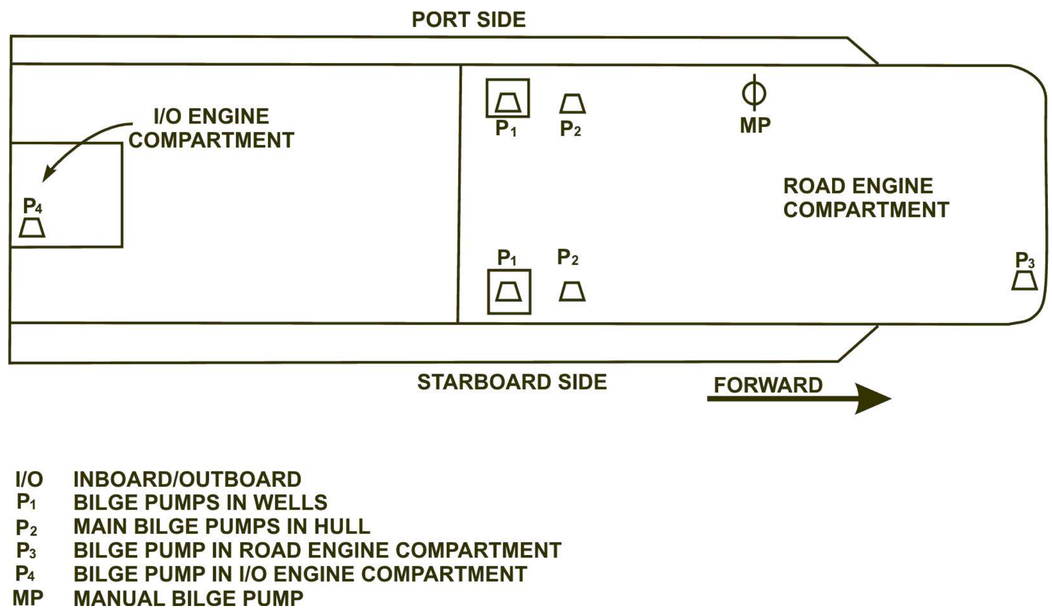

Figure 3. Bilge pump locations

	Main Pumps		Emergency Pumps		Forward Engine Compartment	After Engine Compartment	Manual Pump
	P1, port	P1, starboard	P2, port	P2, starboard	P3	P4	MP
Make Model	Attwood V625	Attwood V1250	Attwood V1250	Attwood V1250	Rule Mate 1100	Attwood V625	Beckson model 136PF6
Rated (L/min)	39.7	78.8	78.8	78.8	69.4	9.7	–
Constraint	11 mm	12 mm	11 mm	11 mm	25 mm	20 mm	–
Strainer	fine	fine	nil	nil	nil	nil	nil
Effective Head	1100 mm	900 mm	1070 mm	1070 mm	choked	inboard outlet	inboard outlet, hose not connected
Discharge observable by driver	yes	no	yes	yes	no	no	yes
Control	driver panel	driver panel	driver panel	driver panel	column + float switch	local float switch	manually operated
Status	Inoperable, electrically inoperable	Inoperable, fouled with solid debris	Operable, discharge rate of 21.2 L/min	Operable, discharge rate of 21.2 L/min	Inoperable, heat damage	Operable, but discharge inboard	Operable, but discharge inboard
Comment	–	Syphoning	–	–	–	–	–

Table 1. Bilge pumps

1.7.2 Bilge Pump Condition

The quoted maximum rated discharge capacity is generally that which is attainable at zero pressure head. The actual operational capacity depends on several parameters related to the installation, which include the following:

- operating discharge pressure head,
- length and diameter of discharge hoses,
- diameter and location of overboard discharge,
- unrestricted pump suction, and
- maker's installation instructions.

Of the six electrically driven bilge pumps on board the vehicle at the time of the occurrence, two were found to be effectively operable. Actual discharge rates measured during the tests of the two emergency bilge pumps (Attwood V1250) that were operational were 335 US gal/h (21.2 L/min) each. This discharge rate was approximately 36 per cent of that specified for this pump model when operating at a comparable pressure head of 3.3 feet (1 m) with an electrical supply of 13.6 volts (V). The reduction of the designed discharge rate was attributable, in part, to the actual voltage available during the tests (approximately 12.5 V), mud and debris obstruction of the wire gauze strainer, and some internal wear in the pump. However, the primary cause of the reduction was due to the greater back pressure at the pumps, caused by the marked and sudden restriction of the discharge area to 19 per cent of the original 25 mm-diameter (1-inch) pump discharge piping where it joined the 11 mm-diameter (7/16-inch) overboard discharge fitting.

Further inspections showed that the electrical circuits of the Attwood V625 and V1250 main bilge pumps incorporated 15-ampere and 20-ampere fuses, instead of 2- and 4-ampere fuses as indicated on each of the respective pump housings and specified in the maker's *Installation Instructions* (Form No. 69439, Rev. B). Furthermore, these instructions also included the following information:

> ! WARNING :
> Always use the fuse amperage rating specified for your pump model.
> Failure to do so could result in serious personal injury or fire hazard.
>
> Attwood pumps are designed to exhaust STANDING WATER ONLY.
> They are not intended to prevent rapid accumulation of on-board water due to rough weather, hull damage, and/or other unsafe navigational conditions.
>
> WIRING INSTRUCTIONS :
> - - - - - NOTE : Failure to make waterproof connections and fuse pump properly will void the product warranty. (sic)

The bilge pump wiring and other electrical service circuits included connections that were hand-twisted and wrapped with electrical tape. The wiring connections did not incorporate soldered and heat-shrunk watertight tube fittings, as in generally accepted marine and automotive practice.

The main bilge pumps were secured to manufacturer-supplied horizontal mounting brackets that were located in the bilge drain wells. The emergency bilge pumps and those fitted at the forward and after ends of the vehicle were unattached to any structural member. These pumps were free to move or fall over in the event of shocks due to uneven road surfaces or the sudden surge of floodwater inside the hull.

1.7.3 Bilge Pumping Requirements

Bilge pumping requirements for small passenger vessels are set out in the *Marine Machinery Regulations* and the *Small Vessel Regulations* (SVR). With respect to the *Lady Duck*, the *Marine Machinery Regulations* require at least two effective bilge pumps and the SVR require one bailer and one manual bilge pump. However, the regulatory requirements were designed for small commercially operated vessels of conventional construction and layout and are tacitly based on the premise that vessels have an acceptable level of watertight integrity and possess adequate freeboard for the intended service.

The *Lady Duck*, which was not of conventional construction, was equipped with six power-driven bilge pumps and one manual bilge pump. At the time of the sinking, two of the power-driven pumps were effectively operable. No bilge high level alarm was fitted in the *Lady Duck* and none was required by regulation.

1.8 Vehicle Operational Trials

1.8.1 Trials Preparation and Sequence

A series of trials was conducted by the TSB to determine the trim, freeboard, wave making, and other operational characteristics of the *Lady Duck* throughout a range of speeds, wave heights, and flooding conditions to provide a basis on which the operational condition of the vehicle at the time of the sinking could be assessed.

The trials were conducted with three TSB personnel on board the vehicle, which was loaded with sand bags to simulate a typical fully loaded operating condition. The steel visor plate at the front of the road engine compartment was fixed in the fully raised position, and the hood sides, engine ventilation openings and forward cowl ventilators were temporarily sealed weathertight. The flexible foam gasket in way of the hood and visor top at the forward end of the forward engine compartment was retained in its original in-service condition. The Mercruiser I/O motor at the after end of the vehicle was made operational for the in-the-water trials, but the road service engine at the forward end was not restored to working order.

The original outfit of damaged or inoperative electrically driven bilge pumps was replaced with new pumps of similar models and capacities, but the original bilge piping system and discharge fittings were retained. The starboard-side main bilge pump discharge pipe protruding from the transom was raised clear of the water to prevent any syphonic flooding throughout the speed trials. Plywood flooring in the passenger space was removed to provide a clear view of the internal hull structure, drive shaft bearing, bilge pumps, and piping systems.

Freeboard measuring frames were installed at the forward and after ends of the vehicle, with a "crossbar" on the forward frame located level with the top of the fixed internal visor plate. The frames were installed to provide clear external indications of the fore and aft trim and effective freeboards during the speed, bow wave, and flooding trials.

Photographic, video, and documentary records of the trials and tests were maintained by TSB personnel located on shore and on board the vehicle. Vehicle inspections and all in-the-water trials were attended and observed by representatives of the Ministry of Transportation of Ontario (MTO), TC, the Quebec coroner's office and the owner. These representatives were also supplied with copies of the results of the following trials:

- Hull integrity, trim and freeboard tests
- Speed, bow wave and forward freeboard trials
- Bilge piping syphonic action trials
- Ramp launching trials
- Floodwater and trim at various forward freeboards

1.8.2 Hull Integrity, Trim and Freeboard Tests

While the vehicle was being launched at the start of the trials, a significant quantity of water entered the hull by way of the main drive shaft bearing. The condition of the bearing was as it was when the vehicle was recovered, having been replaced three days before the occurrence. In order to reduce the inflow of water and allow the trials to continue, the vehicle was hauled clear of the water and the bearing was fully charged with grease, pumped in through a piped lubrication fitting located at the outboard end of the bearing housing, and accessible from outside the watertight boundary of the hull.

Due to on-road operation, the drive shaft bearing (Fafnir model RCJ-1-15/16) was an industrial-type roller bearing, not specifically designed for marine stern tube applications. The arrangement of the drive shaft hull penetration was not in accordance with accepted marine stern tube practice. The bearing housing did not incorporate any compressible packing or sealing gland at the inboard end to prevent the entry of excessive amounts of water into the hull and was not readily available for inspection.

At the start of the progressive speed trials, an initial after trim of 250 mm (10 inches) and an effective forward visor freeboard of 470 mm (18½ inches) were recorded. Throughout the trials, the watertight integrity of the hull was compromised due to continuous leakage from the drive shaft bearing, shell plating fractures in way of the forward and after wheel wells and where the front wheel steering linkage penetrated the hull.

The causes and locations of these fractures were most likely due to hull flexing and sudden shock loads imposed on the lightly constructed and intermittently welded bottom structure stiffening to the shell plating, when the vehicle encountered uneven and bumpy road surface conditions during on-shore driving operations, when the vehicle struck the river bottom or during recovery operations.

The rates of ingress from these sources varied with the speed and trim of the vehicle and their combined accumulation was not determined during the tests, as it could not be differentiated from other concurrent and greater inflows that occurred as the trials progressed. However, the vehicle was pumped clear before the start of successive speed trials, such that the cumulative ill effects of these leaks on trim and forward freeboard were minimized for each trial condition.

1.8.3 Speed, Bow Wave and Forward Freeboard Trials

Twelve trials were conducted with the hood made temporarily weathertight, with only the forward visor top gasket in the original condition it was in at the time of the occurrence. Six of these trials were conducted in calm water and the remainder, in waves created by escort vessels, simulating wave conditions likely to be met in actual passenger-carrying service (up to approximately 600 mm in height).

All trial speeds were determined on site by radar measurement from shore. There was no guard or stop fitted to the drive and throttle control lever of the Mercruiser I/O motor to impose a limit to the speed to which the vehicle could be driven. The top speed recorded during the trials was that obtained with the throttle lever set at the maximum available.

As the speed was increased, the height of the related bow waves and the concurrent reduction in effective freeboard in way of the forward visor crossbar were observed and video-recorded from the escort vessels and from shore. The onset and subsequent increases in the flow of water over the top of the forward visor as speed was increased were also observed and recorded by video camera installed inside the forward engine compartment.

Trial speeds were progressively increased from 5 km/h up to a maximum of 10.25 km/h, and the related bow wave heights ranged from 90 mm (8½ inches) to in excess of 470 mm (18½ inches). At speeds up to about 5 km/h (see Photo 4), the bow waves were comparatively small. However, as the speed was increased, the bow waves became disproportionately higher and the initial effective visor freeboard of 470 mm (18½ inches) was significantly reduced.

Photo 4. Vehicle speed of approximately 5 km/h in calm water

Photo 5. Vehicle speed of approximately 8 km/h in calm water

In calm water at a speed of 8 km/h, the bow wave was some 265 mm (10½ inches) high and the effective forward freeboard to the top of the visor was reduced to 205 mm (8 inches) (see Photo 5). At a speed of 9.85 km/h, the bow wave was level with the visor top (see Photo 6). At the maximum speed of 10.25 km/h, the bow wave partially covered the hood with water and heavy spray and overflowed the top of the forward visor. The configuration of the top of the forward visor and its attached gasket was ineffective in preventing entry of water through the space remaining between the top of the gasket and the underside of the hood.

Photo 6. Vehicle speed of approximately 10 km/h in calm water

The temporary seals over the hood sides, engine ventilation openings, and forward cowl vents were effective. However, at speeds above 10 km/h, the floodwater continuously overflowed the visor top gasket and accumulated in the forward half of the vehicle. The volume of floodwater from this source was not determined due to the concurrent accumulation of water from the drive shaft bearing and hull leakage. The forward bilge pump and the two main bilge pumps were activated to clear the vehicle of all floodwater.

Six speed trials conducted in water disturbed by the wakes from escort vessels showed that flooding over the top of the visor occurred sooner and at lower speeds than when in calm water conditions. At higher speeds, the amount of water and heavy spray covering the hood top occasionally washed up as far as the driver's windshield. The rate of entry and quantity of water accumulation were also greater, and the forward pump, both main bilge pumps, and the two emergency pumps were used to clear the vehicle of floodwater.

Eight speed trials were conducted with the temporary weathertight seals removed from the hood sides, air ventilators and forward cowls—an operational condition similar to that at the time of the occurrence. Four of the trials were in calm water conditions and the remainder, in disturbed water.

Significantly more floodwater was shipped and retained when in the unsealed condition. In disturbed water, at 8.3 km/h, water overflowed the top of the visor and also downflooded through the ventilator openings, forward cowls and hood sides (see Photo 7). At 9.75 km/h, the rate of downflooding increased considerably, water continuously overflowed the visor top, and a substantial quantity accumulated in the forward half of the hull (see Photo 8). The forward bilge pump, both main bilge pumps, and the two emergency bilge pumps were used to clear the vehicle of this accumulation.

Photo 7. Vehicle speed of 8.3 km/h in disturbed water

Photo 8. Vehicle speed of 9.75 km/h in disturbed water

In disturbed water conditions, heavy spray and some “solid” water covered the hood, causing significant downflooding through the ventilator openings, forward cowls and hood sides. However, the greatest ingress of water was from the front, past the hood front gasket and over the top of the forward visor plate, where the overflow took on a continuous waterfall effect. At 10.24 km/h, the rate of downflooding and rapid accumulation of water in the forward half of the vehicle was such that it was considered imprudent to continue at this speed for the time needed to complete the trial without the operation of all bilge pumps forward of midships.

The midships bilge pumps and the forward pump were employed between all the trial runs to ensure that the hull was virtually dry and clear of floodwater at the beginning of each succeeding test. This procedure was adopted to ensure that the effective forward freeboards recorded throughout the range of speed trials were the “best attainable” and, as such, would be reduced in service by any unnoticed accumulation of floodwater. Any such reduction would have detrimental effects on the seakeeping characteristics of the vehicle, and either lower the speed at which the onset of downflooding through the non-weathertight hood and over the top of the visor would otherwise occur or cause higher flooding rates at the same speeds.

The trial results showed that, because of bow wave effect, the forward static freeboard of 470 mm (18½ inches) was halved at a speed of 7.6 km/h. At this speed, the remaining freeboard of 235 mm (9¼ inches) would only be retained while the hull was free of all bilge or floodwater.

1.8.4 Bilge Piping Syphonic Action Trials

Detailed descriptions of the pumps and the related discharge piping are included in section 1.7.1 and Appendix A. Tests were carried out to verify the onset of any water syphoning effects caused by the configuration of the discharge piping of the main bilge pump located in the starboard side drain well near midships. The discharge piping and pump did not incorporate any means to prevent the return flow of water into the hull in the event of pump malfunction while the piping was primed.

The tests were carried out with the outboard end of the discharge pipe extending beyond the transom and some 305 mm (12 inches) below the water surface, similar to the operational condition at the time of the sinking. Tests with the discharge pipe not primed showed that syphonic action did not occur while the vehicle was stationary, moving ahead, or when going astern.

Further tests carried out after the discharge piping was primed by the very brief operation of the main bilge pump showed that a steady and continuous flow of water syphoned into the hull. The inflow continued while the vehicle was stationary, moving slowly ahead and astern, and also when moving forward at 8 km/h.

Due to the concurrent ingress of water into the hull from other sources, the rate of flooding caused by syphonic action alone could not be determined during the water-borne tests. However, laboratory simulation of the loaded condition, with the discharge piping immersed as it was in service conditions, showed a steady flow rate of some 11.5 L/min.

1.8.5 Ramp Launching Trial

Trials were conducted to determine the launching characteristics of the vehicle, and to verify how much water was shipped over the top of the forward visor, through the cowl ventilators, the hood top ventilator openings and hood sides, when entering the water at various speeds. The ramp declivity at the Hull Marina was 1 in 6.4 and the vehicle was in a simulated fully loaded condition with an initial effective forward freeboard of 470 mm (18½ inches) to the top of the visor plate.

Launching speeds ranged from 3 km/h to 11 km/h and were recorded by a radar speed-measuring device. The first series of trials was carried out with all openings, except the forward end of the hood, temporarily sealed and another set was conducted with all temporary seals removed. The foam plastic gasket fitted in way of the visor top at the front of the hood was retained in its original in-service condition throughout the trials.

The vehicle was initially winched into the water at minimum speed with the hood completely open. The forward freeboard at which the front of the vehicle lifted and became fully buoyant was found to be 240 mm (9½ inches). The vehicle was retained in this position for approximately 10 minutes before being hauled ashore, at which time some six litres of floodwater, which had accumulated due to hull leakage, was removed.

At the lower launching speeds, the visor was not submerged and, while some spray covered the hood, there was little or no entry of water into the hull. However, at an entry speed of 11 km/h, the visor was submerged, the hood and windshield were completely awash, and some 29 litres of water was shipped.

When the vehicle was launched at 8 km/h with all temporary seals removed from the hood, the visor was just submerged, the hood briefly awash and 22 litres of water was shipped (see Photo 9). When the vehicle was launched at 10 km/h, the visor was submerged approximately 80 mm (3¼ inches), the hood and windshield were fully awash, and 32 litres of water was shipped on board.

Photo 9. Vehicle launched at 8 km/h, visor submerged by approximately 25 mm

With the vehicle in a fully loaded condition, ramp launching speeds in excess of 8 km/h resulted in a significant quantity of water being shipped. In service, and in the absence of bilge high level alarms, the actual quantity of water shipped at the beginning of each tour would not be known by the operator, and its discharge was dependent on the prompt operation of the forward bilge pump.

1.8.6 Floodwater and Trim at Various Forward Freeboards

A series of flooding trials were carried out to determine the progressive change of trim and the quantity of floodwater required to reduce the effective forward freeboard to the height of the bow waves generated at various speeds.

The combination of the reduced forward freeboard due to accumulated floodwater and the bow wave height at a particular speed represents the flooded trim and speed at which water would overflow the top of the visor and cause continuous and major downflooding into the forward part of the hull.

A forward freeboard of 470 mm (18½ inches) and an after trim of 254 mm (10 inches) were recorded at the start of the flooding trials when the vehicle was free of all but a small quantity of bilge water. The vehicle was then progressively filled with water from a number of 210-litre-capacity barrels; because of the configuration of the vehicle, the floodwater was retained in the forward half of the hull. As the weight of water increased, the forward freeboard decreased and the after trim was gradually reduced.

The actual quantity of water and fore and aft trim were recorded at various forward freeboards directly related to the bow wave heights determined during the preceding speed trials. While water from the seventh barrel was entering the hull, the vehicle began to trim by the bow, and a small quantity of hull leakage water accumulating at the after end of the passenger deck began to gravitate forward.

Test records showed that the vehicle reached level trim when some 1375 litres of floodwater was on board and that, at that time, the effective forward freeboard was 240 mm (9½ inches). The preceding speed trials showed the bow wave height generated at 7.6 km/h to be 240 mm (9½ inches), indicating that this bow wave would be level with the top of the forward visor at this speed, when in calm water with the vehicle in a similar flooded condition.

1.9 Sinking Sequence

1.9.1 Vehicle Route and Location of Sinking

Before departure, the driver was instructed that the duration of the water-borne part of the tour was to be reduced to approximately 30 minutes and the *Lady Duck* was to briefly visit the Rideau Falls area. While returning to the Hull Marina, the vehicle passed by a pleasure craft, near the Macdonald-Cartier Bridge, the operator of which remarked on the appearance and trim of the tour vehicle and took a photograph (see Photo 10).

Photo 10. *Lady Duck* approximately five minutes before sinking. Reproduced with permission.

Subsequent photo-geometry and triangulation surveys carried out after the sinking verified the position of the vehicle, at the time the photograph was taken, as being approximately 250 m east of the Macdonald-Cartier Bridge. These surveys and the photograph also led to the determination of the vehicle speed at that time.

A review of Photo 10, in conjunction with the TSB speed, bow wave, trim, forward freeboard and flooding trials, and related information, shows the following:

- The vehicle “level” trim was consistent with some 1375 litres of floodwater having been shipped and retained on board, and the forward freeboard reduced to approximately 240 mm (9½ inches).
- The bow wave was covering the forward end of the hood, submerging the visor plate and entering the forward cowl ventilators.
- The height of the bow wave at a speed of 8 km/h was approximately 267 mm (10½ inches) and exceeds the reduced forward “level” trim freeboard.

- All the passengers remained seated and not alerted at this time.

- An average speed of 8 km/h and an elapsed sailing time of five minutes was consistent with the distance from the sinking location and the position of the vehicle when photographed.

1.9.2 Downflooding and Sinking Sequence

The trials indicated how watertight integrity of the hull was not maintained. The accumulation of floodwater within the hull due to syphonic action, shaft bearing and hull fracture leaks initiated the reduction of forward freeboard before the onset of downflooding over the top of the forward visor. Furthermore, at moderate speeds, the forward freeboard was halved by a bow wave effect, leaving insufficient residual freeboard to prevent the entry of water into the hull in the event of floodwater accumulation or encounter with natural waves and wakes of other vessels in the area.

The forward bilge pump, which was best situated to cope with an accumulation of water in the front of the vehicle, was inoperative and the emergency bilge pumps near midships did not stem the total inflow. As the vehicle was headed toward the Hull Marina, the water accumulated in the forward end of the hull and the vehicle continued to trim more and more by the bow, causing the rate of the downflooding to accelerate. This cycle continued until forward reserve buoyancy was lost and the vehicle suddenly sank bow first.

The most likely sequence of events is illustrated in Figure 4.

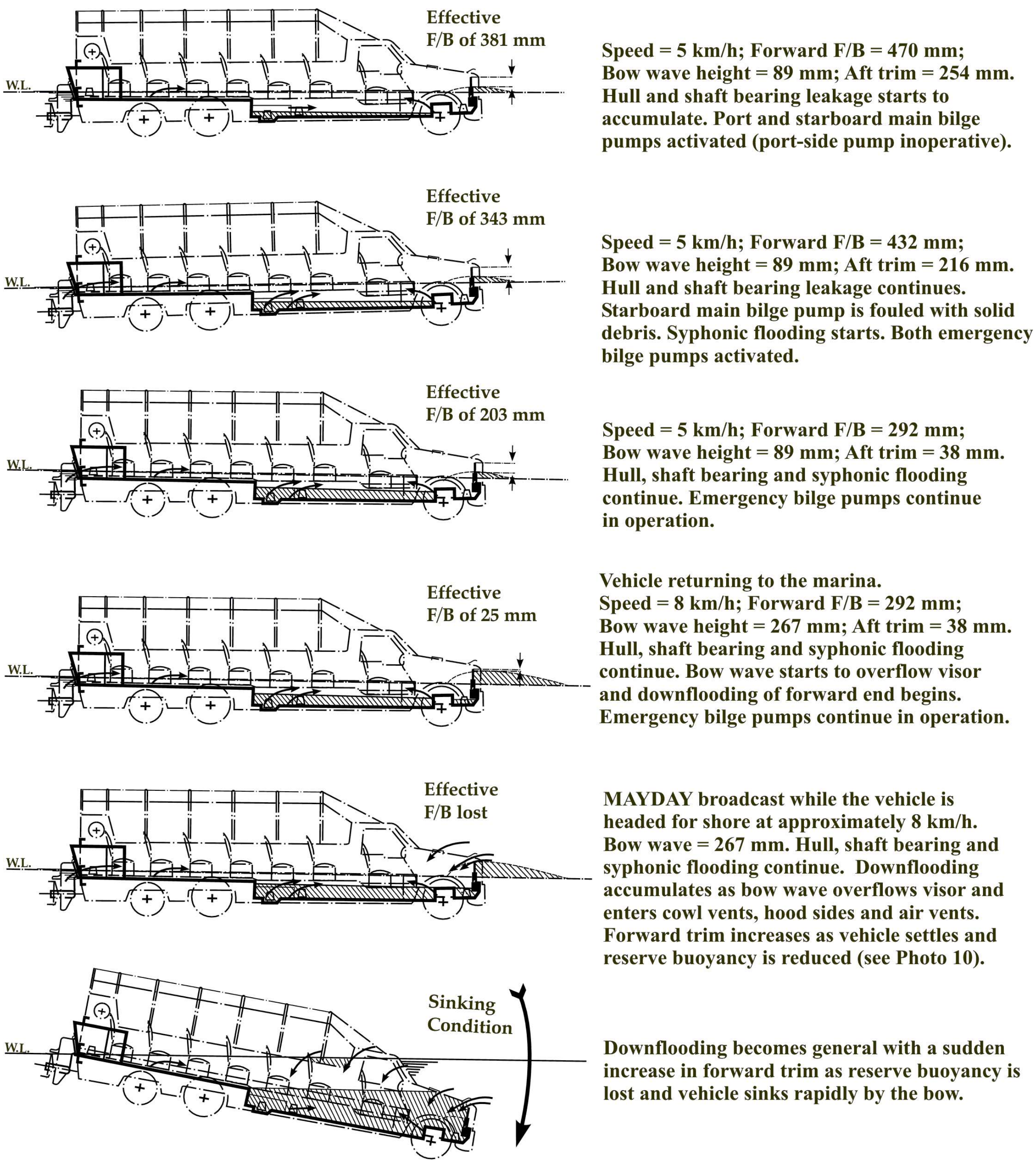

Figure 4. Sinking sequence

1.10 Ministry of Transportation of Ontario Vehicle Inspection

At the request of the TSB, a highway carrier safety inspection of the vehicle was conducted by the MTO, on 03 and 04 September 2002, while the vehicle was at the TSB laboratory. The following deficiencies were noted and were in evidence on the day of the occurrence:

- The validation tag on licence plate BP2 110 indicated an expiry date of October 2001. Plate expired on 31 October 2001 as per permit A1699127. This vehicle was in operation in the City of Ottawa on 23 June 2002, at which time the registration had been expired for 7 months and 23 days. MTO records indicate that the registration was renewed on 31 July 2002 for a period extending to 31 October 2002.

- The annual inspection certificate and sticker were expired.

- The annual inspection sticker (No. F656674) was improperly affixed to the left lower corner of the windshield and displayed a punched date of April 2001. An on-board copy of the annual inspection certificate (No. F531222), showing the vehicle description, vehicle identification number and plate number, matched the subject vehicle, except that the certificate number did not match the sticker affixed. The annual inspection sticker was found to be invalid. No evidence of a semi-annual inspection sticker was affixed to the vehicle.

- The rear identification lamps, side marker lamps, and clearance lamps were missing from the vehicle.

- Passenger seats were not securely mounted.

- The driver and right front passenger doors would not open. The outer body of the vehicle had been modified by the attachment of a hull sponson, effectively sealing the door in a closed position.

- The suspension support bracket for the third axle was found to be cracked and broken.

- Tires on the number three axle did not meet minimum standards for tread depth and damage to tread face.

- As a result of incorrect installation of the number three axle, braking efficiency was reduced.

- The vehicle was not equipped with at least two doors or exits. An emergency exit door was not found. The rear boarding ramp did not provide for the free egress of passengers.

It was not possible to operate the road engine during the inspection of the vehicle since the engine had not been serviced after the occurrence. As a result, it was not possible to fully inspect the vehicle to minimum standards.

On 18 November 2002, the licence plate was removed from the vehicle by the MTO and the vehicle was placed in unfit status as a result of its condition.

1.11 Vehicle Inspection and Certification (Marine)

1.11.1 Small Passenger Vessel Inspection Requirements

As a vessel with a gross tonnage of less than 5, carrying not more than 12 passengers, the *Lady Duck* was not subject to compliance with the *Hull Construction Regulations* or the *Hull Inspection Regulations*, made pursuant to the *Canada Shipping Act* (CSA). However, it was subject to inspection pursuant to subsection 316(3) of the CSA, and compliance with other regulations, including the *Small Vessel Regulations* (SVR), *Collision Regulations* (CR) and *Marine Machinery Regulations*.

When water-borne, the vehicle was required to comply with the life-saving, safety and navigation equipment requirements of Part IV of the SVR, and the navigation lights and sound-signalling appliances necessary to comply with the CR. Such compliance was the responsibility of the owner.

Additionally, as a water-borne passenger vehicle with a gross tonnage of less than 15 carrying not more than 12 passengers and that entered service in the spring of 2001, the *Lady Duck* was subject to the application of the Small Vessel Monitoring and Inspection Program (SVMIP), which evolved from the Interim Small Passenger Vessel Compliance Program (ISPVCP).[7] The interim guidelines in Appendix B of the SVMIP applied until the *Construction Standards for Small Vessels*, TP 1332, was revised.

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[7] This ISPVCP was developed in response to an amendment to the CSA that raised the exemption threshold for annual inspection from a gross tonnage of 5 to 15 for vessels carrying not more than 12 passengers. A policy implementing an Interim Passenger Vessel Compliance Program was introduced in June 1999 (Ship Safety Bulletin 11/99). The program expired on 31 December 2000 and was subsequently extended (Ship Safety Bulletin 04/01) to December 2002 and renamed ISPVCP. On 29 January 2003, the program was reintroduced as the 2003 Interim Small Vessel Compliance Program (2003 ISVCP).

The SVMIP is a voluntary compliance program in which all small vessel owners and operators are encouraged to adopt a self-monitoring inspection regime. In this manner, they can ensure that their vessels are in compliance with safety requirements that pertain to their operation, under which vessels are required:

- to have a first inspection and receive a “Notice of Survey”;
- to have an “Annual Seaworthiness Information Report” completed by the owner;
- to be subject to random inspection and compliance monitoring by a Marine Safety inspector, whereby a “Letter of Compliance” will be issued; and
- to be approved by TC and subject to inspection during construction.

There is conflicting information with respect to the information exchanged between the owner and the regulator concerning the first inspection. However, there is no record to indicate that a formal request for inspection was made to TC.

In a memorandum dated 10 June 1999 to all TC inspectors, the Chairman of the Board of Steamship Inspection (CBSI) indicated that this interim program was designed to promote safety and at the same time offer owners and operators a reasonable time to deal with the changes.

To implement the program, a standard was developed. The memorandum stated the following: “This interim standard is not highly prescriptive and allows a great deal of discretion on the part of the inspector. All decisions which meet the intention of the goals of this program will receive the support of management.” The intent of the program was to permit inspectors to make decisions based on an holistic approach to safety rather than a strict application of regulations. Notwithstanding the program, an inspector is still required to apply CSA provisions that call for detention of a vessel considered to be unfit, unsafe or defective.

The program was to be implemented on an “as needed” basis under the authority of the CBSI and the approval of the National Marine Safety Management Committee (NMSMC). This program was communicated formally to inspectors through ship safety bulletins (SSBs). Managers were briefed by regional managers with respect to the SVMIP. Managers were, in turn, expected to brief inspectors, and each office was expected to have one inspector designated as being primarily responsible for small vessels. The inspector responsible for small vessels was to be given training in the application of the SVMIP and to serve as a resource within the office for any issues pertaining to small vessels.

TC established a Small Passenger Vessel Inspection Course (SPVIC) for its managers and inspectors. The pilot course was delivered in March 2002 (see Appendix F—Small Passenger Vessel Inspection Course, Manual Overview). In addition, two courses were delivered in September and December 2002. As of July 2003, 74 managers and inspectors have attended the course and intentions are to hold additional courses.

1.11.2 *Lady Duck* Inspection Following Previous Occurrence

The *Lady Duck* was involved in an occurrence on 30 June 2001 (TSB report M01C0033). A brief description of the occurrence and the actions taken can be found in Appendix C.

Following that occurrence, examinations and tests to assess the watertight integrity of the hull were carried out independently by the TSB and TC in accordance with their respective mandates. Safety requirements, including watertight integrity, effective freeboards, trim and stability assessments, were completed to the satisfaction of TC. Related trim and intact transverse stability testing of the vehicle were conducted by TC under the aegis of the ISPVCP, with TSB as an observer. During these assessments, which were conducted with the vehicle ashore and afloat, moving at speeds somewhat less than those used in service, there was minimal ingress of water.

TC, having carried out a first inspection, issued a Form S.I. 7 on 03 July 2001, curtailing operation of the vehicle until applicable safety requirements and standards were met. The Form S.I. 7 required 18 corrective measures to be addressed to meet the SVMIP first inspection requirements. The owner then contacted the TC regional office in Sarnia, Ontario, for clarification with respect to the basis for these requirements. After the discussion with the owner, the TC regional office consulted with the TC Kingston office and the manager in charge of small vessel inspections.

In a letter sent to the owner on 04 July 2001, items on Form S.I.7 were reviewed and qualified as "remains effective" or "no specific regulatory requirement, but this is a recommendation only by the attending inspector" (see Appendix E). The former items were all required by regulation, and the latter were "safety requirements" listed in the SVMIP. A copy of SSB 04/2001, describing the SVMIP, was also passed to the owner at this time. Subsequently, the owner did not request to be placed on TC's SSB distribution list for future safety-related information, nor did TC add the owner to the list.

TC then issued another Form S.I. 7 on 20 July 2001, with eight additional items to be attended to by 31 July 2001 in order for the vehicle to be permitted to return to service. This form also advised the owner to notify TC if any abnormal seepage of water was discovered in future operation.

On 01 August 2001, another Form S.I. 7 was issued that required two items to be added to the operator checklist for the *Lady Duck* as follows: the exhaust fan was to be turned on before starting the marine engine, and the forward bilge pump was to be left on "automatic."

On 06 May 2002, TC conducted a random inspection and compliance monitoring under the SVMIP. The inspection consisted of a visual inspection of the safety and navigation equipment, including verification of the appropriate number of lifejackets, in relation to the regulatory requirements of the SVR and the CR, and a brief trial of the vehicle on the water. The inspector did not reiterate any of the items on previous Forms S.I.7 that had been reviewed by TC and identified as recommendations, and limited the inspection to compliance with regulatory requirements. The inspection also included bilge pump testing to confirm their operation (they were turned on and heard to be running). The compliance monitoring section of Ship Inspection Certificate (SIC) 99 was then endorsed.

At the time of this inspection, the hood of the vehicle incorporated two triangular ventilation openings. Two additional 75 mm-diameter (3-inch) cowl ventilators, located at the front of the hood, above the top of the visor plate, were fitted by the owner after the inspection. This was not reported to TC, notwithstanding that SIC 99[8] included the following: "This Notice is valid for the vessel as configured on the date of inspection. No alterations to the vessel are to be undertaken without the prior approval of TC Marine Safety."

1.11.3 Small Commercial Vessel Registration/Licensing

The *Lady Duck* was an amphibious passenger vehicle with a provincial automobile licence for highway operation and was explicitly excluded from the marine licensing requirements of Part I of the SVR (see Appendix B for statutory and regulatory safety requirements, paragraph 7(2)(d) of the SVR).

In accordance with a memorandum of understanding between TC and the Department of Fisheries and Oceans (DFO),[9] the departments agreed that the responsibility and authority for small vessel licensing, except for small commercial vessels, is with DFO, while responsibility and authority for ship registration, including small commercial vessels, is with TC.

As an amphibious vehicle with a gross tonnage of less than 15, the *Lady Duck* was excluded from either licensing or registration data banks, because there was no requirement to licence an amphibious vehicle for which a provincial automobile licence for highway travel was required.

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8 Small Vessel Monitoring and Inspection Program notice of inspection and compliance monitoring issued to vessels with a gross tonnage of not more than 15 and carrying not more than 12 passengers.

9 Memorandum of Understanding Between Transport Canada and Fisheries and Oceans Canada Respecting Marine Transportation Safety and Environmental Protection.

1.12 Personnel Qualifications and Certification

1.12.1 Driver Training

The *Lady Duck*, being a vessel with a gross tonnage not exceeding 5 and carrying not more than 12 passengers, does not require a marine-certificated driver. Nevertheless, the driver held a Minister's Certificate (TC), Master Limited,[10] for the operation of the *Lady Dive I* and the *Lady Dive II*, a Minister's Certificate (TC), Restricted Engineer,[11] an Examiner's Certificate (TC), Master Limited/Restricted Engineer,[12] for the operation of the *Lady Dive III*, and a Radio Operator's Restricted Certificate, all of which were valid at the time of the occurrence. In addition, the driver held a passenger vehicle road licence from the MTO valid at the time of the occurrence.

In April 2002, the driver completed a Marine Emergency Duties (MED) course at St. Lawrence College in Kingston, Ontario. A total of 45.5 hours of instruction covered all sections of the approved syllabus for the MED A1 Basic Safety Course (19.5 hours) and MED A2 Small Vessel Safety Course (26 hours).

One of the objectives of the Basic Safety Course is to ensure that seafarers are able to provide assistance in fire and abandonment emergency situations. During the course, five hours are spent on life-saving appliances and abandonment, including both theory and practical application. Course content includes training on the use of lifejackets, immersion suits, lifebuoys, liferafts and equipment, and survival craft and launching devices.

Before entering the tour service, company drivers received from 12 to 40 hours of on-the-water instruction on board the *Lady Duck* and two larger amphibious passenger vehicles from company personnel. The occurrence driver had been with the company since May 2001 and he estimated having received 12 hours of hands-on training using the company's larger vehicles

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10 Minister's Certificate (TC)
Master Limited (no greater than 60 tons, gross tonnage) carrying passengers; not employed in commercial towing operations, on board amphibious craft *Lady Dive I & II* operating between Ottawa and Hull. Issued 2001/04/26. Valid until 2006/04/26.

11 Minister's Certificate (TC)
Restricted Engineer—Motorship, on board amphibious craft *Lady Dive I & II*, Minor Waters, Class II. Issued 2001/04/26. Valid until 2006/04/26.

12 Examiner's Certificate (TC)
Master Limited (< 60 tons)—Restricted Engineer, carrying passengers; not employed in commercial towing operations on board Lady Dive Amphibus (A.K.A. *Lady Dive III*), operating on the Ottawa River between Ottawa and Hull. Issued 2002/05/15. Valid until 2002/08/14.

and passed a practical assessment for his Master Limited certificate, using one of those vehicles, the previous spring.

Training on board the *Lady Duck* included familiarization with vehicle controls and operational procedures. In general, drivers practised and became familiar with the manoeuvring characteristics of the vehicle, with particular attention given to entering and leaving the water at the Hull Marina ramp. The training addressed such things as the location and operation of the vehicle's road and marine lights, horn, public address system, VHF radio, bilge pumps, fire extinguishers, stowage of lifejackets, etc. The driver of the occurrence vehicle had been given familiarization training on the *Lady Duck* by the company's mechanic before operating the vehicle.

During training for routine preparation of the *Lady Duck*, drivers were verbally instructed to check that the forward and after engine fuel and other fluids were at operating levels and that all other systems were operational before beginning passenger service.

Training for routine in-service operation also called for drivers to check the operation of the bilge pumps while afloat, as well as the closure of the bilge drain valves and plugs before starting service and when the vehicle was ashore and parked between tours.

1.12.2 Tour Guide Qualifications and Training

This was the second summer in which the tour guide on board the vehicle had been employed by the company. The total time spent afloat was less than six months, and the tour guide had not completed MED training. The *Crewing Regulations* require every crew member to successfully complete MED training before the completion of six months on board.

Tour guides were assigned to the *Lady Duck*, the *Lady Dive I* or the *Lady Dive III*. The *Lady Dive* vessels were of different configuration, were considerably larger than the *Lady Duck*, with a seating capacity in excess of 40 passengers, and carried a liferaft in addition to other required emergency equipment and life-saving appliances.

There was no formal training program offered to guides before conducting tours on any of the amphibious vehicles and there were no written company policies or procedures on what and how to train *ab initio* tour guides. Tour guides were provided with a script to study, which described various land and water sites on the tour and included two references to safety:

- For your own safety, I just want to remind you to stay in your seat as well as keep your arms and legs in the bus at all times; and

- Show everyone where the lifejackets and emergency exits are situated, and that they can stand up a few at a time to take pictures.

Newly hired tour guides accompanied experienced guides on tours to get a feel for how the tours should be conducted. Once the senior guide was satisfied that a tour guide had demonstrated a comfort level with delivering the script to passengers, the guide was booked to handle tours with a driver.

With respect to the safety equipment on board amphibious vehicles, the tour guides were shown the location of the PFDs, lifejackets, lifebuoy, emergency exits and, in the case of the *Lady Dive I* and *Lady Dive III*, the rear boarding ramp.

In the spring of 2002, the senior guide responsible for scheduling tour guides organized a meeting of those hired to date. At that meeting, the tour guides boarded the *Lady Dive I* and were taken on a familiarization land tour of the city. Following the tour, the guides were briefed by a company mechanic on the location of safety equipment on the *Lady Dive I*. The mechanic also briefed them on the location of safety equipment on the *Lady Duck*. This meeting was a "one-off" event, organized on the senior guide's initiative and not as a result of any company requirement.

Tour guides were not provided with any hands-on training on how to operate any of the safety equipment and there was no reference in the script to demonstrate how to don a lifejacket. Although it was reported that demonstration of proper use of lifejackets was conducted on the larger amphibious vehicles, donning a lifejacket or a PFD was not part of the routine safety briefing on the *Lady Duck*.

No company documentation or training was provided to crews on emergency evacuation procedures and the roles of the driver or the tour guide were not defined in the event of an abandonment of the *Lady Duck*.

Research on emergency evacuations, especially on aircraft, has shown that strong leadership by operating personnel, involving firm direction and appropriate behaviour, serves to decrease evacuation times and reduce panic among passengers. As emergencies are not commonplace, the research also emphasizes the importance of thorough initial training and regular refresher training.[13, 14]

[13] H.C. Muir and A.M. Cobbett. *Cabin crew behaviour in emergency evacuations*. Civil Aviation Authority/Federal Aviation Administration Paper DOT/FAA/CT-95/16, 1995.

[14] U.S. National Transportation Safety Board (NTSB). *Special investigation report: Flight attendant training and performance during emergency situations*. Report No. NTSB/SIR-92/02, 1992.

1.12.3 Mechanic Qualifications and Training

The company's full-time mechanic in charge of vehicle maintenance had no formal training and held no formal certification. His work-related mechanical experience was four seasons with this company.

1.13 Company's Standard Operating Procedures

As a result of the occurrence involving this vehicle on 30 June 2001 (TSB report M01C0033), a formal system was introduced to check and record the completion of routine vehicle preparation procedures before and during daily operation (see Appendix C). The driver was to verify the status of the seacocks, sign the safety checklist, and have it countersigned by the tour guide or the kiosk attendant for retention ashore. The list also included the number of passengers on board, names of driver and guide, time of departure, time of entry in the water and exit from the water, and return to the kiosk.

Form S.I. 7 issued on 01 August 2001 required two items to be added to this checklist: the exhaust fan was to be turned on before starting the marine engine, and the forward bilge pump was to be left on "automatic." As late as 12 August 2001, these items had not been added to the company checklist.

A safety checklist for the day of the 2002 occurrence was not recovered nor provided by the owner. However, a different document recovered from the vehicle for the day of the occurrence showed that the driver had signed off on completion of a water test (water-borne operational test) and vehicle circle check (walk around).

With the exception of the two documents above, the company had no formal standard operating procedures[15] in place for the vehicles nor any written policy addressing personnel training.

1.14 Weather Conditions

Between 1200 and 1700 on 23 June 2002, the Gatineau airport weather station recorded southwesterly winds of 7 km/h, gusting to 15 km/h. Thunderstorm and heavy rain showers were recorded after the occurrence from 1707 to 1913 with northwest gusts at 28 km/h and with gusts to 56 km/h at 1800.

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15 Standard operating procedure: a set of instructions covering the features of operations that lend themselves to a definite or standardized procedure without loss of effectiveness. The procedure is applicable unless ordered otherwise (North Atlantic Treaty Organization glossary of terms and definitions).

Since the accident occurred at about 1610, the weather was not considered to be a factor in this occurrence.

1.15 Vehicle Maintenance Records

A *Driver's Vehicle Inspection Report* was kept by the company mechanics under the auspices of the MTO for daily inspection of the vehicle. This document recorded defects or repairs; however, there were no references to bilge pump repairs or maintenance. No other record of maintenance was available for examination after the occurrence.

1.16 Communications

The vehicle was not equipped with either an automatic or manual distress radiotelephone alerting system, such as digital selective calling or an emergency position indicating radio beacon, to alert Search and Rescue (SAR) authorities. This equipment was not required by regulations for this class of vessel.

Directional VHF antenna coverage of MCTS in Prescott and in Montréal does not extend to the National Capital Region. Currently, there is no plan to offer such radio coverage to the Ottawa region. SAR response is available through two Canadian Coast Guard (CCG) auxiliary craft[16] and any other private or commercial craft in the area that may be monitoring VHF channel 16 (the emergency channel).

In 1999, the operators of the Hull (now Gatineau) 911 service proposed to the CCG that a marine VHF station be incorporated in the system. However, no further action has been taken in this regard.

The *Ship Station (Radio) Regulations, 1999* prescribe the radio equipment to be carried by commercial vessels for distress, urgency, safety, and general communications. Ships carrying more than six passengers on a voyage within a VHF coverage area shall be equipped with one VHF radiotelephone. A proposed amendment to the regulations will require passenger ships, engaged on a voyage outside a VHF coverage area, to be equipped with radio equipment capable of establishing continuous two-way communications with a MCTS centre or a person ashore. The amendment was published in the *Canada Gazette*, Part I, on 12 April 2003, vol. 137, No. 15. It is anticipated that the amendment will come into force in 2004.

16 CCG auxiliary is made up of volunteers who are primarily pleasure craft operators and commercial fishermen who use their own vessels or community-owned vessels for safe boating education and SAR-related activities. In the Ottawa area, there are two auxiliary vessels.

1.17 Passenger Safety

1.17.1 Passenger Safety Briefing

Safety briefing requirements are contained in Part IV of the SVR, section 26.1 (for text of acts, regulations or publications, refer to Appendix B). Relevant to the *Lady Duck* operation are subsections 1(a), 1(d), 1(e), 1(f) and 2. Before beginning the land portion of the tour, the guide briefed the passengers on procedures and safety features in French and English. This briefing advised passengers to stay in their seats and to keep arms and legs inside the vehicle at all times.

Before the water-borne portion of the tour, the guide provided an additional safety briefing, in French and English, which informed the passengers that there was a "lifejacket" hung on a hook beside each seat, that children's lifejackets were at the back of the vehicle, and that the emergency exits were the windows along each side of the vehicle as well as the back window over the retractable stairs. During land-to-water transition, the passengers were instructed to remain seated until the vehicle had entered the water and was floating, at which time they would be able to stand up, a couple at a time, to take pictures.

The "lifejackets" to which the tour guide referred were actually PFDs, not the approved keyhole lifejackets stowed under the passenger seats. The referred children's lifejackets were appropriate for the operation.

No demonstration on how to don either the approved keyhole lifejacket or the PFD was given, nor was the passengers' attention drawn to the location of the lifebuoy or distress equipment or their methods of operation.

1.17.2 Evacuation Sequence

After ordering the evacuation, and as he was moving aft to help the passengers don their PFDs, the driver was swept out of one of the window exits. To evacuate, all other occupants turned to the rear exit that had been their entrance point.

The guide and one passenger, recognizing that there was a "bottleneck" at that exit, evacuated through the window exit beside the aftermost seat on the port side. Reportedly, the vehicle was almost vertical and the guide used the top of the awning to help pull herself out from under the water. The passenger also reported experiencing difficulty exiting through that side window.

The passengers who egressed through the rear exit encountered difficulties because of the need to climb up to the opening at the top of the raised boarding ramp, the small opening provided by that exit, and minor injuries were received when passing through the opening.

Common to all the accounts was the difficulty in abandonment presented by the rapidity of the sinking, the trim of the vehicle as it sank, and the “bottleneck” created at the rear exit. Reportedly, panic set in as passengers attempted to evacuate through the rear exit.

1.17.3 Use and Availability of Life-saving Equipment

During the evacuation, one survivor held onto a PFD. Two others wore PFDs when they exited, neither of which was fastened. One of the survivors was given a lifejacket before exiting, but it was a child’s lifejacket and was too small to allow the head to pass through. Another passenger, on surfacing, also used a child’s lifejacket that was ineffective as a flotation device for that person. The driver and one of the passengers had not donned PFDs, the driver because he was swept overboard as he was moving to the rear of the vehicle and the other person because he had moved to the rear of the vehicle at the driver’s request and was no longer within reach of the PFD at his seat. The driver was able to link his arm around a floating PFD after he was ejected from the vehicle.

1.17.4 Life-saving Equipment Requirements

Life-saving equipment requirements for commercial vessels over 8 m in length are contained in Part IV of the SVR, section 29 (for text of acts, regulations or publications, refer to Appendix B). Life-saving equipment carried on such vessels shall provide a level of safety that is equivalent to or higher than those standards.

In accordance with SSB 04/2001 and the SVMIP, Appendix B, section 2, paragraph (g), additional equipment is recommended, including an inflatable liferaft, inflatable platforms, and/or a suitable boat. Form S.I. 7 (see Appendix E) specified these items and, following a review by TC, they were listed as recommendations only by the attending inspector.

In the SPVIC, marine safety inspectors are given instructions on life-saving equipment inspections and passenger safety briefings. Although this guidance is applicable to small passenger vessels with the emphasis on vessels of a tonnage equal to or less than 15 and that carry more than 12 passengers, many of the inspection items, such as lifejackets, lifebuoys and safety briefings, applied to the *Lady Duck*.

Inspectors were required to ensure that all lifejackets were checked for strength of the outer casing, that all ties were tested for strength and completeness, that retro-reflective tape was complete and in place and that whistles were attached. Further, inspectors were to determine that lifejacket stowage was easily identified, accessible and clearly signed, and that children’s lifejackets were stowed separately and readily deployable.

The SPVIC instructions indicate that lifebuoys should be checked to ensure that they meet the regulations and inspectors should inform owners/operators that, although not required by law, they are encouraged to have buoyant apparatus that floats free.

1.17.4.1 Lifejackets

The standard approved lifejacket to be carried on board the *Lady Duck* was the keyhole style, constructed to the provisions of sections 3 to 7 of Canadian General Standards Board (CGSB) Standard 65-GP-14M.[17] Twelve adult and three children's lifejackets were recovered. At the time of the occurrence, the *Lady Duck* had the required number of lifejackets on board.

The recovered adult lifejackets were D.O.T.-approved in 1972, six years before CAN/CGSB Standard 65-GP-14M came into effect. Although the lifejackets were older than the published standard, there was no requirement to replace them as long as the lifejackets were individually inspected yearly by a TC inspector and their condition pronounced adequate for the function they perform. Inspection for adequacy would include such factors as the integrity of the seams and ties, buoyancy, fabric discolouration, and required markings and whistles. A TC random inspection on 06 May 2002 included a verification of the number and serviceability of the lifejackets.

Examination of the lifejackets after the occurrence revealed that five of the recovered adult lifejackets were not equipped with whistles and none was marked with retro-reflective tape, as is now required by CAN/CGSB Standard 65-GP-14M. The markings, including the side-view sketch, were faded, in some cases to the point of being unreadable. On some of the lifejackets, the ends of the tie tapes were frayed.

The three recovered children's lifejackets were D.O.T.-approved, were equipped with whistles and retro-reflective tape, and were marked appropriately. On two of the three children's lifejackets, the side-view sketch measured 55 mm by 70 mm, smaller than the requirement of 55 mm by 115 mm.

Photo 11. Lifejacket under the seat with booster cables on top

The adult lifejackets were stowed in lockers under each of the passenger seats. Examination after the occurrence revealed that it was not easy to remove the lifejackets from beneath the seats, as they tended to catch on the lip of the

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17 Canadian General Standards Board (CGSB) Standard 65-GP-14M, *Standard for: Life Jackets, Inherently Buoyant, Standard Type*, published in September 1978.

metal box in which they were stored. Care was necessary when removing the lifejacket during the investigation so as not to tear the shell fabric. Furthermore, since it was necessary to leave the seat to access the lifejackets, there could be considerable congestion in the single aisle. In three of the eleven lockers, there were various items (a nylon rope, a container of motor oil, and a set of booster cables) stored on top of the lifejackets (see Photo 11).

The children's lifejackets were stowed at the rear of the vehicle, stacked on top of the I/O engine compartment.

1.17.4.2 Lifebuoy

The *Lady Duck* was not equipped with an appropriate lifebuoy. The lifebuoy on board was a 610 mm-diameter (see Appendix E), rather than the 762 mm-diameter lifebuoy required by Part IV, section 29 of the SVR. The 762 mm lifebuoy is the largest of the lifebuoys required under the SVR and is subject to a more comprehensive list of requirements than the lesser 610 mm, including the requirement for retro-reflective tape affixed at four equidistant points around the core of the lifebuoy and the attachment of a life line of not less than 9 m in length.

Examination of the 610 mm lifebuoy revealed that, although it was stamped with TC approval number TC.143.014.045, it did not meet applicable standards as set out in both TP 7325, *Standards for Lifebuoys and Integral Equipment*, and section 8, Schedule III of the SVR. The lifebuoy grab lines were of varying lengths (570, 590, 600, and 610 mm) rather than the required length of not less than 610 mm for each line. The lifebuoy was attached to the top of the after bulkhead above the I/O engine compartment by way of a bungy cord, the hooks of which were clasped together behind the lifebuoy. Because of the mode of attachment, it would not have been available for immediate deployment.

In Form S.I. 7 of 03 July 2001, the TC inspector requested that two 610 mm-diameter lifebuoys be installed on the vehicle. A TC letter dated 04 July 2001 amended this request to "one (1) approved lifebuoy with 9 m of rope."

1.17.4.3 Personal Flotation Devices

A personal flotation device is defined in the SVR as a

> buoyant life-saving apparatus other than a lifejacket, that is intended to be worn by a person and that meets the standards set out in section 1.3 of Schedule III.

Section 1.3 of Schedule III indicates that the standards for PFDs are

> ... those set out in
> (a) Canadian General Standards Board standard CAN/CGSB-65.11-M88, Personal Flotation Devices; or
> (b) Underwriters Laboratories standard UL 1180, Fully Inflatable Recreational Personal Flotation Devices, with the Canadian addendum.

Although not required by the SVR, the *Lady Duck* was equipped with 12 PFDs readily available and located on hooks adjacent to the passenger seats. All PFDs recovered were size "Large to XLarge," designed for chest 102 cm to 122 cm (40 inches to 48 inches) and for people over 41 kilograms (90 pounds). The PFDs were stamped with a label, indicating that they met standard CAN/CGSB-65.11-M88 and were approved by the CCG.

At the time of the occurrence, two younger victims were wearing adult PFDs that were too large for their body size.

1.17.5 Emergency Evacuation

1.17.5.1 Emergency Exits

When the passengers boarded, they did so through a boarding ramp on the rear left corner of the vehicle. After all passengers boarded, the ramp was folded up by an electric winch into an opening of 1830 mm high by 685 mm wide (72 inches high by 27 inches wide) that forms a watertight seal for operation in the water. Once the ramp was secured, the opening, which was also an exit in the event of abandonment, was reduced to 788 mm high (31 inches) and 685 mm wide (27 inches) at its widest point, decreasing in width to 533 mm (21 inches) near the top of the exit (see Photo 12).

Photo 12. View from inside the vehicle of rear exit with boarding ramp in retracted position

Photo 13. After boarding ramp in retracted position

The ramp was articulated in that, when the ramp was retracted, its bottom two stairs folded upside down against the exterior of the vehicle. Once the vehicle was in the water, the boarding ramp could not be lowered (see Photo 13).

To access this rear exit for emergency egress, passengers had to make their way along a 584 mm-wide (23-inch) aisle and then make two turns to move between the rearmost seat on the port side and the front left side of the I/O engine compartment. The narrowest point of this route was 514 mm (20¼ inches). Once at the exit, passengers had to climb approximately 1016 mm (40 inches), with no permanent foothold to aid them, to the top of the retractable stairs to reach the available opening. There were several sharp metal corners on the top of the retractable staircase and winch assembly. The two bottom stairs of the ramp folded upside down against the exterior of the vehicle; the first of the two presented an almost slide-like property to anyone attempting to egress through this exit. Once passengers were at the top of the retractable stairs, there was no platform to step onto to facilitate egress into the water. Passengers had to find a posture to jump without any support structure to aid them in that movement, while ensuring that they cleared the hazard presented by the exterior stairs and the I/O motor.

Human engineering standards, such as Military Standard 1472D (MIL STD 1472D), provide guidance for design of, among other things, egress areas to ensure accommodation and compatibility by the user population. Subsection 5.6.3.2 of this standard, entitled *Clearance Dimensions*, indicates that clearance dimensions for passageways and accesses, which must accommodate or allow passage of the body or parts of the body, shall be based upon the 95th percentile values for applicable body dimensions.

In subsection 5.7.8.3, *Whole Body Access*, the standard states that dimensions for rectangular access side openings for body passage should not be less than a depth or height of 660 mm (26 inches) for light clothing and 740 mm (29 inches) for bulky clothing, as well as a width of 760 mm (30 inches) for light clothing, with 860 mm (34 inches) required for bulky clothing.

With respect to the rear exit on the *Lady Duck*, while the height of the opening, 788 mm (31 inches), was in excess of what MIL STD 1472D recommends, the width of 685 mm (27 inches) reducing to 533 mm (21 inches) fell short of being able to accommodate the full user range on which the 95th percentile values are predicated.

It is instructive to note that Chapter 4 of the *International Code of Safety for High-Speed Craft* provides direction on accommodation and escape measurement. Regarding the dimensions of passages and accesses that form part of evacuation paths, subsection 4.7.13 indicates that the dimensions should be such as to allow easy movement of persons when wearing lifejackets. There should be no protrusion in an evacuation path that could cause injury, ensnare clothing, damage lifejackets, or restrict evacuation of disabled persons.

The SVMIP, Appendix B, section 8, *Passenger Complement,* indicates that, for Class I and Class II vessels, the passenger complement is to be established on the basis of 610 mm for each passenger on firm secured seating. Seat clearance front-to-back must be 300 mm and aisles must be at least 755 mm in width. Class III vessels, such as the *Lady Duck*, are only required to provide suitable seating for each person on board.

A continuous fabric awning was attached to a metal frame, constructed such that its support structures formed window frames along each side of the vehicle. These frames did not obstruct egress from the openings. Each window frame was individually wrapped in fabric and secured by zippers. Eight of the window openings measured approximately 864 mm by 914 mm (34 inches by 36 inches) from the interior. There were also openings, immediately behind the cab on both sides of the vehicle, that measured 495 mm wide (19½ inches). They were irregularly shaped vertically to accommodate the downslope of the fabric awning. An additional window, located at the very rear of the starboard side, was 533 mm wide (21 inches) and was also irregularly shaped vertically to fit the dimensions of the vehicle.

The roll-down transparent weather screens on each side of the vehicle were fitted with zippers and snap fasteners to secure them. The zippers were of two types: large zippers with double-sided slides and small zippers with single-sided slides. Of the larger openings along the side of the vehicle, four were equipped with small zippers on each side of the screen, two had large zippers on each side of the screen, and two were equipped with a combination. When the screens were zipped down, all slides on the small zippers were on the outside of the vehicle (one roll-down transparent weather screen on the starboard side near midships was zipped in the secured position on the day of the occurrence). In the closed state, none of the slides was visible or easily reachable from inside the vehicle, as they lay 50 mm (2 inches) below the gunwale, nor were the screen bottoms, as they were snapped to the outside of the vehicle.

The sides and rear exits were not marked as emergency exits, nor was there any requirement for them to be so marked. No guidance was provided to passengers on how to use them. None of the passenger seats were equipped with a safety information card, nor was there any requirement for them to be.

1.17.5.2 Vehicle Cab Doors

The cab doors on both sides of the vehicle were permanently sealed; only their windows could be raised or lowered, and provided limited means of escape from the cab in the event of abandonment.

1.18 Safety Organizations Serving Small Passenger Vessels

A number of programs have been developed to assist owners and operators of small passenger vessels to comply with TC's regulatory and voluntary safety regimes. They include business licensing arrangements, under provincial or municipal authority, that require proof of compliance (e.g. an inspection certificate) as a condition of issuance. Quebec has a general program, described in section 1.18.1, while Victoria, British Columbia, has a program requiring small whale watching vessels to comply with standards developed by an industry association in conjunction with TC, described in section 1.18.2. The Canadian Passenger Vessel Association (CPVA), described in section 1.18.3, has developed a safety training course to support its members; however, its membership profile is not representative of all industry sectors nor regions of the country.

1.18.1 Commission des transports du Québec

In the Province of Quebec, the Commission des transports du Québec was created to increase public safety in the areas of road, marine and rail transportation. Its mission also includes the protection of roadway heritage and management of economic activity in many transportation areas to ensure service availability and quality.

Any person who offers passenger transportation services on water for commercial purposes must hold a permit issued by the Commission. That permit provides assurance that the holder has the knowledge and expertise required to offer such services, that the holder has obtained the minimum insurance coverage indicated in the regulations, and that the vessel meets safety requirements. The carrier must provide a crew with applicable knowledge and experience to allow them to make competent use of the permit they have received.

Carriers must also provide the Commission with an insurance certificate, stating that every one of the ships for which they requested a permit is covered by a maritime civil liability insurance policy with a guaranteed minimum limit of five million dollars. This applies to every vessel with a gross tonnage over 5 or a capacity of over 12 passengers. Carriers must also meet the requirements of TC by providing a ship inspection certificate issued by TC.

For vessels with a smaller capacity, a letter of compliance, issued by a maritime expert recognized by TC or one of its inspectors, is required along with a note confirming the capacity of the ship and the competence of the crew to undertake commercial activities over a given territory. The maritime civil liability insurance certificate for ships with a gross tonnage equal to or below 5 or a capacity of not more than 12 passengers must have a minimal guarantee of one million dollars per vessel.

Maintaining crew qualifications and ship quality and holding an insurance policy are the first conditions required for a maritime passenger transport permit covering all vessel categories.

Since the *Règlement sur le transport maritime de passagers* came into force in 1998, the Commission has registered 252 vessels, including 86 vessels of a gross tonnage equal to or below 5, and 106 vessels with a capacity of not more than 12 passengers.

Because the vehicle was registered in Ontario, the *Lady Duck* was not required to hold a permit issued by the Commission. No parallel organization exists in Ontario.

1.18.2 Operator Vessel Safety Standards for Whale Watching Vessels

In the Province of British Columbia, in collaboration with TC and the Whale Watch Operators Association Northwest, safety standards have been put in place for the operation of whale watching vessels of a gross tonnage equal to or below 5 and carrying not more than 12 passengers that operate from the Greater Victoria city area.

The standards are composed of the following three sections:

- Standards for Victoria area whale watching companies operating vessels of gross tonnage less than 5 and carrying 12 or fewer passengers

  These standards were submitted to TC with the intention of developing them into a TC standard. They contain specific safety requirements that address vessel construction and seaworthiness, safety equipment, communication equipment, navigation equipment, and operator proficiency requirements.

- Code of Conduct

  The Code was established by the Whale Watch Operators Association Northwest as a guideline for operating procedures to ensure the safety and comfort of the occupants aboard rigid hull inflatable whale watch vessels. The Code is not intended to be part of the TC standard. It contains, *inter alia*, guidelines that address occupant safety, weather concerns, areas of adverse conditions, speed limits, and operator etiquette.

- Training syllabus for the whale watching operators proficiency Victoria Harbour and approaches for commercial vessels of gross tonnage not exceeding 5 and that do not carry more than 12 passengers

  The syllabus was prepared by TC (Victoria) in consultation with the Whale Watch Operators Association Northwest and is not intended to be part of the TC standard. It provides an outline of the information considered essential to the safe execution of an operator's duties. The material is also intended to be a guide for the operator's examination.

No similar standards applicable to the *Lady Duck* exist in the Province of Ontario.

1.18.3 Canadian Passenger Vessel Association

The Canadian Passenger Vessel Association (CPVA) is composed of more than 120 commercial passenger vessel owners and operators who offer transportation services to the public in Canadian waters.

The purpose of the CPVA is to exchange ideas and information among the membership and to maintain a dialogue with the regulatory agencies on rules that govern the industry. The CPVA promotes the ideals of marine safety among its membership and a continuing quality of services for the travelling public.

The CPVA has developed a safety training course for non-certificated personnel serving on board seasonal passenger vessels. The objective of this course is to provide a ship-specific safety course that may be given by a certificated officer or other approved person at a one-day session at the outset of the season. This course is a substitute for MED A1 for crew that had received provisional approval on 28 March 2002, and had received final approval by TC two days before this occurrence. It includes theoretical and practical elements on emergencies, emergency response, life-saving appliances, abandonment, survival, fire fighting, accidents on board, and rescue. The operator of the *Lady Duck* was not a member of the CPVA.

2.0 Analysis

The analysis will focus on the operational condition of the vehicle, vehicle inspection, passenger safety, safety management, regulatory safety culture, emergency communications, dissemination of safety information and the vehicle's seaworthiness.

2.1 Vehicle Operation and Characteristics

2.1.1 Vehicle Pumping System

When the driver of the *Lady Duck* realized that the front of the vehicle was lower than normal, he confirmed that the emergency bilge pumps were discharging water. However, the combined discharge capacity of these two pumps did not stem the increasing ingress of water overflowing the forward visor and the vehicle trimmed progressively by the bow. These were the only operational pumps whose discharges could be observed from the driver's position. The two main bilge pumps were inoperable (see Appendix A—Bilge Pump Examination and Testing).

Small vessels, similar in size to the *Lady Duck*, are required to carry one manual pump and one bailer. The installation of one manual bilge pump and six power-driven pumps on the *Lady Duck* significantly exceeded the normal outfit expected on a vessel of comparable size and service. The pump configuration was in response to TC's concerns regarding the distribution of pumps to cover the lowest areas in the forward and after engine compartments, and the possible lack of watertight integrity of the vehicle. The following concerns were noted in Forms S.I. 7 issued by TC:

- provide means of sealing the forward engine compartment watertight;
- provide an additional bilge pump in the forward compartment and leave it on automatic;
- provide an additional bilge pump in the engine compartment located aft;
- improve the stern door sealing arrangement; and
- notify TC if abnormal seepage of water was discovered.

The front visor was secured in place. However, the bilge pumps were not installed in accordance with manufacturer instructions. Specifically, the wiring connections to the pumps were not watertight or adequately secured, and the main pumps were over-fused. Debris in the impellers stalled the pumps and, as the fuses were too large, induced the failure of the pump motors. Of the six electrically driven bilge pumps, the two that were effectively operable did not stem the ingress of water.

The operator of any vessel must maintain an adequate level of awareness respecting the operating condition of the vessel. Water retained within a vessel can cause several adverse operational problems affecting safety. This is particularly true on small vessels where safety margins are limited.

In this instance, when the vehicle entered the water, the driver switched on both main bilge pumps, anticipating their discharge from each side of the vehicle. When no water was seen discharging near midships, both emergency pumps were activated and water was seen discharging from both sides of the vehicle. This sequence of events is consistent with the driver's knowledge of the previous location of the discharges from all four pumps, and indicative that he was unaware that the starboard side main bilge pump discharge had been redirected aft and out of his line of sight. Following the vehicle's entry into the water, the starboard side main bilge pump failed. As the vehicle remained afloat approximately 30 minutes after leaving the ramp at the Hull Marina, an estimated 345 litres of floodwater would have entered the hull due to syphonic action through the discharge piping of the then inactive starboard side main bilge pump.

On vessels with a low freeboard, the operator needs to be aware of the existence of water in the bilge and that the bilge pumping system is effectively coping with any ingress of water. Such reliance on the bilge pumping systems can lead to operators not readily recognizing or appreciating the existence or severity of an evolving unsafe condition. Consequently, the operator is deprived of valuable information to make appropriate and timely decisions to successfully identify and resolve the developing situation. Since a bilge high level alarm was not installed and the condition of the bilges could not be observed by the driver, the perception of the emergency situation was delayed due to a lack of information on the amount of water in the bilges.

2.1.2 Passenger Safety Briefings

The tour guide had no formal training or written instructions on suitable pre-departure safety briefings. Consequently, only incomplete verbal instructions were given, and passengers were not advised of the location and use of all safety equipment.

In addition, passengers did not receive a demonstration on how to correctly don their lifejackets. The size of a lifejacket or a PFD must be appropriate to the body size of the wearer to perform as designed. If the life-saving appliance is too large, too small, or incorrectly worn, the wearer can be at risk of sustaining personal injury and/or drowning. In this occurrence, the PFDs worn by two of the victims were too large for their body size.

Although passengers were informed that the rear exit and side windows were emergency exits, no instructions were given about what to do in the event of an abandonment. For example, passengers were not told how to open the windows if they were zipped closed. Passengers were not instructed to look around to determine their nearest exit and they were not cautioned that it may not be the same one used to enter the vehicle.

It is recognized within the passenger transportation industry that timely provision of critical safety information helps passengers prepare for potential emergency situations. Such information facilitates the ability of passengers to assume a certain level of responsibility for personal safety, thereby mitigating a portion of risk to which they may be exposed. The Board has made recommendations, based upon the important safety benefit derived from passenger briefings, in its investigations involving the *Tan 1* (TSB report M93L0004) and the *True North II* (TSB report M00C0033). On 01 May 2002, an amendment to the SVR requiring these briefings came into force. However, the outcome of the *Lady Duck* occurrence demonstrated that either this requirement may not be known to all operators of small passenger vessels or that the derived safety benefit may not have been fully appreciated.

2.1.3 Emergency Evacuation Training

Before the vehicle's rapid sinking, many of the occupants had put on a PFD and lined up at the rear exit to egress. Other than the driver calling for the passengers to abandon the vehicle and the tour guide attempting to throw PFDs/lifejackets to the passengers, there was no direction provided by the crew and they did not facilitate the evacuation toward other exits.

The company had no formal evacuation policies, procedures or training that addressed the possibility of a vehicle evacuation. Although the driver had received abandonment instructions during the MED A1 and A2 course, no specific training or drills were conducted on company vehicles, including the *Lady Duck*, to put that training into practice. Further, none of the tour guides received hands-on training on the safety equipment, including fire extinguishers, distress equipment and, in the case of the company's larger vehicles, the liferafts.

Although the side window exits were larger than the rear exit and available as a means of escape, 11 of the occupants initially turned to the rear exit to evacuate. For a few, this may have been due to the driver's earlier request to move to the rear of the vehicle. The others may have been reacting in a manner that has been seen in other evacuations, where people tend to exit through their point of entry. Only two occupants recognized that there was a "bottleneck" there and chose a side window as their point of egress.

Studies on the evacuation of aircraft have shown that passengers tend to look for and expect instructions and guidance from the professional crew.[18] In this occurrence, there were no formal company policies or procedures for training tour guides on safety-related issues. Without the benefit of emergency evacuation training, crews on small passenger vessels are left unaware of and unprepared for the dynamics of an emergency and in a position of having to improvise in a situation where there is little or no time to spare.

Training the drivers and tour guides on how to facilitate an evacuation on the *Lady Duck* and emphasis during the safety briefing that the primary evacuation route was through the side windows would have provided the passengers with the appropriate information to avert "bottlenecks" and likely facilitated an orderly evacuation.

2.1.4 Life-saving Equipment

Carriage of the approved lifejackets is required by regulation. The lifejacket, developed for professional mariners, was designed to provide buoyancy and, in the case of injury, keep an unconscious wearer's head face-up above the surface. The PFD, on the other hand, was developed for pleasure craft operators. The premise behind the development of the PFD was that, while it offers reduced performance as compared to a lifejacket, in that it will not keep a wearer's face clear of the water, it will keep users afloat and is more likely to be worn than the higher performance, but cumbersome, lifejacket.

The carriage of PFDs on board the *Lady Duck* was not discouraged during an inspection by TC in May 2002 and they remained the first line of defence for water survival. During the evacuation, the passengers who donned PFDs before evacuating were kept afloat until rescued by nearby boaters. While PFDs were not the approved life-saving appliance for the vehicle, it may be that their use on a vehicle such as the *Lady Duck*, where hull design and the lack of inherent buoyancy can lead to rapid sinking, was more appropriate than the lifejacket. Although they are easier to don and more comfortable to wear, they do not provide all the benefits of an approved lifejacket.

A safety deficiency respecting the accessibility of lifejackets has been identified in previous occurrences, including the *True North II* (TSB report M00C0033) and of a small open charter boat (TSB report M92W1031). The Board, concerned about the accessibility of lifejackets for use in an emergency, recommended that TC require that lifejackets be stored in a manner that is readily accessible.[19]

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18 S. Mohler, J. Swearingen, E. McFadden and J. Garner. *Human factors of emergency evacuation* (AM-65-7). Federal Aviation Agency, Office of Aviation Medicine, Oklahoma City, 1964.

19 TSB Recommendation M01-03

In this instance, in order for the passengers to retrieve the lifejackets from their storage location below each passenger seat, it would have caused congestion in the narrow centre aisle. During vehicle examination after the occurrence, removing a lifejacket without tearing it on the edges of the metal storage box was a challenge for investigators let alone for passengers who, in a time-critical situation, could have jeopardized the integrity of the lifejacket. Further, other items that were stored on top of the lifejackets presented a challenge to their quick retrieval. This continues to be an issue for small passenger vessels.

Standard approved lifejackets were required to comply with CAN/CGSB Standard 65-GP-14M, September 1978, as referenced in the *Life Saving Equipment Regulations*. Examination of the lifejackets after the occurrence revealed that some of the children's lifejackets and none of the recovered adult lifejackets met those requirements.

Although the lifejackets on the *Lady Duck* were 30 years old, their carriage would have been permissible as long as each one met the regulatory requirements. A routine inspection process would ensure that substandard equipment would be replaced. However, for such a process to be effective, it would have to be conducted on a regular basis. Random inspections would not accomplish the most timely elimination of substandard equipment.

Two non-standard decorative lifebuoys were permanently attached to the exterior of the vehicle. These items were not part of the life-saving equipment, although they were approximately the same size and looked like the approved 610 mm-diameter lifebuoy. The use of such items or any safety equipment as decoration is misleading from a safety perspective.

2.1.5 Emergency Signage

Passengers' knowledge of critical safety information, gained through safety briefings, may be reinforced by posting emergency signage and safety information; neither was provided on the *Lady Duck*. The availability of safety information and reference to its existence during safety briefings would better prepare passengers for potential emergency situations. Signage on the side windows would have emphasized their availability as an emergency exit.

2.1.6 Suitability of Rear Exit as a Primary Exit for Egress

Before the water-borne portion of the tour, passengers were briefed that the window openings along the sides and at the rear of the vehicle were to be used as exits in the event of an abandonment. Conventional human engineering standards would therefore dictate that any opening identified as an emergency exit should be large enough to accommodate 95th percentile values of body dimensions wearing an approved lifejacket. While the side windows were of a size and location that allowed unobstructed egress with a lifejacket donned, the width of the rear exit did not meet conventional standards. Use of the rear exit was further impeded by the fact that the boarding ramp could not be lowered once the vehicle was in the water, to protect the watertight integrity of the vessel, and its stowage reduced the opening available. During the evacuation of the *Lady Duck*, the rear exit was not easily accessed and its size presented a challenge for egress. Given these limitations, the side windows should be considered the primary exits in the event of an abandonment.

2.1.7 Transparent Roll-down Side Screens

On the occurrence tour, two transparent roll-down side weather screens were zipped closed. Although no one attempted to use these exits, the availability of any closed window as an exit was questionable due to the inaccessibility of the zipper slides. Nevertheless, the closing arrangement was such that it would have been difficult to open the windows had they been zipped closed.

2.1.8 Fabric Awning Design

Hazards associated with continuous canopies in vessels without inherent reserve buoyancy, like the *Lady Duck*, have been documented by the NTSB (see Appendix D). In the investigation of the sinking of an amphibious passenger vehicle, the *Miss Majestic*, the NTSB concluded that, "...the canopy on the *Miss Majestic* was a major impediment to the survival of the passengers."

The NTSB recommended that, until such vehicles are provided with sufficient reserve buoyancy to remain upright and afloat in a fully flooded condition, the canopies (awnings) should be removed for water-borne operations or a Coast Guard-approved awning should be installed "...that does not restrict either horizontal or vertical escape by passengers in the event of sinking" (M-02-2). Further, the NTSB recommended that "...where canopies have been removed on amphibious passenger vehicles for which there is not adequate reserve buoyancy, require that all passengers don lifejackets before the onset of waterborne operations" (M-02-3).

The *Lady Duck* sank so rapidly that some of the passengers were unable to egress before the vehicle was underwater and they drowned. As the vehicle sank, the natural buoyancy of the victims, some of whom had donned PFDs, forced them into the overhead awning, preventing vertical escape. An awning designed to be easily removed before entering the water, combined with a requirement for passengers to wear lifejackets, would have mitigated the consequences.

2.1.9 Vehicle Licensing/Certification

Amphibious vehicles are not subject to licensing under the SVR. Therefore, an amphibious vehicle with a gross tonnage of less than 15 is not entered in the data banks of either the DFO for pleasure craft or TC for small commercial vessels.

Truck and bus operators operating within Ontario are required to register as commercial vehicle operators (CVOs) by the MTO. It is an offence to operate a commercial motor vehicle without being registered. CVO registration creates a Commercial Vehicle Operator Record that, once set up, allows the collection of licensing and compliance data (accidents, convictions, inspections).

Amphibious vehicles operate in a dual mode (land-water) and are subject to two regulatory authorities (provincial-federal). Because of a lack of marine experience, owners of amphibious vehicles may operate without being aware of the applicable marine requirements. Currently, there is no regime in place to ensure that TC is made aware of an amphibious vehicle being placed into service. If the applicant for a provincial vehicle licence was instructed by the licensing authority to contact TC regarding marine requirements, this would help mitigate the risks.

2.1.10 Vehicle Operational Condition and Characteristics

After the accident, the vehicle was the subject of structural, mechanical, pumping and other safety-related equipment inspections and tests. A series of speed, freeboard, trim, wave-making, and flooding trials was also completed to determine the operational characteristics and physical condition of the *Lady Duck*. Review and analysis of these inspections, tests and trials showed that the safe operation of the vehicle was at risk due to the following:

- The condition of the vehicle meant that watertight integrity could not be maintained. Watertight integrity was compromised by fractures, the absence of effective watertight glands and seals, and water syphoning action through bilge piping.

- When operating in calm water conditions, the *Lady Duck* was vulnerable to shipping water over the bow, because of low initial static forward freeboard and of proportional loss of effective forward freeboard due to the bow wave created by the speed of the vehicle.

- When operating in water disturbed by the wakes of other craft, the *Lady Duck* was highly vulnerable to shipping water when relatively moderate waves were encountered.

- The effective static forward freeboard in the loaded condition, when reduced by the progressive accumulation of floodwater in the hull, was insufficient to prevent the entry of water from bow waves generated at service speed.

- The non-watertight construction of the hood and the installation of 75 mm-diameter (3-inch) cowl ventilators at its forward end, after the completion of TC's inspection, allowed the ingress of water when the forward freeboard was reduced and waves were encountered.

- The design and construction of the vehicle were such that all bilge and floodwater initially accumulated in the forward half of the hull caused a forward trimming moment and a reduction of effective forward freeboard. This reduction of forward freeboard made the vehicle more vulnerable to shipping water at speeds lower than when completely free of floodwater.

- Launching trials at the Hull Marina showed that, when the visor was submerged before the front of the vehicle became fully buoyant, water was shipped and accumulated in a well specifically served by the forward bilge pump. Malfunction of this pump would result in floodwater being retained on board, causing a reduction of the effective forward freeboard at the start of each water-borne tour.

In the event of pump malfunction or failure, any accumulation, including floodwater due to hull leakage, could not be detected by the driver. The combined weight of the shipped water and floodwater from drive shaft bearing leakage and bilge piping syphon effects would reduce the forward freeboard. This would render the vehicle more vulnerable to shipping water over the visor as speed was increased and its own bow wave and the wakes of other vessels were encountered.

In summary, limiting the speed of the vehicle, having adequate freeboard, maintaining watertight integrity and having fully operational bilge pumps with alarms would have, to a large extent, mitigated the risks presented by the non-conventional design of this vehicle.

2.2 Managing Safety

Effective safety management requires all organizations, large or small, to be cognizant of the risks involved in their operation, competent to manage those risks, and committed to operating safely. However, there is no regulatory requirement for operators of small passenger vessels to have a safety management system.

The picture that emerged from this investigation was one of an organization pursuing minimal compliance with regulations rather than one seeking to minimize risk through all available means.

2.2.1 Cognizance of Risks Presented in the Operation of the Lady Duck

The *Lady Duck* was designed and built by its operator to conduct amphibious tours. Characteristics of the vehicle indicated a lack of awareness of marine standards of construction and maintenance, in that the vehicle was constructed with low freeboard, without watertight fittings at through-hull penetrations and with incorrectly installed bilge pumping arrangements. This created the potential for a regular ingress of water, a risk that was, to some degree, mitigated by fitted drainage systems and additional bilge pumps.

2.2.2 Competence to Manage Risks

Generally, organizations have two ways to manage risks effectively. For novel or non-routine tasks, the organization may rely on a high level of expertise and training to ensure that tasks are completed safely. For routine operations, procedures may be provided to prescribe how tasks will be carried out.

This occurrence revealed many aspects of the company’s operations where procedures remained undocumented and informal, including the following:

- Minimum knowledge requirements for drivers and guides were not defined and the training process for these positions was not documented.

- Vehicle deficiencies were reported by drivers in a written log for maintenance action, but subsequent drivers did not review this log as a matter of routine.

- No guidance was provided to drivers in terms of minimum vehicle equipment serviceability; it was left to the driver to judge whether the vehicle was fit to operate.

- Despite the potential for the low freeboard of the vehicle to be overcome by a bow wave at certain speeds, there were no physical or administrative defences in place to prevent the vehicle from being operated at these speeds.

- There was no procedure or contingency plan outlined to the driver or the guide on how to conduct emergency communications or to respond to emergency situations and, in the extreme, to effect a timely evacuation of the vehicle.

This lack of formalized procedures placed the onus on drivers to make decisions with respect to the safe operation of the vehicle.

This occurrence also revealed that the training provided by the company to enable drivers to make such decisions was minimal and informal. It was reported that the occurrence driver had received 12 hours of company training to operate the amphibious vehicle. To provide an understanding of the vehicle systems (including bilge pumping), the driver was “shown around” the vehicle by the company mechanic. No company records were available to verify the amount of training provided, or the competency level achieved, in terms of understanding the vehicle and its systems. Faced with a situation in which neither of the two bilge pumps were seen to be discharging, the driver had neither the training to properly assess the risk associated with that deficiency nor a formal procedure to provide guidance on a specific course of action. This created a situation where, in verbal communication, the driver deferred to the judgement of the mechanic who, in turn, believed that it was the decision of the driver whether the vehicle should continue in service.

Thus, the organization operating the *Lady Duck* demonstrated neither a sufficient cognizance of the risks associated with operating the vehicle in the marine environment nor the competence to manage those risks effectively.

2.2.3 *Commitment to Safe Operation*

The organization did not demonstrate a commitment to operating safely in that it did not seek the advice of TC with respect to the condition of the vessel and was reticent to follow recommendations that were not specifically required by regulation, in the following ways:

- Reportedly, the owner/builder did not notify TC of the start of construction of the vehicle, and there is no documentation of a formal request for inspection while it was being constructed.
- Following the occurrence of 30 June 2001, the owner questioned TC regarding the need to implement the corrective measures set out by the inspector on Form S.I. 7, and although the owner took action to address items required by regulations, not all the items assessed as recommendations were addressed.
- TC was not informed of modifications made to the vehicle (addition of air ventilation cowls in the hood and modifications to bilge pumping arrangements) that had the potential to have an impact on its watertight integrity.
- Although bilge high level alarms were installed in some of the company's amphibious vehicles, this safety device was not fitted to the *Lady Duck* because, being a smaller vessel, it was not required by regulation.

TSB statistics demonstrate that there is a disproportionate number of fatalities in accidents involving smaller vessels.[20] There are particular risks associated with small passenger vessel operation that arise from operating conditions or vessel characteristics. An effective safety management system is key in any organization to ensure that individuals at all levels have the knowledge and the tools to effectively manage risk. Currently, there is no requirement for overview or guidance from the regulator to operators of small passenger vessels with respect to safety management.

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[20] Between 1975 and 2002, there were 166 shipping accidents involving small vessels resulting in 57 fatalities. In contrast, during the same period, there were 5 fatalities that resulted from 1083 shipping accidents involving all other passenger vessels. Refer to Appendix G—List of Supporting Reports.

2.3 Regulation of Small Passenger Vessels and Safety

There is a public expectation that a commercial enterprise is sufficiently regulated to provide a satisfactory level of safety. Members of the travelling public likely do not differentiate between large and small passenger vessels in terms of the degree of risk. Most believe that action has been taken to ensure that the vessel, regardless of its size and area of operation, is properly maintained, the crew is competent, the vessel will be operated in a safe manner and that contingency plans are in place should an emergency arise. To this end, TC's marine safety mandate encompasses responsibilities relating to promoting the safety of vessels and environmental protection.

There are, however, distinct challenges associated with achieving this mandate with respect to regulating small passenger vessels, due to:

- limited resources;
- the large number of small passenger vessels in operation;
- the inability of regulations to cover every eventuality or novel aspect of construction and operation of a wide range of small commercial vessels;
- the diverse and geographically dispersed population of operators;
- the limited nautical knowledge and experience of some operators and owners; and
- the reluctance of some owners to implement recommendations that exceed the regulatory requirements.

2.3.1 Complexity and Adequacy of Safety Requirements

Given the distinct challenges associated with promoting small passenger vessel safety, the regulatory framework must be clear, easy to apply and provide an adequate level of safety regardless of vessel size and configuration.

Current marine requirements contained within the CSA, its regulations, standards, and guidelines are complex and, as such, it is difficult for owners, operators, and TC inspectors to determine which requirements apply to a particular class of vessel. This has been acknowledged by TC and is reflected in the training given to inspectors with respect to small commercial vessel inspections.

This complexity was demonstrated in this occurrence with respect to the first inspection requirement of the *Lady Duck*. At the time of the first occurrence, TC determined that this vehicle, with a gross tonnage of less than 5, did not require a first inspection. Nevertheless, following a review of the regulatory framework, it was later given a first inspection. This complexity of the regulations is reflected in the following:

- Under subsection 316(3) of the CSA, every Canadian vessel shall have its hull, machinery, and equipment inspected before it is first put into service. Under section 406, vessels such as the *Lady Duck* are exempt from an annual inspection. According to the CSA, inspections are to be conducted in accordance with regulations.

- The *Hull Inspection Regulations* are not applicable to vessels with a gross tonnage of 5 or less. This led to the interpretation that the *Lady Duck* did not require a first inspection.

- Following the 2001 occurrence, the vehicle had a first inspection under the auspices of the SVMIP. Although this is an interim program that does not have the force of regulation, it provides for a mandatory first inspection as required by the CSA.

In conducting a first inspection, the inspector must determine what regulations apply, since the CSA requires that inspections be conducted in accordance with regulations. Table A of the SVMIP[21] provides some guidance in this regard through a small passenger vessel safety requirements matrix. For vessels such as the *Lady Duck*, the matrix indicates that the requirements are the CSA, the guidelines in Appendix B until TP 1332 is revised, and the SVR. Therefore, an inspector examining the requirements will find that

- the CSA provides for a first inspection, and
- Appendix B contains interim guidelines (that are not enforceable),

thus leaving the SVR as the only requirement that can be enforced during inspection.

The regulatory framework that applied to the *Lady Duck* did not adequately address the risk involved in the vehicle's operation. Although the *Lady Duck*, with a gross tonnage of less than 5 and carrying not more than 12 passengers, had a first inspection, it was not subject to construction requirements, did not require a qualified operator, and the company was not required to have a safety management structure in place. In contrast, when more than 12 passengers are carried, vessels are subject to additional requirements that address the hull, machinery, electrical systems, fire protection equipment, life-saving equipment, and stability, thus affording a greater level of passenger safety.

As a consequence, the effectiveness of the regulatory framework is compromised in that the complexity of regulations, standards, and programs that apply to small passenger vessels may not be readily understood by the owners, operators, and inspectors who must apply them. Furthermore, the current regulatory framework does not address all aspects of small passenger vessel operations. Consequently, vessels that may not be fully fit for their intended purpose may operate, placing passengers at risk.

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[21] As described in SSB 04/2001, *Interim Small Passenger Vessel Compliance Program*

2.3.2 Promoting Safety versus Ensuring Compliance

Following the sinking of the small passenger vessel *True North II* (TSB report M00C0033), the Board indicated that, for the TC ship inspection regime to achieve its safety objectives, systemic deficiencies needed to be addressed in a broader context. The Board, concerned that a "rule-book" approach can produce too narrow a focus where safety inspectors do not address safety deficiencies not covered by regulations, recommended that:

> The Department of Transport, Marine Safety, instill within its organization an approach to safety that would enable management and safety inspectors to identify and address all unsafe practices and conditions and not limit inspection only to compliance with rules.
>
> (M01-02, issued 11 May 2001)

This recommendation encourages a culture in which inspectors are empowered to look beyond the regulations and address any safety deficiency. In response to that recommendation, TC stated that it

> is instilling within its organization a culture that encourages inspectors to look at operations, equipment performance as well as the prescriptive regulations.

This indicates a desire, on the part of TC, to move in the direction of promoting safety in addition to ensuring compliance. However, from the *Lady Duck* investigation, it was apparent that service delivery and organization practices had not yet been brought in line with this intention.

The difference between the desired objective described by TC and the practices observed in this occurrence is an indicator of the difficulties involved in achieving change within an organization whose day-to-day operations are founded upon ensuring compliance through the force of regulation. During the first inspection (2001), the inspectors applied the safety requirements of the SVMIP, which were intended to supplement the regulatory framework for small passenger vessels. Regional management, faced with a request for clarification from the owner, and the knowledge that the safety requirements of the SVMIP could not be enforced, changed some of these requirements to recommendations and communicated them to the owner as "recommendation only by the attending inspector." In this instance, the "rule-book" approach rendered management incapable of supporting safety requirements that did not carry the force of regulations. As a result, at the subsequent random inspection in spring 2002, the inspector opted to refer to applicable regulations, to the exclusion of the SVMIP or other assessment criteria.

TC continues its efforts to instill an approach to safety where the front-line inspectors are able to apply their marine expertise when determining the suitability of a vessel, its crew, and the owner's ability to safely operate the vessel. These inspectors require the tools to initiate appropriate action where it can be verified that an unsafe situation exists. Further, that approach also shows that vessel owners and operators must consider and implement inspection recommendations pertaining to the safe operation of their vessel or propose acceptable alternatives. Promoting safety in addition to ensuring compliance will require a long-term effort at all levels within the marine community.

The use of a "rule-book" approach continues to undermine TC's efforts to create a culture within the marine community where inspectors, owners, and operators look beyond regulations and manage risks. This leads to a situation where safety deficiencies may go unidentified, placing passengers at risk.

2.3.3 Seaworthiness

The condition defining the overall safety and soundness of all vessels and small craft is often expressed by the term "seaworthy." Although the term is generally accepted, attainment of this condition is dependent on the particular circumstances under consideration. The current *Canada Shipping Act (1985)* and the latest revised version *Canada Shipping Act (2001)* include, but do not specifically define "seaworthy." However, all accepted definitions of seaworthiness refer to the sufficiency of a vessel for its intended voyage. For example:

- *Black's Law Dictionary* (Fifth Edition), St. Paul, Minnesota, West Publishing Co., 1979 states the following:

  > Seaworthy—This adjective, applied to a vessel, signifies that she is properly constructed, prepared, manned, equipped, and provided, for the voyage intended. A seaworthy vessel must, in general, be sufficiently strong and staunch and equipped with appropriate appurtenances to allow it to safely engage in the trade for which it was intended.

- *International Maritime Dictionary* (Second Edition),Van Nostrand Reinhold Co. states the following:

  > Seaworthiness—The sufficiency of a vessel in materials, construction, equipment, crew, and outfit for the trade or service in which it is employed.

The TSB trials revealed safety shortcomings, calling into question the "seaworthiness" of the *Lady Duck*. These shortcomings included the following:

- lack of watertight integrity;
- defective pumps;
- low freeboard in conjunction with the operational environment;
- less-than-adequate equipment and its condition; and
- inability of personnel to effectively deal with emergencies.

In order to ensure seaworthiness, a person or an organisation who has an impact on the operation of the vessel must determine the risk associated with the intended voyage or service, and how the construction, preparation, crew selection, and the equipment mitigate that risk.

The persons or organisations whose actions establish whether a vessel is seaworthy are the owner, operator and the regulator. Conversely, failure of the owner, operator and the regulator to take an appropriate action may result in a vessel's seaworthiness being insufficient.

2.4 Emergency Communications

Part of the CCG's MCTS mission is to provide communications and traffic services for the marine community to ensure the safety of life at sea in response to international agreements.[22] The issue of communications and of MCTS antenna coverage on the Ottawa River was discussed in TSB reports on an occurrence involving the passenger vessel *Miss Gatineau* (TSB report M00L0043) and the previous *Lady Duck* occurrence (TSB report M01C0033).

There are currently at least 21 commercial passenger vessels and numerous pleasure craft operating on the Ottawa River between Carillon, Quebec, and Ottawa, Ontario. Notwithstanding this, CCG's MCTS do not provide marine VHF coverage in the Ottawa area. Vessels operating outside VHF coverage and not more than five miles from shore are not required to carry a VHF radiotelephone. As a result, vessels operating on the Ottawa River between Carillon and the Ottawa area cannot access SAR resources (including local municipal fire and police departments) through the established MCTS communications system using VHF radiotelephone. Consequently, operators who use VHF radio as their initial means of communicating a distress situation are at risk, in that they rely solely on two CCG auxiliary craft or other private or commercial craft in the area who may or may not be monitoring VHF channel 16. The fire departments of Ottawa and Gatineau are equipped for marine emergency response duties when alerted through a 911 emergency response system.

Proposed amendments to the *Ship Station (Radio) Regulations, 1999*, which prescribe the radio equipment to be carried by commercial vessels, were published in the *Canada Gazette*, Part I, on 12 April 2003, vol. 137, No. 15. All passenger vessels, engaged on a voyage outside a VHF

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[22] See the CCG MCTS Web site at www.ccg-gcc.gc.ca/mcts-sctm/general_e.htm (June 2003).

coverage area, are required to be equipped with radio equipment capable of establishing continuous two-way communications with an MCTS centre or a person ashore. It is anticipated that the proposed amendment will come into force in 2004.

In this occurrence, bystanders with cellular telephones called 911. Because the company had no formal standard operating procedures and emergency preparedness plan, and the driver had not been trained for such contingencies, the driver's radio distress call was made on emergency VHF channel 16. Since the Hull Marina monitors channel 68, this call was probably not received by any traffic service organization, although it may have been received by private vessels monitoring VHF channel 16. In summary, vessels issuing distress calls in this area are not able to contact MCTS on the appropriate distress channel and must rely on 911 emergency services and on local vessels that may be monitoring the emergency frequency. The lack of effective monitoring and formal emergency communication constitutes a degree of risk to the persons aboard a vessel in distress.

2.5 Dissemination of Safety Information

In the past, safety information (that is, SSBs) was disseminated to stakeholders by way of an established mailing list. However, in recent years, SSBs have also been posted on the Internet.[23] While anyone may request inclusion on this mailing list, not everyone who operates a small vessel is aware of its existence. A review of the SSB mailing list maintained by TC revealed that a substantially large number of small vessel operators, including the owner of the *Lady Duck*, are not on the list.

In response to TSB Marine Safety Advisory 07/01 (TSB report M01L0100), addressed to TC, TC has recognized that the current method of disseminating safety information is not always effective. Consequently, an evaluation of the system is underway to determine the most effective method of communicating relevant safety information to specific audiences best suited to enhance safety.

[23] www.tc.gc.ca/marinesafety/bulletins/toc_e.htm

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The condition of the vehicle was such that watertight integrity could not be maintained, and there was continuous entry of water into the hull.

2. The non-watertight construction of the vehicle hood, the installation of 75 mm-diameter (3-inch) cowl ventilators at the hood's forward end, and the low forward freeboard in the loaded condition allowed the ingress of water from bow waves generated at service speed.

3. The lack of information on the amount of water in the bilges, associated with the absence of a bilge high level alarm and the position of a discharge out of sight of the operator, deprived the operator of information essential to declare an emergency in a timely manner.

4. The company installation of the bilge pumps was not in accordance with manufacturer instructions. Of the six electrically driven bilge pumps installed, the two that were effectively operable did not stem the ingress of water.

5. The company did not have an effective safety management structure/system in that the procedures concerning the operation of the *Lady Duck* were informal and undocumented.

6. The regulatory framework that applied to the *Lady Duck* did not adequately address the risk involved in the vehicle's operation, in that the *Lady Duck* was not subject to construction requirements, did not require a qualified operator, and the company was not required to have a safety management structure in place.

7. The rear exit did not meet human engineering standards to permit easy egress for a full range of users.

8. The natural buoyancy of the victims, some of whom had donned personal flotation devices (PFDs), forced them into the overhead awning, preventing their vertical escape.

3.2 Findings as to Risks

1. Safety briefings did not mention the availability and location of the lifejackets. A demonstration on how to don either a lifejacket or a PFD was not given and there was no signage indicating the location of the lifejackets.

2. The complexity of regulations, standards and programs that apply to small passenger vessels is such that they may not be readily understood by inspectors, owners, and operators who must apply them. This complexity reduces the effectiveness of the regulatory framework to help ensure safety.

3. The current regulatory framework does not address all aspects of small passenger vessel operations. Consequently, vessels that may not be fit for their intended purpose may be operating, placing passengers at risk.

4. The use of a "rule-book" approach by Transport Canada (TC) continues to undermine its efforts to create a culture within the marine community where inspectors, owners and operators look beyond regulations and manage risks. This leads to a situation where safety deficiencies may go unidentified, placing passengers and crew at risk.

5. None of the exits was marked as an emergency exit. No guidance was provided, either by signage or during the safety briefing, as to their means of opening.

6. When the roll-down transparent weather screens on each side of the vehicle were zipped closed, the zipper slides that were used to secure the weather screens were neither visible nor easily reachable from inside the vehicle. Such arrangements compromise the safety of passengers.

7. Stowage lockers under the passenger seats did not allow for easy retrieval of the lifejackets. Lifejackets that are not readily accessible preclude their use in emergency situations, thereby compromising the safety of passengers and crew.

8. The lack of hands-on training leaves tour guides ill-prepared to use safety equipment effectively in emergency situations.

9. Marine Communications and Traffic Services do not provide marine very high frequency (VHF) coverage in the Ottawa area. Search and Rescue response is limited to two Canadian Coast Guard auxiliary craft or other private or commercial craft in the area. These craft monitor emergency VHF channel 16 intermittently.

3.3 Other Findings

1. The PFDs worn by two of the victims were too large for their body size.

2. Some of the children's lifejackets and none of the recovered adult lifejackets met the requirements of CAN/CGSB Standard 65-GP-14M, September 1978.

3. The lifebuoy carried on board did not meet applicable standards for this vehicle and was so secured to its support that it could not be immediately deployed.

4. The use of non-standard lifebuoys or any safety equipment as decoration is misleading from a safety perspective.

5. The current method of disseminating safety information through ship safety bulletins is ineffective since a large number of small vessel operators, including the owner of *Lady Duck*, are not aware of these bulletins.

6. TSB tests showed that the strength of the seat anchorages of the *Lady Duck* was lower than TC's *Motor Vehicle Safety Regulations* requirement.

7. Highway carrier inspection of the vehicle conducted by the Ministry of Transportation of Ontario (MTO) revealed deficiencies that had a significant impact on the safety of the vehicle on the road.

8. The lack of coordination between TC and the MTO permits owners of MTO-registered amphibious vehicles to operate without being aware of the applicable marine requirements and TC may not be informed of a new commercial amphibious vehicle being put in service.

4.0 Safety Action

4.1 Action Taken

4.1.1 Pre-departure Safety Briefings

In July 2002, the Transportation Safety Board of Canada (TSB) sent Marine Safety Advisory (MSA) 07/02 to Transport Canada (TC) indicating that steps should be taken to ensure that operators of passenger vessels conduct required safety briefings before departure and that the content and delivery of those briefings are in keeping with the intent of the regulation.

In response, TC has indicated that the following action, among others, was taken to date:

- On 11 July 2002, a letter was issued to Ontario operators and one manufacturer of amphibious passenger vehicles, informing them of the regulatory requirement for passenger safety briefings. Similar letters were issued to operators of amphibious passenger vehicles throughout the country. The same information, including reference to passenger safety briefings, was sent out as an advisory note to TC marine inspectors.

- On 27 July 2002, TC issued Ship Safety Bulletin (SSB) 06/2002 to advise operators of the regulatory amendment requiring safety briefings on all passenger vessels, and the importance of these briefings.

- TC has added the above SSB and a discussion of safety briefings as a teaching point in the Small Passenger Vessel Inspection Course for marine inspectors.

TC further advises that efforts are being undertaken to educate the general public to expect and request a safety briefing before departure. These communication efforts include, as of 03 July 2003, three different public service announcements broadcast on Météo Média and the Weather Network and posters in tourist areas.

4.1.2 Bilge Pumping System

In August 2002, the TSB sent MSA 08/02 to TC, indicating shortcomings with the operation of the bilge pumping system.

In response, TC has indicated that the following actions were taken:

- Immediately after the accident, all amphibious passenger vehicles were inspected, including bilge pumping and alarm systems.

- On 11 July 2002, a letter was issued to Ontario operators and one manufacturer of amphibious vehicles, informing them of precautionary measures and best practices concerning bilge pumping systems. The same information was sent as an advisory note to TC marine inspectors.

- On 23 August 2002, TC issued SSB 09/2002, highlighting the importance of bilge pumping and alarm systems on small vessels.

4.1.3 Lifebuoy Requirements

On 23 December 2002, the TSB sent Marine Safety Information Letter (MSI) 12/02 to TC, indicating that the lifebuoy fitted on the vehicle was 610 mm in diameter rather than an approved 762 mm lifebuoy, as required by *Small Vessel Regulations* (SVR). Further, examination of the 610 mm lifebuoy revealed that, although it was stamped with TC's approval number TC.143.014.045, it did not meet applicable standards as set out in both TP 7325, *Standards for Lifebuoys and Integral Equipment*, and section 8, Schedule III of the SVR. The lifebuoy grab lines were of varying lengths (570, 590, 600, and 610 mm), rather than the required length of not less than 610 mm for each line. In addition, the lifebuoy was attached to the top of the after bulkhead of the vehicle by way of a bungy cord, the hooks of which were clasped together behind the lifebuoy and out of sight. Because of the mode of attachment, it was not available for immediate deployment.

In response, TC agreed that the lifebuoy should have been 762 mm in diameter and it appears that the manufacturer did not produce the lifebuoy according to the approved prototype. TC met with the manufacturer and reviewed its quality assurance and inspection procedures. An audit of four lifebuoys revealed that grab lines met the lifebuoy standard. A follow-up inspection by TC was planned for spring of 2004.

4.1.4 Small Vessel Regulations

On 10 January 2003, the TSB sent MSI 01/03 to TC, advising that a summary review of the SVR revealed inconsistencies that could be confusing to operators who must abide by the regulations and to inspectors who must enforce them.

TC indicated that, as a result of ongoing initiatives, amendments to the SVR were published in *Canada Gazette*, Part I, in December 2003, which will, *inter alia*:

- incorporate TP 1332, *Construction Standards for Small Vessels*, by reference, establishing minimum mandatory standards. TP 1332 has also been reformatted to make it easier to read;

- establish life-saving equipment carriage requirements for vessels with a gross tonnage of 0 to 15;
- address inconsistencies regarding lifejackets;
- introduce stability requirements for new vessels.

The amendments incorporating TP 1332, expected to come into force in 2004, will require new small vessels to comply with that construction standard. Existing small vessels, including small passenger vessels, will be required to comply with the standard insofar as it is reasonable and practicable to do so.

Inconsistencies regarding lifebuoys will be addressed in phase II of the Regulatory Reform, scheduled to commence in 2005 or earlier.

4.1.5 Lifejackets

At the November 2002 Canadian Marine Advisory Council (CMAC) meeting, TC advised that regulatory amendments being planned include requirements that all passenger vessels carry enough lifejackets suitable for children and that all lifejackets be stored, readily accessible, in clearly marked locations. The *Life Saving Equipment Regulations* were subsequently amended on 24 February 2004. However, the *Life Saving Equipment Regulations* do not apply to vessels with a gross tonnage of 5 or less that are certified to carry not more than 12 passengers. It is anticipated that those vessels will be covered by similar amendments being proposed for the SVR.

4.1.6 Small Commercial Vessel Safety

At the CMAC meeting in November 2002, the Small Vessel Working Group proposed, *inter alia*, that TC prepare a comprehensive outline on implementing International Organization for Standardization (ISO) stability and buoyancy assessment on new and existing vessels of between 6 m and 12 m in length and carrying not more than 12 passengers.

A study has been initiated to examine amphibious vehicle safety and the following issues will be addressed: hull integrity, bilge pumps, escapes, seating, intact and damaged stability, operation, and personnel. The study is intended to assist TC in making decisions respecting such vehicles.

The *Small Commercial Vessel Safety Guide* (TP 14070), which is intended to provide owners and operators with an overview of the safe operating practices, certification, construction, and safety requirements, has just been completed and published.

Furthermore, TC has adopted a policy for assessing stability of existing vessels. Owners may choose to have their vessel assessed to one of three standards developed by the United States, the United Kingdom or the ISO. Additionally, there will be a fourth option for assessing stability, a TC-simplified stability requirement based on ISO. For vessels that do not go beyond 20 nautical miles from shore, owners may select one of the three standards or opt to assess their vessel to a set of simplified requirements.

A notice to advise owners and operators of this policy is being prepared for public information for release by the end of May 2004. Presentations, explaining the policy and the procedure for assessing vessels against the simplified requirements, have been held in all TC regions.

In 2003, TC introduced the Small Vessels' Operator Proficiency Course to address, *inter alia*, minimum training for operators of small passenger vessels with a gross tonnage of less than 5. The goals of this non-mandatory course include: providing participants with a basic understanding of the hazards associated with their vessel and prevention of shipboard incidents; knowledge to deal with emergencies; and knowledge and skills to safely operate a vessel in sheltered waters. To obtain certification upon the successful completion of the course, participants must have met the qualifying sea service and successfully completed the Small Vessel Basic Safety Training (Marine Emergency Duties A3) and Marine First Aid, Basic Certificate or equivalent. Consideration of making the proficiency course mandatory will be addressed by TC in a discussion paper under the Marine Personnel Regulations.

4.1.7 Requirements for Radio Communication

Amendments to the *Ship Station (Radio) Regulations, 1999*, published in the *Canada Gazette*, Part I, on 12 April 2003, will require vessels of more than 8 m in length, of closed construction, to carry a very high frequency (VHF) digital selective calling radiotelephone on all home trade voyages, except for home trade voyages class IV that are within a Vessel Traffic Services (VTS) coverage area. This does not apply to vessels on inland or minor waters voyages.

While these amendments do not apply to vehicles such as the *Lady Duck*, an additional amendment to the regulations is being prepared that will require all passenger vessels that are not currently required to fit a VHF radio, regardless of area of operation, to have a reliable means of two-way communication. When the amendment comes into force, vessels operating in VHF coverage areas will require a VHF radiotelephone and vessels operating in areas where VHF coverage is not provided will require some other means of communicating with a responsible party ashore. In terms of inspection, the operator or master will be required to demonstrate the operational readiness of the selected means of two-way communication.

4.1.8 Small Vessel Inspection System

A database for recording vessel particulars and details of inspections has been developed by TC. A study recommending a framework for evaluating small vessel risk factors has been completed. The findings of the study will be combined with the data collected by the Small Vessel Inspection System to develop risk indices of vessels to aid in selecting vessels for random and targeted compliance monitoring inspections.

4.2 Action Required

To ensure a vessel is seaworthy, i.e. fit for its intended purpose, the specific risks of an operation must be well understood and measures must be put in place to mitigate these risks. This applies not only to the construction of the hull, its machinery, and equipment, but also to crew competency and operation.

To that end, the owner/operator must continuously identify and address the risks that may be encountered in day-to-day operations. Risk-mitigating options must be considered and defences, which may be administrative and/or physical, put into place to reduce or eliminate the probability or consequences of an unwanted event.

To mitigate common risks, the regulator must provide a framework that is easily understood and applied by small passenger vessel owners/operators. In addition, to address risks specific to an operation, the regulator needs to take steps to ensure owners/operators have mechanisms in place to identify and mitigate risks on an ongoing basis.

4.2.1 Management of Safety by Operators of Small Passenger Vessels

Between 1975 and 2002, there were 166 shipping accidents involving small passenger vessels resulting in 57 fatalities. In contrast, during the same period, there were 5 fatalities that resulted from 1083 shipping accidents involving all other passenger vessels. Thus, passengers involved in an accident aboard a small passenger vessel are more likely to suffer serious consequences. Therefore, the hazards associated with the operation of small passenger vessels must be identified and addressed to prevent accidents and reduce the impact of accidents that may occur.

The effective management of safety requires operators to be able to identify the hazards associated with their operation, assess the risk arising from those hazards, and identify mitigation strategies to reduce the risks to the lowest possible level. However, as demonstrated in this occurrence, small passenger vessel operators may not be aware of the risks associated with the operation of their vessels or possess the competence to manage those risks.

A safety management system (SMS) represents a "systematic, explicit and comprehensive process for the management of safety risks"[24] and is being widely embraced as the mechanism through which knowledgeable owners/operators can effectively identify and mitigate risks. An SMS in the marine environment will include, among other elements:

- procedures and instructions to ensure the safe management and operation of vessels;
- defined levels of authority and clear lines of communication between and amongst the management ashore and the management on board each vessel;
- procedures for the maintenance of vessels;
- procedures for reporting accidents, incidents, and hazardous situations;
- procedures for preparing for and for responding to emergency situations; and
- analysis and documentation of lessons learned.

The Board notes that TC's *Small Commercial Vessel Safety Guide* (TP 14070) encompasses some of the principles underlying an effective SMS. However, it does not go so far as to provide the means or structure through which such principles can be achieved.

As demonstrated in this occurrence, the absence of a formal structure for vehicle maintenance and emergency response has the potential to adversely affect passenger safety. Although regulations are coming into effect in other modes to make SMS a requirement for most operators, the *International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention* (ISM Code), which specifies the requirements in terms of safety management within the marine mode, is only required for certain convention ships. This includes passenger ships and cargo ships with a gross tonnage in excess of 500. However, ships that remain within Canadian waters are not considered convention ships. As such, although the code is voluntarily applied by many larger passenger vessel operators, there is no regulatory requirement for the operators of small passenger vessels to have an SMS.

At the request of TC, a study to evaluate the feasibility of implementing an SMS for the Canadian domestic fleet (including small passenger vessels) not subject to the ISM Code was completed in May 2002.[25] The study noted that other countries, such as Australia, New Zealand, United Kingdom and Denmark, have in place or are developing requirements for safety management-type systems applicable to their small passenger vessels. The application of safety management principles to small vessels was, in general, to address safety shortcomings and to promote a higher level of safety in line with the expectations of the travelling public. Currently, TC is examining the results of the study.

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24 *Safety Management Systems for Flight Operations and Aircraft Maintenance Organizations*, TP 13881, Transport Canada, 2002.

25 *Safety Management Systems for Domestic Canadian Vessels*. Transport Canada, Marine Safety, May 2002.

Recognizing that the ISM Code may be beyond the scope of most small operators, a system tailored to the needs of operators of small passenger vessels, which incorporates principles of effective safety management, would assist small vessel operators to help ensure that the company, the vessel, and its crew are fit for their intended purpose. Given the benefits associated in preventing accidents, and the need for a structured approach for operators to effectively manage the risks associated with their operation on an ongoing basis, the Board recommends that:

> The Department of Transport take steps to ensure that small passenger vessel enterprises have a safety management system.

M04-01

4.2.2 Adequacy of the Regulatory Framework for Small Passenger Vessels

The current regulatory framework does not address all aspects of the operation of small passenger vessels with a gross tonnage of 15 or less carrying not more than 12 passengers and, as demonstrated in this occurrence, the *Canada Shipping Act* (CSA), its regulations, standards, and guidelines are complex and their applicability by ship inspectors and owners/operators is not consistent.

TC acknowledges the complexity of its regulatory framework. The CSA is to be replaced by the *Canada Shipping Act (2001)*, which received Royal Assent in November 2001. It is planned that the *Canada Shipping Act (2001)* will come into force in 2006. In order to give full effect to the *Canada Shipping Act (2001)*, over 100 regulations must be reviewed and restructured. Regulation development is proceeding in two phases. Phase 1 includes new regulations required to support the *Canada Shipping Act (2001)*, and existing regulations that are inconsistent with this Act need to be overhauled. Phase 2 will include those regulations that are consistent with the new Act, but need to be modernized. Regulations that are not in urgent need of reform for safety reasons will also be reviewed and amended in Phase 2.[26]

Within Phase 1, there are initiatives underway affecting small passenger vessels. For example, a requirement for a certificated master of commercial passenger vessels with a gross tonnage of less than 5, and completion of applicable Marine Emergency Duties (MED) courses before obtaining a Master Limited certificate are being examined as part of the reform of the *Crewing Regulations* and *Marine Certification Regulations*.

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[26] *Canada Shipping Act (2001)* Regulatory Reform Project, Public Consultation, Consultation Overview, Transport Canada, Fall 2003.

In another initiative, TC has introduced an amendment that will incorporate, by reference, the *Construction Standards for Small Vessels* (TP 1332). New small passenger vessels will have to comply with the standard. Existing small passenger vessels will comply only to the extent that it is reasonable and practical to do so.

However, in the Board's view, other safety shortcomings need to be addressed. For instance, even though crew members are currently required to have basic safety training at a recognized institution before completing six months on board a Canadian vessel, it may take two or more operating seasons on board small passenger vessels that operate on a seasonal basis to accumulate the six months. It is not uncommon for seasonal operators to hire new crew at the beginning of a new operating season. The Board is encouraged that cooperation between TC and the Canadian Passenger Vessel Association (CPVA), representing some 50 commercial operators, has resulted in the development of a TC-approved in-house training course. However, CPVA membership represents only a small percentage of small passenger vessels in operation.

The current regulatory regime for small passenger vessels applies to a wide range of vessels whose risk profiles vary substantially. Further, prescriptive regulations and benchmarks have been established on what could be described as "arbitrary" criteria, be they length/tonnage restrictions, number of passengers, etc. Such an approach may not fully reflect the risks inherent in an operation. For example, while there is a requirement that the complement of every passenger ship certified to carry more than 12 passengers be sufficient in number to direct and control the passengers who are on board in an emergency, there is no such requirement for passenger vessels carrying not more than 12 passengers.

In the past, there was a tendency for owners/operators of small passenger vessels to rely on annual inspections by TC as the means of ensuring compliance. Subsequent to the increase to the exemption threshold for annual inspection, there has been increased reliance by TC on self-inspection. In fact, regulatory compliance for small passenger vessels with a gross tonnage of 15 or less relies on self-inspection by owners/operators who may not be fully conversant with all safety requirements. Until such time as the regulatory framework can be easily understood, the implementation of a self-inspection regime will be problematic and risks to the travelling public will continue.

The application of the existing and future regulatory framework is dependent upon an up-to-date registry of vessels in operation. While TC estimates that approximately 10 000 small passenger vessels with a gross tonnage of 15 or less are required to be either licensed or registered, as of December 2003, TC reports that there were 736 licensed and 375 registered small passenger vessels. TC is taking steps to address this discrepancy through the establishment of a Small Vessel Register and expects to have all vessels identified by 2011.

The Board acknowledges the initiatives by TC to reform the current regulatory framework to make it more streamlined, applicable, and effective. However, given the planned timeframe of 2006 for completion of this reform, and the large number of small passenger vessels that have yet to be identified, the Board recommends that:

> The Department of Transport expedite the development of a regulatory framework that is easily understood and applicable to all small passenger vessels and their operation.

M04-02

4.2.3 Passenger Evacuation

In an emergency, passengers need time to access and don lifejackets and to identify and reach evacuation points. The time necessary to safely escape from a vessel in distress must be less than the time it takes for the vessel to flood and sink. While large passenger vessels are required to be subdivided to control flooding, small passenger vessels of open construction are not, nor are they required to be inherently buoyant in the event of flooding. As a result, the timely decision and effective evacuation of passengers from small passenger vessels are critical before buoyancy is lost and the vessel sinks. Therefore, safety measures must ensure that the sinking of a vessel is delayed at least as long as it takes to send distress messages and complete the safe evacuation of the vessel.

On 01 May 1999, the amphibious passenger vehicle *Miss Majestic*, with an operator and 20 passengers on board, entered Lake Hamilton near Hot Springs, Arkansas, United States, on an excursion tour. About seven minutes after entering the water, the vehicle listed to port and rapidly sank by the stern. One passenger escaped before the vehicle submerged but the remaining passengers and the operator were trapped by the vehicle's canopy roof and drawn under water. As the vehicle sank, six passengers and crew were able to escape and, upon their reaching the water's surface, were rescued by pleasure boaters in the area. The remaining 13 passengers, including three children, lost their lives. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle.

As a result of the occurrence and subsequent investigation, the National Transportation Safety Board (NTSB) recommended that the U.S. Coast Guard:

> Require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew.

(M-02-1)

and

> Until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), require the following:
> (1) removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking ....
>
> (M-02-2)

In making these recommendations, the NTSB highlighted the critical relationship between a vessel's reserve buoyancy and its design characteristics that allow for the safe evacuation in the event of emergencies.

The passengers and crew of the *Lady Duck* experienced similar difficulties in abandonment due to the rapidity of the sinking, the trim of the vehicle as it sank, and the overhead canopy that prevented passengers from floating free from the vehicle. Additionally, other design features, such as the narrow aisle between the seats, the inadequate exit door aft, two windows that were zipped closed, and the lack of exit signage on the side windows, contributed to a bottleneck when passengers attempted to evacuate the vessel. As a result, similar to the *Miss Majestic* occurrence, the *Lady Duck* sank so rapidly that some of the passengers were unable to egress before the vehicle was underwater, and they drowned.

Small passenger vessels are rarely of standardized design and, consequently, the arrangements for boarding, accommodating, and disembarking passengers vary greatly, particularly in vessels of novel construction such as the *Lady Duck*. TC has standards for commercial passenger vehicles, such as buses, trains and aircraft, and, to a lesser extent, for small passenger vessels with a gross tonnage greater than 15 or carrying more than 12 passengers.[27] However, there are no statutory requirements for small passenger vessels, such as the *Lady Duck*, to be ergonomically designed to afford passengers and crew the best possible opportunity to safely evacuate in the event of an emergency.

The Board is aware of proposed amendments to incorporate by reference the *Construction Standards for Small Vessels* (TP 1332). However, review indicates that small commercial vessels in excess of 6 m, such as the *Lady Duck*, are not required to incorporate sufficient inherent buoyancy to prevent sinking, and there are no provisions for the timely and unimpeded evacuation of passengers in the event of an emergency. The Board, therefore, recommends that:

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27 TP 7301E, *Stability, Subdivision and Load Line Standards*, STAB 5, Appendix A, Seating Arrangements for High Density Passenger Vessels.

> The Department of Transport ensure that small passenger vessels incorporate sufficient inherent buoyancy and/or other design features to permit safe, timely and unimpeded evacuation of passengers and crew in the event of an emergency.

M04-03

4.2.4 *Distress Communications and Coordination of Search and Rescue*

In emergency situations, crews and passengers rely on prompt alerting of others to provide assistance. VHF marine radios represent a reliable means of issuing distress calls in that designated VHF emergency channels are monitored and calls can be received by other vessels, which may be in a position to provide immediate assistance. This ability to communicate on open channels also permits for effective coordination of Search and Rescue (SAR) activities by SAR authorities.

The described safety benefits of VHF use, however, may not be realized when operating within areas where there is no continuous VHF radio monitoring. A vessel issuing a distress call on VHF channel 16 must, therefore, rely on local vessels that may or may not be monitoring the frequency.

In the Ottawa River, Canadian Coast Guard (CCG) SAR coverage is provided up to the Carillon dam only, located near the interprovincial boundary between Ontario and Quebec. Coincidentally, the western limit of propagation of CCG's VHF coverage area also ends at Carillon. From there to Ottawa along the Ottawa River, some 70 miles, local VHF radio monitoring is carried out intermittently by police, CCG auxiliary craft, private and commercial craft, marinas, and sailing clubs in the area. Other services—such as 911, cellular telephones, and other radio frequencies (e.g. citizens' band radios)—are used to report distress in the Ottawa River.

Nautical publications, such as the *Small Craft Guide, Rideau Waterway and Ottawa River*, describe VHF communications network and services. However, there is no information within the publications to indicate the lack of VHF monitoring coverage for this section of the Ottawa River to better inform and prepare the mariner for emergencies needing external assistance.

In addition to this occurrence, since 2000, there have been 10 occurrences involving commercial vessels carrying passengers on the Ottawa River reported to the TSB. As a result of an investigation into one of these occurrences, in which a passenger fell overboard,[28] the Board issued a safety concern that "channel 16 VHF radio communications in the Ottawa area still

[28] TSB report M00L0043

cannot be monitored by MCTS [Marine Communications and Traffic Services] stations, and that local communications and SAR resources are not effectively organized or coordinated by CCG SAR."

In a subsequent TSB investigation into an occurrence involving a passenger vessel,[29] the investigation revealed a similar safety deficiency. Consequently, the Board reiterated its safety concern stating that:

> The Board is concerned with the effectiveness of current SAR and MCTS coverage within the NCR [National Capital Region] because MCTS stations do not monitor marine emergency channel 16 VHF radio communications in the NCR stretch of the Ottawa River, and the timely deployment of vessels cannot be coordinated according to the expectation of the CCG SAR plan.

The Board further encouraged the CCG SAR organization to "reassess the area plan."

In 1999, CCG met with local public protection authorities to discuss boating safety issues, including the absence of radio communication coverage and lack of emergency coordination for the Ottawa River in the NCR. Although the need to address communications and coordination was recognized, no further effective action has been taken to date to address these issues.

Proposed amendments to the *Ship Station (Radio) Regulations, 1999* will require passenger vessels, operating in areas for which no VHF coverage is provided, to have some means of communicating with a responsible party ashore. Most passenger vessels operating in the Ottawa River have such a means at their disposal or in place already—cellular telephones. Although cellular telephones can provide an added measure of safety, they are not a substitute for VHF communications. Even though they can be used to call and inform authorities of an emergency situation, cellular telephones are ineffectual in alerting other vessels, which may be in the best position to provide immediate assistance, nor are they useful for coordinating a rescue activity.

Given the number of commercial passenger vessels and pleasure craft operating in the NCR, it is essential that those involved in SAR operations have the means in place to be alerted immediately and to coordinate response operations for an emergency situation. There are a number of authorities and organizations along the Ottawa River that can be called upon to participate in a marine SAR operation. Although there have been some efforts by some of the local police and fire services to equip their marine units with VHF radios, there is no

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[29] TSB report M01C0033

coordinated means in place to ensure that VHF radio distress calls are monitored and that resources can be effectively organized or coordinated. Consequently, responses to emergency situations on the Ottawa River may not be effectively coordinated.

The National Search and Rescue Secretariat (NSS), an independent government agency reporting to the Minister of National Defence, has responsibility for promoting the national SAR program. The program is a collection of SAR services provided by all agencies and individuals in Canada, regardless of the type of activity or jurisdiction.

Given NSS's leadership role to work directly with federal, provincial and local authorities, and other organizations, to develop and standardize the quality of SAR services, and mitigate risks associated with an improperly coordinated SAR system, the Board recommends that:

> The National Search and Rescue Secretariat, in collaboration with local authorities and organizations, promote the establishment of a system to monitor distress calls and to effectively coordinate Search and Rescue responses to vessel emergency situations on the Ottawa River between Ottawa and Carillon.

M04-04

4.3 Safety Concern

4.3.1 Exchange of Safety-related Information on Amphibious Vehicles

In the course of their day-to-day operations, amphibious vehicles, such as the *Lady Duck*, operate in two distinct environments, and consequently within the regulatory purview of both federal and provincial jurisdictions. In the case of the *Lady Duck*, TC and the Ministry of Transportation of Ontario (MTO) were responsible for ensuring that the vehicle was suitable for operation in its marine and land-based modes.

Any accidents or damage as a result of marine operations are reportable to TC. Consequently, following a marine occurrence, the vehicle will be inspected to ensure that the accident has not affected seaworthiness and passenger safety. However, information concerning accidents occurring during land-based operations, while reportable to the MTO, is not conveyed to TC, nor does TC inform MTO about marine reportable incidents. Damage from such accidents may result in defects that, while not of serious consequence for land-based operations, could affect the vehicle's performance and safety when in the water.

When a new operator approaches the MTO to obtain a Commercial Vehicle Operator Registration, the MTO collects information concerning licensing and compliance data, such as accidents, convictions, and inspections, in a commercial vehicle operator database. Information contained in the database allows for the continued evaluation of the safety performance of the company. However, this information is not provided to TC, nor is it required to be.

One of the goals of the Small Vessel Monitoring and Inspection Program is to "identify vessels which may pose high safety risks."[30] Information available from provincial agencies would assist TC in evaluating the safety of amphibious vehicles and assessing the ongoing safety performance of the operator. Consequently, this would facilitate the identification of high-risk vehicles. The Board believes that exchange of information between TC and the MTO is essential to the safety of marine and land operations. The Board is concerned that, without the exchange of information between provincial agencies and TC, unsafe conditions may go undetected, placing passengers and crew at risk.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 07 April 2004.

30 www.tc.gc.ca/marinesafety/CES/small-commercial-vessels/Passenger-Vessels/SVMIP.htm, 18 December 2003.

Appendix A—Bilge Pump Examination and Testing

Inspection and testing of the bilge pumps and their electrical wiring circuits by the TSB was witnessed by Transport Canada and the owner's representatives.

Electrical supply for main engine starting, general service, and bilge pumps operation was provided by two batteries arranged in parallel. The fuse box for the wiring circuits to all bilge pumps and other built-in electrical services on board the vehicle incorporated one 10-ampere fuse, eight 15-ampere fuses, three 20-ampere fuses, one 25-ampere fuse, and one 30-ampere fuse.

A) The main bilge pump in the drain well on the port side of the vehicle did not respond when switched on at the driving position. The wiring circuit was found intact; however, the fuse was found to be blown. A new fuse was installed, and, when switched on, the pump was heard to rotate. When immersed in 75 mm-deep (3-inch) water, the pump ran for 20 seconds before it slowed down and stalled after a total running time of 30 seconds, during which no water was discharged by the pump. At the end of this test, the pump was very hot to the touch. When the pump was disassembled, the pump impeller was found to be clear of any debris, and the motor electrically inoperable.

B) The main bilge pump in the drain well on the starboard side of the vehicle did not respond when switched on at the driving position. The wiring circuit was checked by multimeter, and it was determined that power was available at the pump. When the pump was disassembled, the impeller was found to be firmly jammed with a small piece of solid debris. On its removal, the impeller and motor were very stiff and difficult to turn. The motor was further examined and found to be electrically inoperable.

C) The emergency bilge pump on the port side of the vehicle was switched on at the driving position and heard to be running. When immersed in 75 mm-deep (3-inch) water, the pump was operated for six minutes, during which a discharge rate of 4.67 gal/min (21.2 L/min) was maintained through discharge piping which, for the purposes of the test, had been temporarily led to the after end of the vehicle.

D) The emergency bilge pump on the starboard side of the vehicle was switched on at the driving position and heard to be running. When immersed in 75 mm-deep (3-inch) water, the pump was operated for six minutes, during which a discharge rate of 4.67 gal/min (21.2 L/min) was maintained through the discharge piping to the after end of the vehicle.

E) The bilge pump located in the after engine compartment was switched on at the engine compartment and the pump was heard to be running. However, because the end of the pump discharge hose was within the hull, operation at the time of the sinking could not have resulted in any reduction of floodwater in the vehicle. Furthermore, because there was no record of the after pump having been activated locally before the occurrence, further testing was considered unnecessary.

F) The bilge pump located in the forward engine compartment was switched on in the manual and automatic modes and did not operate in either. Electrical circuit testing showed that power was being supplied to the pump in both switch positions. Further testing, using a separate power supply, also failed to energize the pump. The pump and integral float switch were disassembled and found to be electrically inoperable. The flat tops of the pump casing were distorted into dome shapes some 9 mm (d inch) high and the float switch was also heat-distorted and jammed midway between the “on” and “off” positions. The heat distortion of the top of the pump and float switch housing was most likely due to their location in front of the main engine and directly under the main engine radiator.

G) The manual bilge pump is a 1½-inch (38 mm) single-piston pump, Beckson model 136PF6 “Thirsty Mate,” manufactured by Beckson Marine Corp. It is located along the port side of the passenger compartment abaft the driver’s seat, and extends into the bilge area to within ½ inch (12 mm) of the hull bottom. The barrel of the pump was found to have been flattened to a ¾-inch (19 mm) cross-section, approximately one foot from its bottom. The disconnected discharge hose was located in the locker under the seat immediately behind the pump. The pump was removed from the vehicle and found to operate freely. The discharge rate varied with the arm strength and endurance of the operator.

Appendix B—Statutory and Regulatory Safety Requirements

Canada Shipping Act (CSA), established by the *Revised Statutes of Canada*, 1985. CHAPTER S-9

Inspection of Canadian steamships not Safety Convention ships	316. (3) Subject to sections 405 to 407, every Canadian steamship that is not a ship described in subsection (1) or (2) shall have its hull, machinery and equipment inspected by a steamship inspector in accordance with the regulations before the ship is first put into service and at least once in each year thereafter or ....
Exemption from regulations	406. Steamships not in excess of 15 tons gross tonnage that do not carry more than 12 passengers and that are not pleasure craft are exempt from annual inspection and from the regulations made under section 338, other than those respecting (a) the construction of equipment and the class and quantity of various types of equipment to be carried; (b) precautions against fire; (c) the construction of hulls; (d) marking to show recommended safe limits for engine power and gross load capacity; (e) the construction and installation of machinery; and (f) propelling power, steering capability and position controlling arrangements.

Small Vessel Regulations (SVR)

Standards and Approval	5. (1) Any lifejacket, lifebuoy, life-saving cushion, personal flotation device, bailer, fire extinguisher or pyrotechnic distress signal referred to in Part II, IV or V that must be carried on a small vessel in accordance with these Regulations shall meet the applicable standards set out in Schedule III or such other standards that provide a level of safety that is equivalent to or higher than those standards.

Part I, Application	7. (2) This Part does not apply to a vessel described in subsection (1) that is (a) registered under the Act; (b) registered or licensed in accordance with the laws of another country and not principally maintained or operated in Canada; (c) a life boat or other survival craft that is part of the equipment of a ship; or (d) an amphibious vehicle for which a provincial automobile licence for highway travel is required.
Part IV, Safety Briefing	26.1 (1) Before a vessel leaves any place where passengers embark, the person in charge of the vessel shall brief all passengers in either or both of the official languages, as needed, respecting the safety and emergency procedures that are relevant to the type and length of the vessel, including (a) the location of lifejackets; (b) the location of survival craft; (c) for passengers in each area of the vessel, the location of lifejackets and survival craft that are closest to them; (d) the location and use of personal protection equipment, boat safety equipment and distress equipment; (e) the safety measures to be taken, including those relating to the protection of limbs, the avoidance of ropes and docking lines and the effect of the movement and grouping of passengers on the stability of the vessel; and (f) the prevention of fire and explosions. (2) The person in charge of the vessel shall, during a safety briefing, demonstrate how to put on each type of lifejacket carried on board the vessel.
Part IV, Over 8 m in Length	29. (1) Every vessel over 8 m in length shall carry (a) one approved standard lifejacket for each person on board; (b) one approved 762 mm diameter lifebuoy with not less than 9 m of rope attached; (c) one bailer and one manual pump; (d) six approved pyrotechnic distress signals of any type and six approved pyrotechnic distress signals of Type A, B or C; (e) one anchor with not less than 15 m of cable, rope or chain; (f) one Class B II fire extinguisher

Hull Inspection Regulations

Application

3. (1) Subject to subsection (3), these Regulations apply to
(a) ships not over five tons, gross tonnage, that carry more than 12 passengers;
(b) passenger ships over five tons, gross tonnage;
(c) non-passenger ships over 15 tons, gross tonnage, that are self-propelled, including lighters, dredges, barges, hoppers and like vessels; and
(d) ships, as defined in Part XV of the Act, that are dredges, rock drills, floating elevators, floating pile drivers and like vessels and are not self-propelled.

(2) [Revoked, SOR/93-251, s. 2]

(3) These Regulations do not apply to fishing vessels except as provided in the *Large Fishing Vessel Inspection Regulations*.

Ship Safety Bulletin 04/2001 and Small Vessel Monitoring and Inspection Program (SVMIP)

The SVMIP requires the following:

- to have a first inspection and receive a "Notice of Survey";
- to have an "Annual Seaworthiness Information Report" completed annually by the owner;
- to be subject to random inspection and compliance monitoring by a Marine Safety inspector, whereby a "Letter of Compliance" will be issued; and
- to be approved by Transport Canada, Marine Safety and subject to inspection during construction.

Small Passenger Vessel Inspection Course

These vessels...(not in excess of a gross tonnage 15 that do not carry more than 12 passengers)... are subject to a first inspection under 316(3) the same as any other commercial vessel. Thereafter they are subject to spot check or audit. The SVMIP will cover the spot check/audit system. Remember spot check/audit also applies to vessels with certificates, if you see a certificated vessel with something wrong that may affect safety of the vessel, you need to board and use your 310(1) power if necessary.

Appendix C—Previous Sinking on 30 June 2001

On 30 June 2001, the amphibious vehicle *Lady Duck* took on water while on the Ottawa River during a combined land and water-borne sightseeing tour of the National Capital Region. All eight passengers and the tour guide donned personal flotation devices and were safely transferred to a private craft and a Royal Canadian Mounted Police patrol boat that responded to an emergency message broadcast by the driver of the vehicle. The *Lady Duck* capsized and sank at the ramp about 30 minutes later as tour company personnel attempted to drive it out of the water. No injuries or environmental damage were reported as a result of the occurrence. The TSB investigation report is available (M01C0033).

As a result of this occurrence, Transport Canada (TC) and the owner took the following actions:

Transport Canada

- TC began a first inspection in accordance with the Small Vessel Monitoring and Inspection Program on 03 July 2001. After the safety equipment deficiencies were satisfactorily addressed, TC rescinded the previously issued detention order on 20 July 2001.

- A copy of Ship Safety Bulletin 04/2001 was given to the owner of the *Lady Duck*. This bulletin included details of applicable standards, safety requirements, and inspection compliance requirements.

- The installation of screwed plugs in the outboard ends of all seacocks, fitted during the TC assessment of the vehicle’s trim and intact transverse stability characteristics, was adopted by the owner as a future operating practice.

- Electrically driven pumps were installed in engine compartments at either end of the vehicle.

- The *Ship Station (Radio) Regulations, 1999* are in the amendment process. These regulations prescribe the radio equipment to be carried by commercial vessels for distress, urgency, safety, and general communications. Passenger ships engaged on a voyage, any part of which is outside a very high frequency (VHF) coverage area, will be required to be equipped with radio equipment capable of establishing continuous two-way communications with a Marine Communications and Traffic Services centre or a person ashore. The regulations amendment were published in the *Canada Gazette,* Part I, on 12 April 2003, vol. 137, No. 15.

Vehicle Owner

- The owner of the *Lady Duck* amended company operating practices by mandating the completion of a safety checklist before each departure of the vehicle. Accordingly, the driver must verify the status of the seacocks, sign the safety checklist, and have it countersigned by the tour guide or the kiosk attendant for retention ashore. The list also includes the number of passengers on board.

- To prevent water from entering the front of the hull through inadvertent operation or malfunction of the vertical sliding visor, the visor is now bolted in the raised position when the vehicle is engaged in routine tourist operation.

Appendix D—Sinking of the Amphibious Passenger Vehicle Miss Majestic

National Transportation Safety Board
Marine Accident Report
NTSB Number NTSB/MAR0201

On 01 May 1999, the amphibious passenger vehicle *Miss Majestic*, with an operator and 20 passengers on board, entered Lake Hamilton near Hot Springs, Arkansas, United States, on a regular excursion tour. About seven minutes after entering the water, the vehicle listed to port and rapidly sank by the stern in 60 feet of water. One passenger escaped before the vehicle submerged but the remaining passengers and the operator were trapped by the vehicle's canopy roof and drawn under water. During the vehicle's descent to the bottom of the lake, six passengers and the operator were able to escape and, upon their reaching the water's surface, were rescued by pleasure boaters in the area. The remaining 13 passengers, including three children, lost their lives. The vehicle damage was estimated at $100 000.

The NTSB investigation into this accident identified the following major safety issues:

- vehicle maintenance,
- Coast Guard inspections of the *Miss Majestic*,
- Coast Guard inspection guidance,
- reserve buoyancy, and
- survivability.

The NTSB determined that the probable cause of the uncontrolled flooding and sinking of the *Miss Majestic* was the failure of Land and Lakes Tours, Inc., to adequately repair and maintain the DUKW.[31] Contributing to the sinking was a flaw in the design of the DUKW as converted for passenger service; that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition. Contributing to the unsafe condition of the *Miss Majestic* was the lack of adequate overview by the Coast Guard. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle.

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31 The Army acronym DUKW indicates that the vehicle model was designed in 1942 (D) and that the vehicle is amphibious (U) and has both front-wheel drive and rear-wheel drive capability (K and W, respectively).

As a result of this investigation, the NTSB made the following recommendations:

To the U.S. Coast Guard and the Governors of the States of New York and Wisconsin:

Require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-02-1)

Until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), require the following:

(1) removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking,

(2) reengineering of each amphibious vehicle to permanently close all unnecessary access plugs and to reduce all necessary through-hull penetrations to the minimum size necessary for operation,

(3) installation of independently powered electric bilge pumps that are capable of dewatering the craft at the volume of the largest remaining penetration to supplement either an operable Higgins pump or a dewatering pump of equivalent or greater capacity,

(4) installation of four independently powered bilge alarms,

(5) inspection of the vehicle in water after each time a through-hull penetration has been removed or uncovered,

(6) verification of a vehicle's watertight condition in the water at the outset of each waterborne departure, and

(7) compliance with all remaining provisions of *Navigation and Vessel Inspection Circular 1-01.* (M-02-2)

Where canopies have been removed on amphibious passenger vehicles for which there is no adequate reserve buoyancy, require that all passengers don lifejackets before the onset of waterborne operations. (M-02-3)

To the U.S. Coast Guard

> Develop and promulgate guidance for all amphibious passenger vehicles similar in purpose to the *Navigation and Vessel Inspection Circular 1-01.* (M-02-4)

Previously Issued Recommendation Classified in this Report

The following safety recommendation was issued to 30 operators and refurbishers of amphibious passenger vehicles in the United States:

> Without delay, alter your amphibious passenger vessels to provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that they will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-00-5)

Appendix E—S.I. 7 Related Issues

Initial items listed on Form S.I. 7, issued 03 July 2001	Items as modified by Transport Canada's Sarnia office sent to the owner, 04 July 2001	Status of items as reported by Transport Canada
1. Means for sealing the forward engine compartment watertight shall be provided (bow visor)	1. Remains effective	1. Done
2. Renew forward end of exhaust pipe through hull penetration	2. Remains effective	2. Done
3. Replace one (1) bilge drain valve on the port side forward	3. Remains effective	3. Done
4. Guard rail to be provided in way of passenger areas and to be a minimum of 1 m high (39 inches)	4. No specific regulatory requirement, but this is a recommendation only by the attending inspector	4. Not done
5. Install fixed CO_2 (10 pounds) in the after engine room	5. No specific regulatory requirement, but this is a recommendation only by the attending inspector	5. Not done
6. Provide suitable insulation for after engine room	6. No specific regulatory requirement, but this is a recommendation only by the attending inspector	6. Not done
7. Portable hand-held lighting to be provided in case of emergency (two)	7. No specific regulatory requirement, but this is a recommendation only by the attending inspector	7. Flashlight provided
8. Remote-control fuel-oil shut-off to be provided	8. No specific regulatory requirement, but this is a recommendation only by the attending inspector	8. Not done
9. Provide one (1) additional bilge pump in the engine room compartment located aft	9. No specific regulatory requirement, but this is a recommendation only by the attending inspector	9. Done

Initial items listed on Form S.I. 7, issued 03 July 2001	Items as modified by Transport Canada's Sarnia office sent to the owner, 04 July 2001	Status of items as reported by Transport Canada
10. All bilge piping to be replaced with rubber (remove plastic piping)	10. Remains effective	10. Done
11. Provide two (2) lifebuoys – minimum of 610 mm (24 inches)	11. Amended to read "one (1) approved lifebuoy with 9 m of rope"	11. Done as revised
12. Provide six (6) pyrotechnics distress signals, type A or B	12. Remains effective	12. Done
13. Provide one suitable magnetic compass	13. No specific regulatory requirement, but this is a recommendation only by the attending inspector	13. Not done
14. Provide one (1) suitable anchor with 30 m (100 feet) of cable	14. Remains effective, but amended to read 15 m instead of 30 m of cable requirement	14. Done as revised
15. Provide one (1) inflatable liferaft for 100 per cent of the complement	15. No specific regulatory requirement, but this is a recommendation only by the attending inspector	15. Not done
16. Provide suitable steel sheathing on the inside of the after engine compartment	16. No specific regulatory requirement, but this is a recommendation only by the attending inspector	16. Done
17. A satisfactory stability test	17. No specific regulatory requirement, but this is a recommendation only by the attending inspector	17. Done
18. A satisfactory afloat inspection	18. Remains effective	18. Done

Appendix F—Small Passenger Vessel Inspection Course

Purpose of the Course (March 25-28, 2002)

The aim of this four-day course is to have marine inspectors understand the priority of and commitment to small vessel safety. They will be familiarized with the regulatory framework of the inspection requirements for small vessels, sources of inspection guidelines, how to document inspections, types of inspections and classes of vessels.

Small Passenger Vessels Inspection Course
Manual Overview

- Participants and Instructors List
- Course Schedule
- Course Outline
- Introduction
- Safety Culture—Exploration
- A Safety Culture in Marine Safety
- Tobermory Video (Handout)
- New Priorities—SPV (see Module 4—Verification of the Existence and Validity of Required Canadian Maritime Documents and Forms)
- Canadian Maritime Document (CMD) (see Module 4)
- Module 1—Definition of a Small Passenger Vessel
- Module 2—Roles and Responsibilities of the Marine Safety Inspector
- Module 3—Safety Relevant Sections of Applicable Documents and Miscellaneous Regulations
- Module 10—Regulatory Requirements for Certification and Crewing
- Stability Presentation (Handout)
- Module 5—Regulatory Requirements and their Application as Related to Hull Inspections
- Module 6—Regulatory Requirements and their Application as Related to Machinery Inspections
- Module 7—Regulatory Requirements and their Application as Related to Lifesaving Equipment
- Module 8—Regulatory Requirements and their Application as Related to Fire Fighting Equipment
- Module 9—Regulatory Requirements and their Application as Related to Radio and Navigational Equipment
- Module 11—Inspection Procedures of Miscellaneous Systems Aboard Small Vessels
- Module 12—Instances Where a Certificate's Validity May Be Restricted Due to Environmental or Other Considerations
- Module 13—Attendant Procedures for the Safety Assessment Checklists

- Checklist Review (TP 1332)
- Checklist Review (TP 11717)
- Module 14—The Associated Administrative Procedures for Inspection Completion
- SIRS (Small Vessels)
- Module 15—Quality Assurance and Documentation as Applied to Small Passenger Vessel Inspections

Appendix G—List of Supporting Reports

The following reports have been prepared in connection with the occurrence:

- *TSB Trials Information, Analytical Notes & Recorded Trials Data* (M02C0030)
- TSB Engineering Laboratory report LP 062/2002, *Strength of Seats Anchorages*
- TSB Engineering Laboratory report LP 051/02, *Watersoaked Logbook Restoration*
- *TSB Overview of Canadian Passenger Vessel Safety 1975-2002*, MAP M02-201

These reports are available upon request from the TSB.

Appendix H—Glossary

CBSI	Chairman of the Board of Steamship Inspection
CCG	Canadian Coast Guard
CGSB	Canadian General Standards Board
CMAC	Canadian Marine Advisory Council
CPVA	Canadian Passenger Vessel Association
CR	*Collision Regulations*
CSA	*Canada Shipping Act*
CVO	commercial vehicle operators
DFO	Department of Fisheries and Oceans
D.O.T.	Department of Transport
F/B	freeboard
g	force as a proportion of the object's weight
gal/h	gallons per hour
gal/min	gallons per minute
G.L.	ground level
I/O	inboard/outboard
ISM Code	*International Safety Management Code for the Safe Operation of Ships and for Pollution Prevention*
ISO	International Organization for Standardization
ISPVCP	Interim Small Passenger Vessel Compliance Program
ISVCP	Interim Small Vessel Compliance Program
km/h	kilometres per hour
L/J	lifejacket
L/min	litres per minute
m	metre
MCTS	Marine Communications and Traffic Services
MED	Marine Emergency Duties
mm	millimetre
MP	manual bilge pump
MTO	Ministry of Transportation of Ontario
MSA	Marine Safety Advisory
MSI	Marine Safety Information Letter
N	north
NCR	National Capital Region
NMSMC	National Marine Safety Management Committee
NSS	National Search and Rescue Secretariat
NTSB	National Transportation Safety Board (United States)
N.W.T.	non-watertight
PFD	personal flotation device
SAR	Search and Rescue

S.I.	Ship Inspection
SIC 99	Ship Inspection Certificate
SMS	safety management system
SPVIC	Small Passenger Vessel Inspection Course
SSB	Ship Safety Bulletin
SVMIP	Small Vessel Monitoring and Inspection Program
SVR	*Small Vessel Regulations*
TC	Transport Canada
TSB	Transportation Safety Board of Canada
U.S.	United States
V	volt
VHF	very high frequency
VTS	Vessel Traffic Services
W	west
W.L.	waterline
W.T.	watertight
°	degrees
‘	minutes