Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

MARINE INVESTIGATION REPORT
M01C0054

STRIKING AND SUBSEQUENT FIRE ON BOARD

BRIDGE 11, WELLAND CANAL
AND
BULK CARRIER *WINDOC*
WELLAND CANAL, ALLANBURG, ONTARIO
11 AUGUST 2001

Canada

Marine Investigation Report

Striking and Subsequent Fire on Board

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and
Bulk Carrier *Windoc*
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Report Number M01C0054

Synopsis

At approximately 2054, while proceeding downbound under Bridge 11 in the Welland Canal, at Allanburg, Ontario, the bulk carrier *Windoc* was struck by the bridge's vertical-lift span, which was lowered before the vessel had passed clear of the bridge structure. The vessel's wheelhouse and funnel were destroyed. The vessel drifted downstream, caught fire, and grounded approximately 800 metres from the bridge. Although the vessel's cargo of wheat was not damaged, the vessel was declared a constructive total loss. The bridge sustained structural damage, and the Welland Canal was closed to vessel traffic for two days. There were no serious injuries or oil pollution.

Ce rapport est également disponible en français.

5.0 Appendices

1.0 Factual Information

1.1 Particulars of the Vessel

	Windoc (ex *Steelcliffe Hall*)
Official Number	383573
Port of Registry	Thunder Bay, Ontario
Flag	Canada
Type	Bulk carrier
Gross Tonnage[1]	18 516.64
Length	218.2 m
Draught	F[2]: 7.95 m A: 7.95 m
Built	Forward and cargo sections: Canada, 1977 Aft section: Germany, 1959
Propulsion	One Burmiester & Wain, single-acting, slow-speed diesel, 6436 kW, single variable pitch propeller
Cargo	26 023.9 tonnes
Crew	14 members
Passengers	None
Owner(s)	N.M. Paterson & Sons Ltd., Thunder Bay, Ontario, Canada

1.1.1 Description of the Vessel

The *Windoc* was originally constructed in Hamburg, (West) Germany, in 1959 as an ocean-going bulk carrier. In 1977, the vessel was rebuilt in Canada. The aft section of the vessel, where the propelling machinery, steering gear, and crew accommodation were arranged, was retained. The hull forward of the engine room was replaced to permit the carriage of more dry cargo, and the wheelhouse was moved aft above the accommodation. The vessel had six cargo holds.

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

2 See Glossary at Appendix B for all abbreviations and acronyms.

1.2 Particulars of the Bridge

1.2.1 Description of the Bridge

Bridge 11 is one of three vertical-lift bridges used for vehicular traffic over the canal. Bridge 11 is located in Allanburg, Ontario, 11.4 nautical miles (nm) upstream from the breakwater at Port Weller, Lake Ontario (latitude 43°04' 35" N, longitude 79°12' 38" W). The bridge had been in continuous operation from the time it was built in 1932. Towers on each side of the canal are used to guide and support the raising and lowering of the span. A fixed camera mounted on top of the bridge's east tower provides the St. Lawrence Seaway Management Corporation (SLSMC) Traffic Control Centre (TCC) controllers a limited view of vessels approaching the bridge from upstream (i.e. from the south).

The span was constructed of steel, and the road surface was paved with asphalt. The distance between the support bearings of the two towers reduced the width of the canal to 60.9 metres (m). The clearance height between the span, when it was in the fully raised position, and the water level of the canal was 36.5 m. The centre line of the span coincides with the centre line of the canal between the support bearings.

The bridge operator's control room was located among the trusses above the centre line of the span. The engines and generators required to power and operate the span were housed directly above the bridge operator's control room.

Signal lights, mounted along the centre line on each side of the span, are used to indicate to approaching vessels whether the span is stationary, in motion, or in the fully raised position.

1.3 Navigation in the Welland Canal

1.3.1 Traffic Control Centre (TCC)

Control and scheduling of vessel traffic in the canal are provided by TCC controllers, as well as coordination of communications with vessels and canal organizations. Controllers communicate directly with vessels transiting the canal by very high frequency (VHF) radio. Controllers communicate directly, by landline and mobile telephone, with SLSMC personnel operating the locks and bridges to ensure overall coordination of vessel traffic. They are able to monitor vessel traffic in real time through the use of remote-controlled and fixed cameras placed throughout the canal. Controllers are also responsible for operating, by remote control, the only automated bridge in the canal.

With respect to Bridge 11, there were three means of communication available between the operator and the TCC controller; landline telephone, VHF radio base-station and a VHF portable radio. Routine reporting of vessel traffic information between the operator and the controller was by landline telephone.

Radio and telephone conversations between controllers and vessels, and between controllers and bridge and lock personnel, are recorded automatically at the TCC. There is a capability for video recording images captured by SLSMC cameras but it must be activated manually.

1.3.2 *Procedures for Vessels Approaching Bridges*

Procedures for vessels approaching a bridge in the canal are stipulated in *The Seaway Handbook*,[3] a copy of which was in the wheelhouse of the *Windoc*. As a vessel's stem arrives at the black and yellow checkerboard whistle sign, a bridge operator activates an amber light which begins to flash. This signal acknowledges that the bridge operator is aware of the presence of the vessel and will start raising the bridge. If the amber light is not flashing, the vessel is to make its presence known to the bridge operator via VHF radiotelephone on the designated channel.

After being acknowledged by the bridge operator, the signal lights on the bridge span, which turn red when in the fully-lowered position, will flash red once the operator begins to raise the span. The vessel may continue towards the bridge but shall not pass the "limit of approach" sign until the bridge span is in the fully-raised position and the signal lights turn green. The "limit of approach" sign for Bridge 11 was located 60 m from the bridge. As the bridge span is lowered, the signal lights on the span will turn from green to solid red.

The operator control room of Bridge 11 had a radar as well as a microwave detector receiver. The microwave detector is located at Port Robinson, approximately 2.2 nm upstream from Bridge 11. These devices are used to alert the operator of an approaching vessel when visibility is reduced. Both devices were fitted with alarms.

1.4 *History of the Voyage*

1.4.1 *Windoc*

On 08 August 2001, the *Windoc* departed Thunder Bay with a cargo of wheat for Montréal, Quebec. At 1748 eastern daylight time (EDT)[4] on 11 August 2001, the vessel arrived at the southern entrance to the canal. It then proceeded under vertical-lift Bridge 21 and

[3] *The Seaway Handbook*, St. Lawrence Seaway Management Corporation, 2001.

[4] All times are EDT (coordinated universal time minus four hours).

bascule Bridge 19A and entered Lock 8. At 1923, it departed the lock, passed under bascule Bridge 19, and proceeded downbound in the canal. Eight of the 22 crew members on board were permitted to disembark from the vessel before it proceeded downbound.

At 2028, the master of the vessel informed the TCC controller on VHF radiotelephone channel 14 that the vessel was off Port Robinson. Accompanying the master in the wheelhouse were the third officer and a wheelsman. The vessel's speed over the ground averaged approximately six knots from Port Robinson to Bridge 11.

The vessel proceeded downbound, and the wheelhouse team observed the flashing amber approach light, located 925 m from the bridge on the west side of the canal, which indicated that the bridge operator was aware of the approaching vessel. The speed of the vessel was reported to be approximately five knots. As the vessel neared the bridge, the signal lights on the bridge were flashing red and the lift span was being raised. When the vessel was approximately 0.75 to 0.5 nm from the bridge, the signal lights changed to solid green and the lift span was in the fully-raised position. With the centre line of the vessel lined up with the bridge signal lights, the vessel proceeded under the bridge.

When the vessel was approximately halfway under the bridge, the third officer observed that the bridge signal lights were solid red and the lift span was descending. At 2053, the master sounded a few blasts on the ship's whistle. The master, without identifying himself or the bridge in question, called the TCC on VHF channel 14 about the lowering of the bridge. The master quickly stopped the engines and ordered an evacuation of the wheelhouse.

The master and third officer left the wheelhouse by the starboard navigation bridge wing. As they proceeded down the external bridge access ladder, the span of the bridge struck the vessel in way of the wheelhouse front windows, subsequently destroying the vessel's wheelhouse and funnel (see Photo 1).

Photo 1. Bridge 11 striking vessel in way of wheelhouse front windows. Reproduced with permission.

The wheelsman remained at his station in the wheelhouse and lay down on the deck as the bridge span passed overhead. He freed himself from the debris and descended by the deckhouse stairwell before the third officer returned to the wheelhouse to look for him. When the TCC controller heard a call on VHF channel 14 about a bridge being lowered, he recognized the voice and used a camera, located at Seaway mile 14.6, west of Port Robinson, to look at Bridge 11. The controller saw that the stern of the vessel had not yet cleared the bridge, and the fixed camera mounted on the east tower of Bridge 11 showed that the picture on the monitor was shaking. Thus, the controller concluded that the bridge had been lowered onto the vessel.

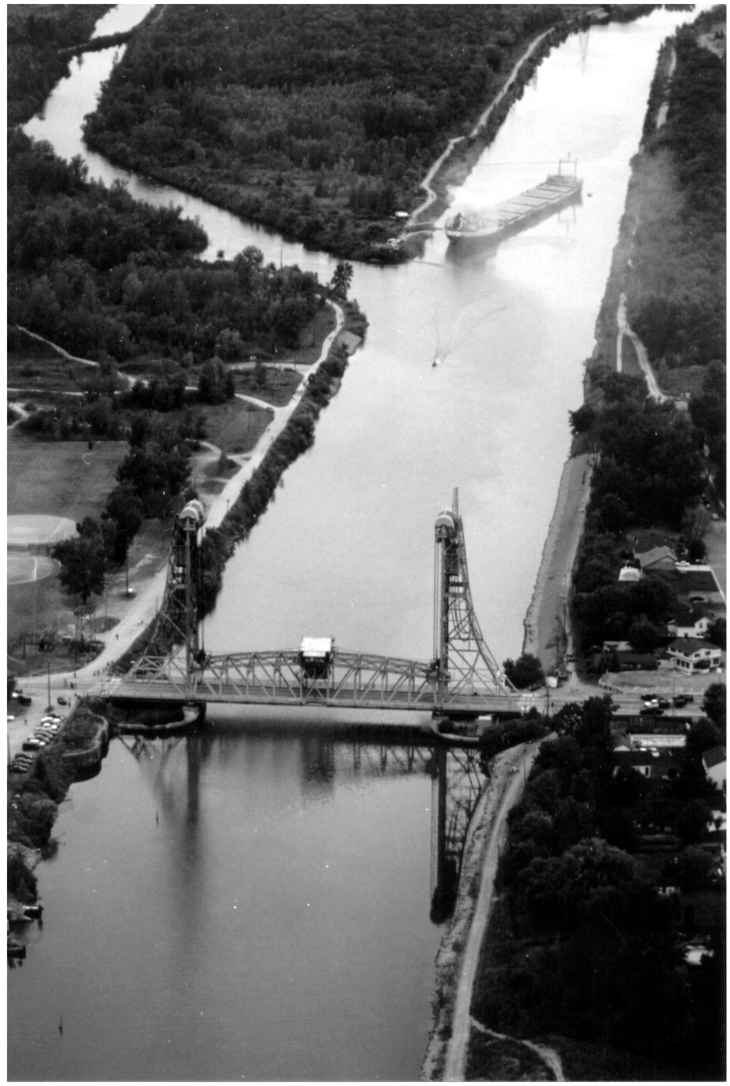

Photo 2. Aerial view looking north at the bridge and vessel after the striking. (Photograph by Harry Rosettani)

After the striking, the vessel's general alarm was sounded. The crew mustered on the main deck and everyone was accounted for.

The vessel drifted downbound from Bridge 11. A fire broke out in way of the main engine casing and spread to the accommodation structure. The starboard anchor was dropped. However, the vessel's starboard bow made contact with the east bank of the canal. The vessel then drifted to the west side of the canal and went aground approximately 800 m from Bridge 11 (see Photo 2).

1.4.2 Bridge Operator

On 11 August 2001, the operator was on his scheduled day off and had completed two 12-hour day shifts during the previous two days. The operator took two Darvon-N tablets at approximately 0800 that morning to relieve back pain and had consumed between two and four glasses of wine around lunch time. Between 1300 and 1400, he received a telephone call from an SLSMC team leader, who asked if the operator would agree to work an overtime shift that evening on Bridge 11. The bridge operator agreed. No information concerning his fitness for work was exchanged at the time of the request, nor was it common practice to do so. SLSMC's policy is that no employee shall report to duty with their ability impaired. After the telephone call, the operator relaxed, ate, and tried to get some sleep but did not sleep. Reportedly, he did not consume any additional alcohol or take any medication after accepting to work the overtime shift.

At about 1745, the bridge operator left his home and drove his vehicle to Bridge 11. At about 1820, the operator arrived at the bridge and made his way onto the lift span. He was met by the bridge operator of the previous shift, who reported he should expect a busy shift that night. No other information was exchanged during the shift change. The operator then climbed up the access ladder and entered the bridge operator's control room to begin his shift.

By 1857, the bridge operator had raised the lift span for the first time during his shift and informed the TCC controller by telephone that the vessel *Algocape* was under Bridge 11. At that time, the operator had a brief conversation with the controller, who informed him that the next vessels he would encounter would be the downbound *John B. Aird* and two upbound yachts. The operator then lowered the lift span to allow vehicle traffic use of the bridge and later raised the lift span for the three vessels. At 1941, during the last telephone conversation between these two parties, the operator informed the TCC controller that the two yachts and the *John B. Aird* were under Bridge 11.

At 2050, the bridge operator called TCC by telephone and reported, in an unintelligible manner, that the *Windoc* was "coming under [Bridge] 11". The controller, listening to the bridge operator on a speaker, did not understand what was said and asked the operator to repeat his message. Immediately after that telephone call, the bridge operator called the TCC again. When the controller answered this call, the bridge operator sounded confused because he asked if he was calling Lock 7. The TCC controller told the bridge operator he would relay the operator's message to Lock 7 as that station was having trouble with its telephones.

After the 2050 telephone call, the bridge operator began lowering the lift span. The operator reportedly lowered the span after he saw the stern of the vessel clear the bridge. The operator did not immediately report the striking of the vessel to the TCC.

At 2054, after hearing the radiotelephone call on VHF channel 14 about the lowering of a bridge on a vessel and seeing the picture on the monitor from the fixed camera mounted on top of Bridge 11 shaking, the TCC controller called the bridge operator by telephone. The controller asked the bridge operator if he had lowered the bridge onto the vessel. The bridge operator told the controller that the vessel had hit the bridge. The controller told the bridge operator to raise the bridge.

At 2056, TCC controllers received calls about an accident and fire at Bridge 11. The controllers called the bridge operator several times but there was no response. It was not until 2106, when the controller called and spoke with the bridge operator that the operator expressed surprise that emergency services were on the way, questioning why emergency services personnel had a need to see him. When specifically asked by the controller about the fire on board the vessel, the operator reported that there was a small fire.

At 2106, a police officer arrived at Bridge 11. The lift span of the bridge was in the lowered but not fully-seated position, and the officer proceeded to the bridge control room to meet with the bridge operator. At 2110, an SLSMC supervisor arrived at Bridge 11 and went up to the bridge control room to meet with the bridge operator. Shortly afterwards, other SLSMC personnel and emergency services arrived on scene. The police officer and the SLSMC area coordinator indicated that they found the operator sitting in the dark and described his condition as shaken up or in shock.

An examination of the bridge operator's vital signs was conducted by a paramedic. The operator was asked by the paramedic to go to the hospital for further examination, but the operator declined his request. At approximately 2230, the bridge operator, accompanied by another person, left the bridge to return home.

Following the occurrence, the operator did not recall any event between the time the decision was taken to lower the bridge and the time SLSMC personnel arrived at the bridge following the occurrence, a period of about 25 minutes.

1.4.3 Communications Between Bridge 11 and the TCC

Tapes of communications between the bridge operator and TCC controllers just before the time of the striking revealed that the operator was having difficulty communicating during this period. When the operator called the TCC to report that the *Windoc* was under Bridge 11, the controller had difficulty understanding him and asked him to repeat the message. A short time later, the bridge operator again contacted TCC while attempting to contact Lock 7. The operator had difficulty understanding that he had contacted the wrong place, his speech was slurred, and he asked the controller to relay his message to Lock 7 on his behalf, which the controller agreed to do. This exchange was conducted over a speaker phone, and before hanging up, the two controllers on duty made comments about the way the operator sounded. Less than two minutes later, the accident occurred.

Following the striking, TCC controllers had another two conversations with the bridge operator. The content of these communications indicate that the bridge operator did not seem to appreciate what had happened.

1.5 Effects of Darvon-N

Darvon-N is the trade name for the chemical propoxyphene napsylate, a narcotic analgesic which acts on the central nervous system. Darvon-N is prescribed for the relief of mild to moderate pain where less potent medications are either not effective or are contraindicated. Darvon-N is ingested orally after which it reaches a peak concentration in the plasma of the individual in 2 to 2.5 hours. The duration of action[5] is three to four hours.

Propoxyphene napsylate is metabolized in the liver to become the chemical norpoxyphene. The half life[6] of propoxyphene is 6 to 12 hours and that of norpoxyphene is 30 to 36 hours. Norpoxyphene also acts on the central nervous system but is significantly less potent than propoxyphene. Propoxyphene will interact with alcohol to produce additive effects on the central nervous system.

1.6 Speech Examination

The assistance of the United States National Transportation Safety Board (NTSB) was requested to examine the recordings of telephone conversations between the bridge operator and the TCC for indications of possible impairment on the part of the bridge operator at the time of the occurrence. Based upon previous experience analysing the effect of psychological factors on speech, the speech analysis group examined 62 telephone conversations between the bridge operator and the TCC which took place between 18 June 2001 and 11 August 2001.

Two types of analysis were conducted. The first consisted of a comparison of physical characteristics of the operator's speech on the night of the occurrence to a baseline sample of the operator's speech on previous shifts. Measures used for the purposes of this analysis included: fundamental frequency; latency (time to respond when telephoned or when the telephone is answered); speech errors; speaking rate and the pronunciation of specific sounds such as "l" and "s". The second type of analysis by the speech analysis group was more qualitative and examined the recordings for overall quality and content on the night of the occurrence (see section 2.2).

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5 Refers to the period of time when the individual taking the medication will be aware of its effects.

6 Refers to the length of time for the body to eliminate half of the initial concentration.

1.7 TCC Coordination of Response Activities

At 2054, after observing the shaking image from the camera mounted on Bridge 11 and speaking to the bridge operator, TCC controllers made several attempts to contact the area coordinator via mobile radio and the *Windoc* via VHF radio, but were unsuccessful. Meanwhile, the TCC controllers continued to manage the vessel traffic in the canal.

At 2056 and 2057, the TCC controllers received telephone calls from a dispatcher with Niagara Regional Police Service, requesting information about an accident at Bridge 11. The dispatcher informed the controller that police, ambulance, and fire department were services on their way to the scene of the accident. The controller who spoke to the dispatcher provided little of the information that was available about the accident, but he did report seeing smoke. The controllers could see smoke on their monitors, but could not see the vessel or the span of the bridge.

At 2100, the controllers made contact with the area coordinator (who was on duty at the time as the marine coordinator) and informed him of the accident at Bridge 11. The area coordinator then proceeded to Bridge 11.

At 2103, the master of the *Windoc*, using a portable VHF radio, called the TCC to inform the controller that the vessel was on fire.

By 2105, the TCC controllers had informed senior management and an SLSMC ship inspector about the accident.

At 2108, in response to its query, the fire department was informed by the controller that a cargo of wheat was on board the *Windoc*.

At 2110, the SLSMC area coordinator reported his arrival at Bridge 11 to the TCC and went to the bridge control room to meet with the bridge operator.

At 2112, one of the TCC controllers called an SLSMC employee at Lock 8 and requested that he go to Bridge 11 but did not know to which side of the canal he should go. Meanwhile, the fire department called the TCC controller and inquired about the status of the bridge. The controller replied that contact had been made with the bridge operator, and the bridge span was approximately 10 feet in the air.

At 2113, the SLSMC ship inspector called the TCC controller and asked to which side of the canal he should proceed. The controller who spoke to the inspector stated that he could not see the vessel but believed it was closer to the east side of the canal.

At 2123, the master of the *Windoc* called the TCC to voice his concern about a possible explosion and informed them that he was going to pull back his fire parties from the stern of the vessel. The master also suggested that the fire department should be able to apply water onto the vessel's stern from the west side of the canal.

At 2125, the TCC controller relayed the master's suggestion to the fire department but did not mention his concern of a possible explosion. The concern was relayed to the fire department when the controller called back six minutes later.

At 2127, a ship inspector, who had now arrived on scene, called the TCC controllers so that arrangements could be made to get him a small boat to board the vessel. A controller called the Port Colborne pilot boat and requested that the vessel proceed to Bridge 11 to provide assistance. However, the pilot boat estimated that they would be at the site at approximately 2300. Furthermore, the pilot boat, with an air draught of approximately 22 feet, would not be able to pass under the bridge to proceed to the *Windoc*. SLSMC did not want to raise the vertical-lift span until a thorough inspection of the bridge and support structures could be undertaken. The controllers began calling other vessels in the area and SLSMC personnel to find a small boat. The controllers were informed that the St. Catharines fire department had small boats that were being deployed to provide assistance in combatting the fire. The controllers were also informed that SLSMC had a small boat en route.

At 2232, the fire department, after having gained access to a suitable launching site, launched its small boats.

At 2253, the Canadian Coast Guard (CCG) Marine Communication and Traffic Services (MCTS) in Sarnia, Ontario, called the TCC about a news media report they received from the Ontario Ministry of the Environment (MoE) Spill Action Centre (SAC) about an accident at Bridge 11.

The controller informed MCTS that SLSMC was responding to the accident. There were no injuries or pollution, and they had not issued an accident report. Earlier, one of the controllers called a local radio station and left a message about the closing of Bridge 11 to vehicular traffic as a result of an accident.

At 2300, the fire department called the TCC and asked whether SLSMC was going to take precautions against a possible fuel oil leak from the vessel and whether MoE had been informed of the accident. After one of the controllers conferred with the SLSMC ship inspector, it was decided that prudence would dictate that an oil containment boom be deployed as a precautionary measure. The controller called a local spill response provider but there was no answer. The spill response provider has an after-hours telephone monitoring service, but the controller had hung up before being connected to the monitoring service.

At 2309, the pilot boat arrived at Bridge 11. SLSMC engineers boarded it and inspected the underside of the span.

At 2310, a controller first called the fire department, then MCTS and SAC, to acquire an oil containment boom, but to no avail.

At 2316, an officer with the CCG Rescue, Safety and Environmental Response Branch called the TCC and provided the controller with an erroneous 1-800 telephone number for the local spill responder. The telephone number was actually for MCTS in Sarnia, which did not have the requested telephone number but did provide the telephone number for another spill response provider located near Hamilton, Ontario. At the time of the accident, there was no standing agreement in place between SLSMC and a spill response provider for response services.

At 2329, the controller was informed by an SLSMC employee that the Corporation had a boom but it would be difficult to deploy; 300 feet of containment boom was located at the south end of the canal, 100 feet was located at the north end.

At 2355, the controller spoke to a spill response provider located near Hamilton who was able to provide and deploy an oil containment boom in the canal. It was deployed across the canal and downstream of the *Windoc* at approximately 0440 the following morning, six hours after boom deployment was first suggested.

1.8 Firefighting Response

The initial explosion and fire had been fuelled by an incinerator fuel oil header tank located in the stack area. After mustering forward of the accommodation, the crew deployed hoses and began fighting the fire using the vessel's emergency fire pump. The initial shipboard firefighting efforts were successful in reducing the fire but, fearing an explosion from the engine room fuel oil day tanks, the crew was pulled back from the fire, leaving the fire hoses lashed in place directing water at the fire. Once municipal fire crews arrived on the canal bank adjacent to the vessel, the master evacuated the crew using a forward liferaft at 2200. The master and chief engineer remained on board to direct shore-based fire crews.

The first of several reports of the striking made by the general public to the Niagara Regional Police Service was at 2056; police, fire, and ambulance services were dispatched to the scene of the accident. The Thorold Fire Department responded with pumper trucks, which arrived on the east side of the canal at 2105. However, the *Windoc* began to drift across to the west side of the canal, forcing the responding fire units to detour, arriving at the *Windoc*'s final position at 2120. Due to a lack of common radio frequencies, the fire department initiated communications with the vessel by shouting across to the master. Initial reports from witnesses had indicated that some crew members had abandoned ship into the water; however, the master of the

Windoc reassured emergency services on scene that all of his crew was safe and uninjured. When the crew was evacuated from the vessel, the master sent a handheld VHF radio ashore for use by the fire department.

Since the *Windoc*'s stern was approximately 20 m away from the canal bank and there was only the vessel's liferaft available for boarding, the fire department would not board the vessel initially. They started fighting the fire using portable pumps and hoses from aerial trucks (see Photo 3). The Thorold Fire Department did not have suitable boats to access the vessel; however, rigid bottom inflatable boats were provided later in the evening by the St. Catharines Fire Department. Neither TCC nor local fire departments were aware of boat launch ramps convenient to the occurrence site, thus delaying the arrival of the boats while a suitable launch site was located.

Photo 3. Aerial view of aft section of vessel with fire department vehicle on site. (Photograph by Harry Rosettani)

At 2230, an SLSMC ship inspector boarded the *Windoc*, using the vessel's liferaft, to assist the captain and chief engineer, who remained on board when the crew was evacuated. At 2330, the seaway inspector observed that the aft bulkhead of the accommodation was warm to the touch and that the forward bulkheads were cool, indicating that the fire was still restricted to the aft portion of the accommodation. At 0145, seven members of the Thorold Fire Department boarded the *Windoc* to assess the situation and coordinate firefighting activities with the captain and chief engineer.

At the time of the occurrence, the ship's fire plan had been stored in the wheelhouse, which was destroyed when the bridge struck the vessel. No copy of the plan was available outside of the accommodation. Notwithstanding the absence of a fire plan, firefighters were briefed by the captain and chief engineer. Using hoses and water supplied by the ship's emergency fire pump, firefighters entered the accommodation to reconnoitre at 0220. Due to their unfamiliarity with the layout of the vessel and the thick smoke, they did not remain inside to fight the fire and exited to the main deck at 0230.

Under instructions from the fire chief, firefighters opened forward watertight accommodation doors in order to clear the smoke from the space. Shortly thereafter, the fire spread to the forward area of the accommodation into the captain's and chief engineer's cabins. Fire crews then fought the fire, discharging hoses through broken portholes in the forward bulkhead.

At 0700, firefighters re-entered the accommodation, discharged the vessel's fixed carbon dioxide extinguishing system into the open engine room, and opened valves to direct water into the vessel's fixed sprinkler system. However, the sprinkler system piping was found to be damaged from the striking and fire, and the system could not be effectively charged. Fire crews continued to fight the fire from outside the vessel's superstructure during 12 August 2001 until the fire was declared out at 1630.

1.9 Injuries to Persons

No injuries were reported.

1.10 Damage

1.10.1 Damage to the Vessel

The wheelhouse, main mast, engine room vents, and funnel were destroyed by contact with the lift span of the bridge. The incinerator fuel oil tank, located in the funnel casing, was ruptured, spilling fuel into the engine room and onto the boat deck. Accommodation on the various decks was destroyed by fire, heat, and smoke. The engine room casing and main engine were damaged by fire, heat and water. The bilge shell plating in way of starboard ballast tank No. 1 was creased and fractured. The aft bulkhead and bilge floors were distorted and torn adrift. The vessel was declared a constructive total loss. No damage to the cargo was reported (see Photo 4).

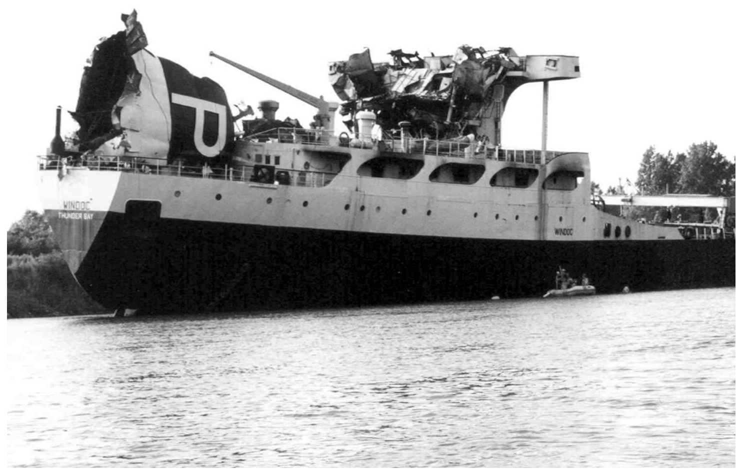

Photo 4. View of damaged superstructure and funnel.

1.10.2 Damage to the Bridge

The bridge sustained structural damage to the centre of the vertical-lift span (see Photo 5). There was also

Photo 5. Damage to Bridge 11. (Photograph by Thorold Fire Department)

damage at the extremities of the span as a result of lateral movement caused by the striking.

Other than minor adjustments on the wire ropes which operate the bridge, there was no damage, mechanical or electrical, to the bridge's systems.

Repairs to the bridge were carried out while the vertical-lift span was in the fully-raised position to permit vessel traffic to transit the canal. Upon inspection by SLSMC engineers, the bridge reopened to vehicular traffic on 16 November 2001.

1.10.3 Damage to the Environment

There was no damage to the environment.

1.11 Certification

1.11.1 Vessel Certification

The vessel was issued certificates appropriate for the vessel type and geographic area of operation.

1.11.2 Bridge Certification

The inspection of the bridge was carried out by SLSMC engineers. There is no requirement for a certificate to be issued.

1.11.3 Personnel Certification

Crew qualifications were valid and conformed with regulatory requirements.

There is no regulatory requirement for the operator of a lift bridge to be certified. The operator had received on-the-job training on bridge operation.

1.12 Personnel History

1.12.1 Master

The master's command experience began in 1981. He had worked for several shipping companies and joined N. M. Paterson & Sons Ltd. in 1989. He sailed as master on board the *Paterson* for five years and was a relief master for the *Windoc*, where he was assigned as master in 2000. He rejoined the vessel in June 2001, where he had been up to the time of the occurrence.

1.12.2 Bridge Operator

In 1979, the bridge operator began working for SLSMC as a labourer. In 1985, he sustained a back injury and was assigned to light work duty in 1987. By 1989, he had received two weeks' training on operating a bridge and worked as a bridge operator. From 1991 to 1995, he worked as a lock operator. In 1995, he was re-assigned as a bridge operator. He worked the last four years prior to the date of the occurrence as an operator for Bridge 11.

The operator experienced a number of recurrences of his back condition since the 1985 injury, leading to absences in 1988, 1990, 1993 and 1994. He received medication for his back condition which included Tylenol III, Darvon-N, and other narcotic analgesics. The operator had changed doctors in 1998 and had not received prescriptions for such medication since that time. The Darvon-N taken on the morning of the occurrence was from a prescription dating back to 1997. The operator indicated that until that morning, he had not used Darvon-N for a considerable period of time, although he was occasionally taking anti-stress (Ativan) and pain (mefenamic acid) medication prescribed for his spouse. Both medications were kept in his locker in the operator's control room on the bridge.

1.13 The St. Lawrence Seaway

1.13.1 St. Lawrence Seaway System

The St. Lawrence Seaway opened to deep-draught navigation in 1959 and is one of the world's largest waterway transportation systems. The Seaway provides ocean-going vessels access to ports west of the Port of Montréal and within the Great Lakes. Vessels up to 225.5 m in length and a draught of 8.0 m are permitted to transit the Seaway. On average, it takes approximately eight to nine days to sail from western Lake Superior to the Atlantic Ocean, approximately 3700 km. The average operating season is from March to December.

Access between Lake Ontario and Lake Erie is provided via the Welland Canal which is orientated north-south and is 43.4 km long. The navigable channel is 106.7 m wide and 9.1 m deep. There are eight locks, which provide a total lift of 99.5 m, and 10 bridges—either vertical-lift or bascule—which cater to vehicular and rail traffic. The height restriction for transiting vessels is 35.5 m. In 1999, 3626 vessels transited the canal.

1.13.2 St. Lawrence Seaway Management Corporation

The St. Lawrence Seaway Authority (SLSA), a Crown corporation, was responsible for Canadian operations of the Seaway. The Authority was established in 1954 by an Act of Parliament to acquire lands and bridges for and to construct, operate and maintain a deep draught waterway between the Port of Montréal and Lake Erie. On 01 October 1998, following commercialization of the Seaway, responsibility for Canadian operations and Seaway structure maintenance was transferred from SLSA to SLSMC, a not-for-profit corporation of Seaway users and other interested parties. The transfer of responsibility was pursuant to the *Canada Marine Act* and a 20-year renewable agreement with the Government of Canada. Under the agreement, the Government of Canada retains ownership of non-movable assets and the SLMSC submits a five-year asset renewal plan. Full-time Seaway staff was reduced from 794 in 1998 to 619 at the end of the 2001 navigation season. Transport Canada (TC) retains regulatory authority for the Seaway.

1.13.3 Niagara Region Management

SLSMC, Niagara Region, is responsible for overall operations and maintenance of the canal which is divided into three geographic areas of operation: north, central and south. The occurrence took place in the south area.

An operations management team—comprised of area managers, a marine services manager, and marine and area coordinators—is responsible for supporting operations and vessel traffic management in the canal. (In the southern area of operation, the area manager was also the marine services manager.)

To manage field operations, each geographic area of operation has a marine coordinator and an area coordinator. The marine coordinator is responsible for vessel traffic operations and the traffic controllers; the area coordinator is responsible for general maintenance and bridge operators. Hours of work for the marine coordinator and the area coordinator are from 0700 to 1900 and from 0800 to 1600, respectively. Between 1900 and 0700, only one marine coordinator is on duty for all three geographic areas of operation.

Employee schedules are organized into four shifts; each shift has a team leader who reports to the area coordinator and assign tasks to employees within their teams. The team leader in the south area is also responsible for asking employees to work overtime.

1.14 Weather and Current

At the time of the occurrence, in quickly approaching twilight conditions, visibility was good; there was no precipitation and winds were light. The speed of the current under Bridge 11 was less than one knot in a northerly direction.

1.15 Lowering of Bridge Vertical-Lift Span

The vertical-lift span in the fully-raised position had a clearance height of 36.5 m above water level. While the amount of time to lower the span from the fully-raised position to the fully-seated position, a distance of 32.9 m, varies with operators, completing the operation generally takes 1.5 to 2 minutes.

The span was being lowered when it struck the vessel in way of the wheelhouse front windows, at a height of approximately 18.6 m above water level. It took between 49 and 65 seconds to lower the span 18 m. With the vessel travelling at a speed of approximately five knots, its bow would have been under or just clear of the bridge when the bridge operator began to lower the span. The approaching vessel's aft superstructure would have been visible to the bridge operator (whether seated or standing) through the south-facing control room window (see Figures 1 and 2, Photos 6 and 7).

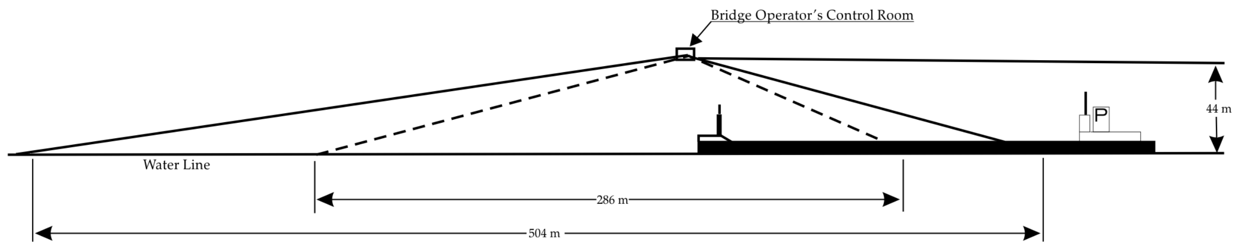

Figure 1. Diagram of a bridge operator's field of view when the bow of the vessel is under the operator's control room. Bridge is in the fully-raised position.

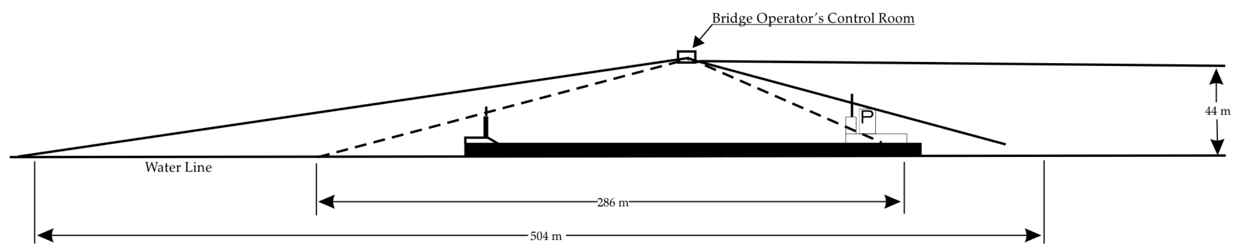

Figure 2. Diagram of a bridge operator's field of view when the vessel is amidships under the operator's control room. Bridge is in the fully raised position.

Legend for Figures 1 and 2:

The area within the straight lines (i.e. ———) represents the lower limit when the operator is seated at the control panel.

The area within the dotted lines (i.e. ------) represents the lower limit when the operator is standing at the control panel.

There was no indication of any mechanical condition that would have prevented normal operation of the bridge at the time of the occurrence. The operator who worked the previous shift reported no problems with the bridge. The operator at the time of the occurrence had raised and lowered the bridge on two occasions without incident since beginning his shift and raising the bridge for the *Windoc*.

Photo 6. Looking north from inside bridge operator control room with bridge in fully raised position (using fish-eye camera lens).

The SLSMC's operations manual for Bridge 11 states that the bridge may be lowered when it is observed that the stern of the vessel is clear of the bridge.[7] The bridge operator described having seen the stern of the vessel through the north windows of the control room (i.e. looking downstream the canal) where the door is located.

Photo 7. Looking south from inside bridge operator control room with bridge in fully raised position (using fish-eye camera lens).

[7] *Operations Manual, Bridges*, Niagara Region, March 1992.

1.16 Emergency Preparedness

1.16.1 Contingency Planning, Training, and Exercising

Pursuant to the *Emergency Preparedness Act*, federal ministers have a statutory responsibility to identify civil emergency contingencies that are within or related to the minister's area of accountability and to develop a civil emergency plan.[8] The St. Lawrence Seaway, including the canal, falls under the purview of the Minister of Transport.

At the time of the occurrence, there was no current, local-level contingency plan in place to respond to emergencies within the canal. There was a draft version of the *St. Lawrence Seaway Authority Contingency Plan for Major Failures or Accidents*, dated 21 December 1992, and a *SLSMC Regional Marine Contingency Plan*, revised March 1999; however, both plans and their appendices were not up-to-date. The draft plan for *Major Failures or Accidents* included a scenario of a vertical-lift bridge struck by a vessel, but the details of the response addressed the damaged bridge only. It did not address other possible vessel-related consequences of accidents and incidents, such as shipboard fires, evacuation, and pollution. The purpose of the *Regional Marine Contingency Plan* was to respond to discharges of dangerous, toxic or other substances on land and in waters for which the Corporation had responsibility. This included discharges from vessels within the Welland Canal.

Both plans identified a command structure for the overall response operation; however, the command structures and the predesignated individuals to assume response roles were based on the organizational structure in place at that time.

Procedures for reporting shipboard fires and the assistance to be provided by lock and bridge personnel were contained in the SLSMC's *Traffic Control Manual, Niagara Region, 2000*, and the *Lock Operations Manual*. Firefighting is conducted by local fire departments. The types of assistance to be provided were essentially focussed on directing the local fire department and authorities to the scene and ensuring that the deck of a vessel inside a lock was raised or lowered to a height that would permit evacuation of the crew.

Of those who had responded to the accident, no one from SLSMC had received extensive training on managing a response to an emergency. A few SLSMC employees received some emergency-related training but it was restricted to pollution response. In 1996, six Seaway employees participated in a half-day pollution exercise and training session at the canal with CCG. A boom deployment exercise was scheduled to be conducted at the canal in 2000 but was

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8 Section 2 of the Act defines "civil emergency plan" as a plan, measure, procedure or arrangement for dealing with an emergency by the civil population, or for dealing with a civil emergency by the Canadian Forces.

cancelled. Other boom deployment exercises were conducted in 1999, 2000 and 2001 in the Montreal-Lake Ontario section of the Seaway. A small vessel safety seminar for SLSMC employees operating small boats was provided by CCG in 1998.

There was no record of a major vessel-related emergency exercise conducted with other agencies at the canal from 1990 up to the date of the occurrence.

1.16.2 Communications and Coordination

The TCC provides a centralized communications network for day-to-day operations. Two controllers are assigned to each 12-hour shift. During emergencies, TCC controllers provide communications for coordinating emergency response activities, in addition to regular traffic management duties.

SLSMC's *Traffic Control Manual, Niagara Region, 2000*, included emergency-related information and procedures, such as actions to be taken when an accident is reported; reporting accidents; firefighting aboard vessels; vessel groundings and collisions; a standby list of SLSMC personnel available on call, and environmental pollution. During an emergency situation, controllers are responsible for providing an initial response when immediate actions are required (such as fire, police and ambulance), to obtain information relating to an emergency and to inform the appropriate coordinators. The SLSMC marine services coordinator is responsible for forwarding information to MCTS who, in turn, will notify other authorities. The marine services coordinator is normally responsible for preliminary investigation of accidents.

1.17 Possible Source of Ignition

An amateur video of the occurrence obtained by the Transportation Safety Board of Canada (TSB) shows numerous electrical arcs caused by wires being severed as a result of the impact with Bridge 11. As the funnel was torn from the engine room casing, exhaust piping from the main engine and two generators was breached, resulting in unshielded hot pipework and the release of hot exhaust gases and incandescent carbon. The hot, yet undamaged, exhaust collector piping at the main engine cylinder head level was also exposed to fuel vapour from the ruptured incinerator fuel oil tank.

1.18 Firefighting Capabilities

1.18.1 Shipboard Firefighting Capabilities

The vessel's firefighting equipment and its installation was in accordance with existing requirements. On-board equipment included the following:

- an electricity-driven main fire pump in the engine room;
- a diesel-driven emergency fire pump in the bow thruster compartment;
- an accommodation sprinkler system and dedicated sprinkler pump in the engine room;
- a fixed carbon dioxide flooding system for the engine room; and
- fire control plans located in the wheelhouse.

The partitions in the vessel's accommodation were built primarily of wood products which did not meet modern standards of structural fire protection. As a result, an extensive sprinkler system and stairwell fire doors had been installed throughout the accommodation and approved as providing an equivalent level of safety by Transport Canada Marine Safety. The sprinkler system piping was secured to combustible internal structures.

All officers and crews, including the relief crew, were trained in firefighting and marine emergency duties. However, at the time of the occurrence, eight crew members were ashore and not available for firefighting or emergency response duties.

The duplicate sets of fire control plans on board the vessel were all located within the accommodation structure and, because of the fire, were unavailable to the firefighters.

1.18.2 Shore-Based Firefighting Capabilities

Five municipal fire departments (from municipalities adjacent to Port Colborne, Welland and St. Catharines), with varying degrees of knowledge, experience and training in marine firefighting, were available in the canal area. The Thorold Fire Department, which was first to respond at the scene, had little or no experience or training in shipboard firefighting and was not equipped with suitable boats for transporting firefighters to and from the shore and the *Windoc*. The St. Catharines Fire Department was equipped with boats, and at the request of the Thorold fire chief, provided their boats for use at the scene.

Given the relatively remote location of the *Windoc*'s final position, no municipal water supply was available to help fight the fire. Pumper trucks were used to draw water from the canal for use in fighting the fire. Given the high suction head caused by the height of the canal bank, difficulties were experienced initially in establishing suction for the pump; a lesser amount of water and water pressure was available for firefighting.

1.19 *Fire Safety in Canadian Ports, Harbours and Seaway*

Since 1989, at least nine[9] major fires have occurred aboard vessels of various types and sizes across Canada, involving a response by municipal shore-based firefighters.

Occurrences involving the following three vessels are of particular interest: *H.M. Griffith*, *Ambassador*, and *Petrolab*. On 27 September 1989, while transiting the canal, the bulk carrier *H.M. Griffith* experienced a fire in the tunnel area under its No. 3 cargo hold. Post-occurrence concerns were raised, in a SLSA internal report, about communications and coordination of firefighting efforts between the vessel's crew and the municipal fire department. The report recommended that the SLSA arrange a meeting with local fire chiefs to establish procedures and clarify roles between them and municipal fire departments. At the time of the *Windoc* occurrence, no such procedure or memorandum of understanding was in place between the SLSMC and local fire departments in the canal area.

In a subsequent occurrence in December 1994, during the unloading of a cargo of rock phosphate in the Port of Belledune, New Brunswick, a fire broke out in the conveyor belt system of the bulk carrier *Ambassador*. The combined efforts of the ship's crew and several shore-based fire departments were required to bring the fire under control; it was fully extinguished some 28 hours later.

In Canadian ports and harbours, responsibility for risk assessment and emergency plans generally rests with the local port official, while firefighting is provided by the local fire department. Concerned that many municipal fire departments may not have properly trained personnel to fight shipboard fires, the Board made these three recommendations:

> The Department of Transport [should] conduct a special audit of firefighting facilities at Canadian ports and harbours under its jurisdiction to ensure that an adequate year-round capability exists to contain shipboard fires.

(M96-06, issued October 1996)

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9 *H.M. Griffith* TSB Report. 704-21-1138; *Ambassador* TSB Report No. M94M0057; *Fraser Princess* TSB Report No. M97W0035; *Sha 122* TSB Report No. M97W0044; *Petrolab* TSB Report No. M97N0099; *Western Viking* TSB Report No. M97W0194; *Southgate* TSB Report No. M98L0139; *Canadian Transport* TSB Report No. M01C0032; and *Vaasaborg* TSB Occurrence No. M01F0024.

> The Department of Transport [should], in collaboration with ports and harbour authorities, take measures to ensure that shore-based fire brigades expected to support on-board firefighting receive appropriate training.
>
> (M96-07, issued October 1996)

> The Department of Transport [should] take appropriate measures to ensure that on-board firefighting capabilities of vessels in Canadian ports and harbours are functional and readily available during cold weather operations.
>
> (M96-08, issued October 1996)

In its response, TC indicated that the Canadian Association of Fire Chiefs (CAFC) is responsible for the standards and training of shore-based fire brigades. CAFC has no jurisdiction over non-member fire departments. The majority of public harbours have only a local volunteer force to fight small fires, and their training generally does not include entering and fighting fires in restricted places. TC also indicated that, at present, there are no legislated requirements for public harbours and ports to engage in firefighting activities aboard vessels. Since 2000, TC has undertaken initiatives to improve marine firefighting at ports and harbours (see Section 4.1.4 for details).

In May 1997, CAFC forwarded a questionnaire to selected municipalities to determine their firefighting capabilities and the type and extent of assistance that could be called upon by operators of marine terminals in the event of a fire on board a vessel in port. Information provided to TSB indicated that fire departments in the canal area were not sent copies of this survey, and therefore did not have an opportunity to participate. SLSA was not notified of these initiatives in 1997. Overall, the survey did not receive wide enough distribution to provide useful information for evaluating the scope of marine firefighting experience among municipal fire departments.

On the evening of 19 July 1997, an explosion and fire occurred on board the tanker *Petrolab* at St. Barbe, Newfoundland, while the crew was washing cargo oil tanks in preparation for loading cargo. The ship's owner was killed and three crew members were injured by the explosion; one later died in hospital.[10] The ensuing fire on board subsequently spread to the government wharf. The combined efforts of two CCG vessels and several shore-based fire departments were required to bring the fire under control. Both the ship and the government wharf were destroyed before the fire was fully extinguished some 63 hours later.

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[10] TSB Report No. M97N0099.

The subsequent investigation revealed that the local fire department was not equipped with foam and had no training in fighting shipboard—in particular, oil tanker—fires. As a result, fire departments did not bring the shipboard fire under control in its early stages, and burning paint on the vessel's outer hull spread the fire to the creosote-impregnated piles of the government wharf.

Subsequent occurrences, in particular cargo fires on board the *Southgate* in 1998, and the *Vaasaborg* in 2001, further highlighted inadequacies in the efficacy of shipboard firefighting by shore-based fire departments.

1.20 Other Safety Action Concerning Safety-sensitive Positions

In the transportation industry, fitness for duty of individuals engaged in safety-sensitive positions is key to furthering safety. Canadian seafarers are required to have a medical examination at specified intervals to maintain the validity of their certificates for use at sea.[11] The *Medical Examination of Seafarers Physician's Guide* (TP 11343) sets out the factors to be taken into account in conducting medical examinations, and the physical requirements and tests to be used to establish whether a seafarer meets the requirements. A urinalysis examination is to be undertaken periodically if clinically indicated; however, it is not to be used for drug testing.

In March 1991, TSB investigated an occurrence involving a collision between an icebreaker and a fishing vessel.[12] The Board found no link between the icebreaker master's medical condition, or his medication, and the accident. Nevertheless, the Board was concerned about the lack of a formal mechanism to identify and monitor persons who are not medically fit for duty and who occupy safety-sensitive positions. In view of the lack of formal operational monitoring of a ship's crew member in a safety-sensitive position, who was on a regimen of prescribed drugs, and the lack of formal operational medical review before re-employment of a person returning to safety-sensitive duties following stress-related medical leave, the Board recommended that:

> The Department of Transport, in cooperation with Health Canada and the Canadian Coast Guard, define policies and procedures to ensure that personnel returning to safety-sensitive duties following any medical treatment are fit for those duties.

(M95-05, issued July 1995)

In response to the recommendation, CCG requires its crew members to have a medical examination in advance of certain voyages and following absences for reason of illness or injury. Those who are unfit shall not be assigned to a sea-going position until they are reassessed by a

[11] Division 8 of the *Crewing Regulations*.

[12] TSB Report No. M91C2004.

physician and found to be fit. The *Crewing Regulations*, which do not apply to CCG, were amended to provide authority to the Minister of Transport to require a re-examination of a seafarer at the request of the seafarer or the seafarer's employer.

Prior to issuing or re-validating a Canadian commercial aircraft pilot licence, the candidate must undergo an annual medical examination and be free from any effect or side effect of any prescribed or non-prescribed therapeutic medication taken.[13]

On 19 December 2001, TC announced the implementation of the *Railway Medical Rules for Positions Critical to Safe Railway Operations*.[14] These *Rules* establish a new medical assessment process and define medical fitness requirements for employees in operations critical to safety. A handbook[15] was developed to provide Canadian railway companies and medical service providers with the information necessary to implement the *Rules*. The *Railway Rules Governing Safety Critical Positions* were also developed and define "safety critical position" and the type of records to be kept by the employer in connection with employees qualified to serve in safety-sensitive positions.

In the United States, NTSB investigated two similar accidents involving light rail vehicles in the same location just six months apart. The investigation revealed that both operators in the accidents had been on medical leave for extended periods shortly before their respective accidents. Both had been prescribed medications with possible side effects that included fatigue and drowsiness. Since the investigation revealed that the authority did not require that employees occupying safety-sensitive positions report their use of prescription and over-the-counter medication before operating equipment, NTSB concluded that the authority lacked information that could have had a bearing on the condition and performance of such employees. Consequently, on 23 January 2001, NTSB issued the following recommendation (R-01-25) to the (United States) Federal Transit Authority:

> Authorize and encourage rail transit systems to require their employees in safety-sensitive positions to inform the rail transit system about their use of prescription and over-the-counter medications so that the rail system can have qualified medical personnel determine the medication's potential effects on employee performance.

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13 Standard for the issuance of a medical certificate, Section 424.17, *Canadian Aviation Regulations.*

14 Transport Canada News Release No. H158/01.

15 *Canadian Railway Medical Rules Handbook (For Positions Critical To Safe Railway Operations*), Railway Association of Canada, 01 December 2001.

The response by the Federal Transit Authority to the NTSB recommendation indicated that the Authority has taken several actions to address the recommendation, such as initiating an assistance program for the transit industry on the potential hazards of medications. Tool kits containing checklists, educational and drug contradiction reference material, were also being developed to educate transit managers, supervisors and employees.

There was no requirement, within SLSMC, for ongoing medical assessment of employees in safety-sensitive positions, nor was there a requirement for individuals in these positions to self-disclose the use of prescription medication to the employer.

2.0 Analysis

2.1 Awareness of Vessel's Position

The bridge operator did not respond to either the VHF radio call from the *Windoc* or to the ship's whistle blasts, which were intended to alert him to the fact that the ship was not clear of the bridge. It is unlikely that the operator could have heard the VHF radio transmission, given the noise level in the bridge control room when the bridge is in operation. TSB examination of the bridge control room of Bridge 21, which is very similar to that at Bridge 11, indicated that the maximum noise level experienced while the bridge is being lowered in normal operation is 92.5 decibels A scale (dBA).[16] Other operators indicated that they sometimes hear VHF transmissions while the bridge is in operation, but that it is not possible to understand the content of those transmissions. In this case, given the proximity of the whistle to the bridge, and the high pitch and decibel level of the whistle, the operator should have been able to hear the ship's whistle. Residents upstream of the bridge reported coming out of their homes to investigate the reason for the repeated whistle blasts.

Nonetheless, the bridge operator described having seen the stern of the vessel through the north windows of the control room where the door is located. If this were the case, the vessel would have been clear of the bridge at the time the bridge span was lowered. Analysis of the ship's position before and at the time of impact shows that the superstructure of the *Windoc* was clearly visible through the south windows of the control room when the operator began lowering the bridge (see section 1.15, figures 1 and 2).

2.2 Effects of Medication and Alcohol on Operator Performance

In the absence of medical testing, which was not conducted following the occurrence, it was not possible to determine exactly which substances may have affected the operator's behaviour. Assuming a normal rate of metabolism for Darvon-N, the bridge operator would have had propoxyphene and norpoxyphene in his system at the time of the accident. Without toxicological test data, specific concentrations of these substances could not be determined. Even if toxicological data were available, it may not have been possible to determine specific effects of the known substances on performance due to numerous variables which influence the speed at which an individual metabolizes these substances and the impact of the substances on an individual's performance.

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16 The Industrial Accident Prevention Association (IAPA) defines dBA as "a measurement of sound pressure that has been modified to take into account that the ear is not equally sensitive to all frequencies". *Hearing Conservation—A Health and Safety Guideline for Your Workplace*, IAPA, July 2000.

Quantitative analyses conducted by the NTSB speech analysis group were significantly affected by the lack of a definitive sample of the operator's unimpaired speech. Although sample communications from the months preceding the occurrence were submitted for examination, the speech analysis group could not ascertain that the speech contained in these samples was free of the effects of fatigue and other potential influences. Speech analysis group members observed multiple occasions throughout the baseline sample where the operator sounded less than fully alert. Therefore, changes in physical properties of the bridge operator's speech which would indicate short-term impairment by alcohol, drugs or fatigue were not observed. There were no statistically significant differences in fundamental frequency, speaking rate, latency or speech errors when speech samples from the night of the accident were compared to baseline samples taken from the months preceding the accident.

A further review by the speech analysis group focussed on the content and quality of the operator's speech on the night of the occurrence. This review revealed patterns which have been associated with performance impairment from alcohol and prescription medications. The group noted that the intelligibility of the operator's speech deteriorated between the time the operator came on duty at 1830 on the day of the occurrence and the period immediately preceding the accident. Spectrographic analysis indicated careless articulation or slurring in the communications which immediately preceded the accident to a greater degree than previous communications that evening. With reference to the operator's speech at the time of the occurrence, the speech analysis group noted:

> . . . the bridge operator's speech sounded forced and sometimes difficult to understand before the accident. Compared to earlier speech, in which the operator engaged in cordial joking with his co-workers, the operator seemed slow in thinking and his expressive tone did not always match that of the previous speakers. He twice misidentified his co-worker (with whom he had joked earlier), and seemed confused regarding the telephone difficulties and the accident itself.[17]

These observations of the operator's behaviour during the period of the occurrence suggest that the operator's performance was likely impaired when deciding to lower the vertical-lift span. The DSM IV[18] definition for substance intoxication includes "clinically significant maladaptive behavioural or psychological changes that are due to the effect of the substance on the central nervous system (e.g. belligerence, mood lability, cognitive impairment, impaired judgement,

[17] Speech Examination Study, prepared by United States National Transportation Safety Board, Washington, D.C., February 2002.

[18] *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (DSM IV). Washington, D.C.: American Psychiatric Association, 1994.

impaired social or occupational functioning)". The DSM IV criteria for alcohol intoxication are similar with the addition of any one or more of the following signs: slurred speech, uncoordination, unsteady gait, nystagmus, impairment in attention or memory, stupor, or coma.

As revealed by the recorded communication, in the period surrounding the accident, the operator's confusion, slurred speech, impaired memory, and lack of appreciation for the seriousness of the event are consistent with substance and/or alcohol intoxication. Comments made by TCC controllers following their conversation with the bridge operator indicate that they may have entertained this possibility. Therefore, it is likely that the operator's performance was impaired while the bridge span was lowered onto the *Windoc*.

2.3 *Fitness for Duty for Safety-sensitive Positions*

It is imperative that persons, assigned to positions where their actions can have a major impact on the safety of persons, property, or the environment, are fit for the tasks to be performed. Safety-sensitive positions were not identified or defined, since SLSMC considered all operations and maintenance positions to be safety-sensitive, given the nature of their work. However, the system did not ensure that individuals occupying such positions were competent and fit for duty.

At the time of the occurrence, new employees hired by SLSMC were given a pre-employment medical examination, which included a standard medical history and a physiotherapy assessment. Following this medical examination, permanent employees were not reassessed periodically unless there was specific reason to do so, such as an employee returning to work following a workplace injury when employees were required to have a medical certificate from the doctor. The decision regarding fitness for duty was taken by a physician contracted to SLSMC following a clinical evaluation of available information. If SLSMC was not satisfied with information provided by the employee's attending physician that the employee was fit for duty, then the employee could be sent to a company-appointed physician for a medical.

Disclosure of current medication in these instances was at the discretion of the employee. Although there was no impediment for the employer to ask about medication, neither was there any requirement for the employee to disclose medication. The possible impact of medication on an employee's performance was considered when the decision was taken to allow the employee to return to work. To ensure privacy, and in keeping with the human rights legislation on the disclosure of personal information, this information was maintained by the occupational health nurse. Coordinators and managers were informed when an employee is able to return to work and of any restrictions on his or her abilities, but they would not be made aware of specific medical conditions or medication an employee may be taking. These procedures were identical for all positions throughout SLSMC.

The operator involved in this occurrence had a history of chronic back pain stemming from a work-related injury in 1985. This condition resulted in repeated absences from work and was treated with rest and analgesics, including Darvon-N and other narcotics. SLSMC's medical documentation concerning the bridge operator contained no record of the operator taking Darvon-N.

Darvon-N affects the central nervous system and as such, patients are cautioned that the medication may impair mental or physical abilities required for the performance of potentially hazardous tasks such as operating a motor vehicle or machinery. It would be unusual for an occupational physician to approve an individual who is taking Darvon-N regularly for occupying a safety-sensitive position. However, in order to make an accurate assessment, the physician would need to be made aware of both the medication being taken and the safety-sensitive nature of the work to be performed. Without a requirement to disclose medication and a system for identifying safety-sensitive job functions, the physician would be unlikely to make an informed assessment. The regime in place for monitoring the medical fitness of employees, particularly those in safety-sensitive positions, was therefore less than adequate.

2.4 *Employee Supervision*

The bridge operator represents the sole line of defence for ensuring that the area below the bridge is clear of vessel traffic before the bridge is lowered. Training and supervision of bridge operators is therefore important for ensuring safety in the bridged areas of the St. Lawrence Seaway.

Employees normally become bridge operators after acquiring sufficient seniority to receive training, which was largely conducted on the job with an experienced bridge operator. Prior to becoming fully qualified as a bridge operator, an employee must complete a written test on normal and emergency modes of bridge operation and be observed operating the bridge in its various modes by a coordinator. Once qualified to operate the bridge, there is no requirement for recurrent training or requalification. An employee normally works as a relief bridge operator until enough seniority is gained to occupy the bridge operator position on a full-time basis. Significant time may pass between the point employees qualify to operate the bridge and the time they occupy the position.

Once occupying the position, bridge operators work 12-hour shifts alone on the bridge. Their only interaction is by telephone or VHF radiotelephone with the TCC and in person with coordinators during visits to the bridge. There was no requirement for coordinators to see the bridge in operation during their visits, and they would not normally visit at night unless there was a specific problem.

Given these practices, there was little opportunity for coordinators and managers to observe specific employees for competence and fitness for duty. If an employee were experiencing difficulties at work, it would have been difficult for a coordinator/manager to detect them.

There are few formal procedures for monitoring performance and safety between peers. Shift handovers on the bridges are informal. The lack of a specific procedure for shift handover means there is little opportunity for bridge operators to observe the fitness of individuals replacing them.

TCC controllers have frequent verbal interaction with bridge operators; however, on the night of the occurrence, the controllers on duty did not inform anyone of their concerns with respect to the bridge operator or take any action to ensure he was fit to continue working.

In summary, bridge operators spend a significant amount of time working alone, and there was little opportunity for management to ensure operators can consistently perform their job functions in an appropriate and safe manner.

2.5 Shipboard and Municipal Firefighting Capabilities

Because of the speed at which a shipboard fire can spread, it is critical that a fire be contained as soon as it is discovered. Once the initial air/fuel vapour explosion occurred in the upper engine room casing and boat deck of the *Windoc*, the immediate supply of fuel for the fire was limited. Videotape recordings of the occurrence show that the firefighting response by the ship's crew was effective in containing and reducing the fire burning on the boat deck.

The master, fearing an engine room fuel oil day tank explosion and observing municipal firefighters arriving on the adjacent canal bank, withdrew the shipboard fire teams to a safe position forward of the accommodation superstructure. The shore-based firefighters, however, were not equipped with boats to safely access the *Windoc* where it lay just offshore.

Although shipboard hoses were left directed to contain the fire, attempts to extinguish it were delayed for several hours while shore-based fire crews obtained suitable boats and boarded the vessel, resulting in the fire spreading to the flammable internal structure of the accommodation.

To ensure watertight integrity in adverse weather, openings in vessels can be closed and secured. These same features, such as watertight doors and ventilation dampers, also ensure that the vessel can be rendered airtight in the event of a fire. As a result of initial firefighting and prompt actions by the *Windoc*'s crew to close dampers and watertight/fire doors, the fire was limited to the engine room casing and aftermost area of the accommodation when municipal firefighting teams boarded at 0130 on 12 August 1999.

The municipal fire department's arrival on scene was timely; however, once on scene, crews were confronted with a situation for which conventional shore-based firefighting training had not prepared them. Due to the watertight integrity of the accommodation structure, water applied to the vessel from the shore-side aerial ladder truck had little effect on the fire, beyond its use as peripheral boundary cooling. Once on board, the shore-based firefighting team was reluctant to enter the burning accommodation. They did not appreciate that the fire was partly contained by the airtight integrity accorded by sealed dampers and watertight doors. Based on the shore-based firefighters' training and experience, opening watertight doors to ventilate smoke from the vessel may have seemed an appropriate tactic; in fact such actions allowed fresh air to reach the smouldering fire and caused the fire to rapidly spread forward through the accommodation superstructure. The responding fire department's lack of training and experience for fighting shipboard fires and the unavailability of equipment to access the vessel hindered firefighting response.

The vessel had more than one set of fire-fighting plans on board. As all copies of the plans were located within the aft superstructure, they became inaccessible at the time of the fire. A fire control plan generally includes information on the location of various fire sections, sprinkler systems, fire extinguishing appliances (e.g. fire hydrants, fire hoses, international shore coupling, etc), ventilation system, and the means of access to different compartments. Information contained in such a plan is essential to make informed decisions to effectively and efficiently fight fires; time is of the essence. Good seamanship practices dictate that a set of fire control plans be stored in a weather-tight container outside the deckhouse to assist shore-side firefighting personnel. The benefit of such a practice has been recognized by the International Maritime Organization (IMO) and is reflected in Chapter II-2, Regulation 20 of the *International Convention for the Safety of Life at Sea* (SOLAS) and Maritime Safety Committee Circular 451 (MSC/Circ.451) *Guidance Concerning the Location of Fire Control Plans for Assistance of Shoreside Fire-fighting Personnel* and also by TC in the regulations that apply to convention vessels. In spite of the safety benefits associated with such a requirement, Canadian non-convention vessels such as the *Windoc* are not given the same consideration.

Provision of a fixed accommodation sprinkler system on board older vessels is intended to provide an equivalent level of safety for those vessels whose internal accommodation structures and partitions are comprised of combustible material. The effectiveness of such systems however can be compromised if the pipework is attached structurally to combustible surfaces. Post fire examination of the *Windoc* disclosed that the sprinkler system piping had been attached to combustible components of the accommodation which, once burnt, allowed the pipework to collapse, rendering the system ineffective when it was activated.

2.6 Emergency Preparedness

Planning, training and exercising at the local level is the most effective means for preparing to respond to emergency situations. Strategies that facilitate an appropriate and measured response to an emergency situation should be documented in a contingency plan for the benefit of those involved in emergency response. Response action decisions need to be made and documented before an emergency occurs. Preparedness can be further enhanced by provision of training and periodic exercises, which help identify shortfalls in the plan. Training ensures that personnel are prepared to respond. Exercises test decisions and improve overall preparedness.

In general, there are five phases of emergency response:

- alert and notify personnel, resources and authorities;
- evaluate the incident and mobilize personnel and resources;
- conduct response operations;
- terminate the response; and
- debrief personnel to evaluate the response.

These phases should be detailed in a contingency plan. In actual practice, these phases often overlap while responding to an emergency. Difficulties and shortcomings were noted in connection with the emergency preparedness of SLSMC, Thorold and St. Catharines fire departments and ambulance services.

2.6.1 St. Lawrence Seaway Management Corporation

SLSMC contingency plans in place for responding to vessel-related emergencies within the canal were inadequate and outdated.[19] They were neither used at the time of the accident nor made available to personnel, some of whom were not aware of their existence.

Early communication of key information is paramount to emergency services, particularly when responding to threats to life and property and in connection with a need to evacuate an area. Approximately three minutes after Bridge 11 struck the *Windoc*, TCC controllers began to field calls from police, fire department and ambulance services for information about the accident. The TCC controllers, who had already spoken with the Bridge 11 operator and were aware that the bridge was lowered onto the vessel, only disclosed some of the information they had at the

[19] *St. Lawrence Seaway Authority Contingency Plan for Major Failures or Accidents*, 21 December 1992. Operations Memorandum No. 10, *SLSMC Regional Marine Contingency Plan*, Revised March 1999.

time. Information concerning the well-being of the bridge operator was not communicated to emergency services. Furthermore, information about the vessel and its cargo was not made available until it was requested by the fire department.

SLSMC cameras did not provide controllers with a clear view of the vessel and the bridge, and controllers did not request information from emergency services or SLSMC personnel who were on scene. Consequently, those responders who were in contact with the TCC controllers and en route to the accident site were not provided details about the accident and were unable to prepare themselves in advance of their arrival. Information about the condition and location of the vessel would have assisted the coordination of the emergency services and SLSMC personnel.

Communication protocols and call-out or notification lists were not in place to assist TCC controllers in alerting emergency response organizations and services. A standby list for 10-17 August 2001 was in place and available to TCC controllers. The list included SLSMC personnel only and primarily identified personnel available to respond to day-to-day operational matters. The *Traffic Control Manual, Niagara Region, 2000*, included information on reporting an accident or incident. TCC controllers forward information about an accident or incident to the marine services coordinator who, in turn, is to provide this information to CCG.

The authorities—TC, CCG, Ontario MoE’s SAC, Environment Canada (EC) and TSB—were not immediately notified of the accident. Excluding TSB, authorities became aware of the accident as a result of media enquiries approximately one hour after the striking. When authorities called the TCC for additional information, controllers again provided little of the information that was available. This delay in communicating with authorities increased the risk of injuries to persons and damage to property and the environment.

The availability and timely deployment of containment booms are critical to minimizing environmental damage caused by the release of pollutants onto the water. In this occurrence, it took six hours to locate and deploy an oil containment boom. The lack of pre-accident arrangements for acquiring oil response equipment further increased the risk of injury to persons and damage to property and the environment.

Exercises conducted in 1996 and the boom deployment exercises were limited in scope and such that the appropriateness and measured response of multiple agencies to an emergency could not be adequately assessed. This is reflected in the absence of an appropriate, current contingency plan for responding to vessel-related emergencies and the lack of emergency-related training of SLSMC personnel, all of which contributed to difficulties experienced in responding to the accident.

In essence, SLSMC’s overall response to the accident was conducted in an ad hoc manner, hampering coordination and deployment of response personnel and equipment.

2.6.2 *Effective Use of Available Firefighting Resources*

Shipboard fires are infrequent in most jurisdictions; many municipal fire departments have not had an opportunity to respond to such an emergency. When called upon to deploy to a shipboard fire, prior familiarization with vessels and the nature of shipboard fires is therefore vital. Also, emergency response centres should be aware of the capabilities and experience of the response units they dispatch.

Bridge 11 lies within the jurisdiction of the Thorold Fire Department—the only fire department within the canal area which did not have shipboard firefighting experience or training.

Common practice in shore-based fire response dictates that the first fire department to arrive on scene assumes overall command of the response. It is incumbent upon the department to closely examine the situation vis-à-vis its own knowledge, experience and capabilities and to request further assistance when necessary. Other than a request for boats, no assistance was requested of nearby, more experienced fire departments. As a result, available firefighting resources in the canal area were not effectively utilized to contain and extinguish the fire in time to prevent the vessel's accommodation from being destroyed.

2.6.3 *Vessel Communications with Seaway and/or Bridge 11*

In the case of a problem with Seaway operations, direct, clear and timely communications represent a defence to ensure safety. In a radio call, intended to alert the TCC to the bridge being lowered, the master of the *Windoc* did not identify himself or the bridge in question. However, he was in the wheelhouse of a vessel rapidly approaching a bridge being lowered towards him and wished to convey warnings as quickly as possible. Even if standard radio communications procedures were followed, it is unlikely that the bridge operator would have been alerted. Machinery noise levels on vertical-lift bridges in the canal are such that VHF radio communications cannot be effectively monitored by bridge operators.

3.0 Conclusions

3.1 Findings as to Causes and Contributing Factors

1. The approaching *Windoc* was visible from the control room at the time the bridge operator started lowering the bridge.

2. It is likely that the operator's performance was impaired at the time of the occurrence.

3. Safety-sensitive positions were not identified or defined within SLSMC and the system in place to ensure that individuals occupying those positions were competent and fit for duty was inadequate.

4. SLSMC's response to the accident was conducted in an ad hoc manner, which hampered coordination and deployment of response personnel and equipment.

5. The responding fire department's lack of training and experience for fighting shipboard fires, the lack of equipment to access the vessel, and the non-accessibility of fire control plans hindered an effective firefighting response.

6. Available firefighting resources in the Welland Canal area were not effectively utilized to contain and extinguish the fire in time to prevent the vessel's accommodation from being destroyed.

3.2 Findings as to Risk

1. The SLSMC regime in place for monitoring the medical fitness of employees, particularly those in safety-sensitive positions, was less than adequate.

2. The bridge operator represented the sole line of defence for ensuring the area below the bridge is clear of vessel traffic before the bridge is lowered.

3. Bridge operators spend a significant amount of time working alone, and there was little opportunity for management to ensure they can consistently perform their job functions in an appropriate and safe manner.

4. Machinery noise levels on vertical-lift bridges in the Welland Canal are such that bridge operators cannot effectively monitor VHF emergency communications when the lift span is in motion.

5. The sprinkler system installed on the *Windoc* was rendered ineffective when the combustible structures supporting it burned, causing the pipework to collapse.

4.0 Safety Action

4.1 Action Taken

4.1.1 Advisory on Medical Fitness of Employees

In November 2001, TSB sent Marine Safety Advisory (MSA) No. 08-01 to SLSMC advising them of the less-than-adequate regime in place for monitoring the medical fitness of SLSMC employees, particularly those in safety-sensitive positions.

In response, SLSMC took the following steps:

- a draft policy on drug and alcohol procedures, including testing, has been prepared;
- a new *Attendance Management Program*, a *Code of Conduct* and a *Code of Discipline* have been implemented to provide employees with management's expectations and a process for corrective actions; and
- the corporate sick leave procedure with respect to submitting documentation has been modified.

In addition, SLSMC is currently:

- identifying safety-sensitive positions; and
- considering retaining the services of an occupational health physician.

4.1.2 Advisory on Emergency Preparedness

In January 2002, TSB sent MSA No. 02-02 to SLSMC concerning the adequacy of their emergency preparedness for responding to vessel-related emergencies within the Seaway.

In response, SLSMC established an emergency planning committee. The committee will be responsible for completing the following by December 2002:

- development of a SLSMC emergency preparedness policy;
- review and update existing contingency plans;
- coordinate plans with external agencies;
- identify and develop training programs;
- develop training exercises; and
- promote emergency preparedness.

Upon completion of the above work, the emergency planning committee will be responsible for updating the plans and monitoring exercises. The committee will also be responsible for reporting its progress annually to the SLSMC management committee.

On 29 May 2002 an emergency preparedness policy had been developed. One SLSMC employee has since received training in exercise design.

4.1.3 Advisory on Supervision of Bridge Operators

In February 2002, TSB sent MSA No. 03-02 to SLSMC concerning the adequacy of supervision of bridge operators to ensure that they can consistently perform their job functions in an appropriate and safe manner.

In response, the Corporation restructured its operations, effective with the opening of the 2002 navigation season. Four new shift supervisor positions have been created to supervise operational staff, including bridge operators, in the Welland Canal. Shift supervisors must also visit the operator at every bridge on every shift. Shift supervisors report to the area manager who, in turn, reports directly to the vice president, Niagara Region.

An initiative is underway to control bridge operations remotely from an operations centre, where additional supervision of the operators can be provided.

SLSMC will also implement procedures for the verbal handover at the end of a shift between bridge operators.

4.1.4 Advisory on Marine Firefighting

In March 2002, TSB sent MSA No. 05-02 to TC, noting the continuing risks posed by the disparities in the readiness of shore-based firefighters to respond to shipboard fires. The advisory further suggested that TC, in cooperation with federal, provincial and municipal agencies, may wish to take further action to ensure that firefighters located in municipalities contiguous to port and seaway facilities in Canada are trained and equipped to effectively respond to shipboard fires.

In response, TC indicated the following initiatives it had taken since 2000:

- TC made available 77 international shore connectors for use by local fire departments in three (Atlantic, Ontario, and Pacific) of the five regions. In the Quebec Region, there are 12 locations where connectors are available for use by firefighters.

- Four regions (Atlantic, Quebec, Ontario and Pacific) implemented measures to put into place emergency plans at selected ports and port facilities. There are 49 emergency plans in place at public ports and public port facilities.

- Awareness sessions were given in four regions (Atlantic, Quebec, Ontario and Pacific) for firefighters who may be called to respond to a shipboard fire at a public port. The sessions provided information, for discussion purposes, on dealing with shipboard fires. A total of 37 sessions were held at 31 ports and communities and 1023 persons attended.

At an October 2002 meeting of the operational group of the Association of Canadian Port Authorities held in Prince Rupert, British Columbia, a presentation highlighted that serious shipboard fires are possible, that municipal crews are untrained, and there is a need for pre-incident coordination.

4.1.5 Municipal Fire Departments/SLSMC Firefighting Initiatives

Following this accident, fire departments for four municipalities (including the Thorold Fire Department) along the Welland Canal established two regional committees to examine firefighting capabilities. One committee addresses the issue of fire fighting equipment for response to shipboard fires. The other addresses training issues, including training related to the United States National Fire Protection Association guidelines for marine firefighting, and standard operating procedures. Both committees have held meetings over the past year and have met with SLSMC and some shipping companies.

The Thorold Fire Department has begun a program of visiting vessels which are laid up in the Welland Canal during the winter months, in order to familiarize themselves with shipboard environments. There are also plans to visit vessels transiting the Seaway.

4.1.6 Changes in Communication Procedures

Effective 01 May 2002, SLSMC introduced new communication procedures for all free-standing bridges between Montreal and Port Colborne. The bridge operator will now make a VHF radio call on the normal working channel to the last vessel through the bridge draw, immediately prior to initiating the bridge lowering / closing sequence. The burden to respond, in the event of a problem, lies with the vessel.

4.2 *Action Required*

4.2.1 *Fitness for Duty and Employee Supervision in Safety-sensitive Positions*

The Board acknowledges that SLSMC has expressed positive intentions in response to safety deficiencies raised throughout this investigation. In response to MSA No 08-01 dealing with medical fitness of employees, SLSMC outlined a number of steps including identifying safety-sensitive positions, drafting a new policy on alcohol and drug testing and updating attendance and sick leave procedures. In response to MSA No 03-02, dealing with supervision of bridge operators, SLSMC indicated they had increased the number of supervisory positions, and implemented new procedures for shift handover and communication between vessels and structures. However, the Board is concerned by SLSMC's philosophy toward the issue of ensuring fitness for duty which was outlined subsequent to these safety communications. The position adopted by SLSMC with respect to fitness for duty is as follows:

- all operating positions (operations and maintenance) are deemed to be safety-sensitive positions;

- individuals are deemed to be fit in accordance with the selection process, medical pre-employment and other procedures agreed with the Union;

- fitness for duty is a decision made by a contract physician following a clinical evaluation and information made available by the employee to the employer; and

- the regime in place for monitoring the medical fitness of employees was in line with the Human Rights Act on the disclosure of personal information.

These policies, in combination, provide limited opportunity and responsibility for peers, supervisors and managers to identify and deal with employees whose fitness for duty may be compromised for any reason. While it is likely that the regime in place for monitoring medical fitness of employees is not in contravention of the *Canadian Human Rights Act*, the legislation may permit greater monitoring than is currently exercised by SLSMC.

In June 2002, the Canadian Human Rights Commission issued its *Policy on Alcohol and Drug Testing*. The underlying philosophy is one of detection and prevention of workplace impairment of all sorts. In particular, it states:

> "There are many causes of employee impairment besides alcohol and drug use that jeopardize workplace safety, such as fatigue, stress, anxiety and personal problems. The Commission encourages employers to adopt programs and policies that focus on methods of detection of impairment

> and safety risks, and that are remedial rather than punitive in nature. These would include employee assistance programs, enhanced supervision and observation, and positive peer reporting systems, which focus on rehabilitation rather than punishment. Testing should be limited to determining actual impairment of an employee's ability to perform or fulfill the essential duties or requirements of the job."

In implementing such a philosophy, the employer has some latitude, particularly where positions are deemed to be "safety sensitive." For the purposes of the policy: "a safety-sensitive job is one in which incapacity due to drug or alcohol impairment could result in direct and significant risk of injury to the employee, others or the environment."

For example, recent cases before the courts have clarified that mandatory disclosure of previous or current alcohol or drug abuse is permissible under the Canadian Human Rights Code for safety-sensitive positions. It is also conceivable that such mandatory disclosure of the use of prescription medication could be justified as a Bona Fide Occupational Requirement under section 15 of the Act, providing reasonable accommodation is considered for affected individuals. The Act also allows for "reasonable cause" or "post-incident" testing for either alcohol or drugs in safety-sensitive environments in certain circumstances (i.e. where the testing is part of a broader program of medical assessment, monitoring and support).

Therefore, given the limited opportunities for SLSMC management to identify employees who may be experiencing personal problems which could affect their fitness for duty, SLSMC should review their supervision and monitoring with respect to fitness for duty to the full extent permissible under human rights legislation. The Board therefore recommends that:

> The St. Lawrence Seaway Management Corporation reassess and clearly identify safety-sensitive positions in their organization in which incapacity due to impairment could result in direct and significant risk of injury to the employee, others or the environment.

M02-01

and that:

> The St. Lawrence Seaway Management Corporation establish programs and policies which are pro-active and promote early detection of impairment and safety risk of employees occupying safety-sensitive positions by management, supervisors or peers and which provide an effective mechanism for remedial action.

M02-02

4.2.2 *Emergency Preparedness*

Decisions about response actions need to be made before an emergency occurs and documented in a contingency plan for the benefit of those who may be involved in the response. However, periodic exercising of the plan is critical to evaluate the state of preparedness. Exercises provide plan holders with feedback on the effectiveness of the plan (and their response system); lessons learned can be applied to improve both the plan and training of response personnel. Typically, a response to a major vessel-related emergency involves various agencies and organizations, each of which requires coordination and integration within the overall response.

In response to this accident, SLSMC established an emergency planning committee which will be responsible for, *inter alia*, coordination of its contingency plan with external agencies, and the development of training programs and exercises. This ongoing work is expected to be completed by year end. An emergency preparedness policy has been developed; one of its guiding principles is the strengthening of co-ordination with external response agencies.

Ongoing work by SLSMC concerning its preparedness for responding to vessel-related emergencies is noted by the Board. However, the Board is concerned that there has been no indication from the Corporation that it will undertake a multi-agency, vessel-related emergency response exercise. Such exercises are necessary to evaluate preparedness for responding to a major emergency. Other agencies have conducted similar exercises within the St. Lawrence River and Great Lakes, but there has been limited participation by SLSMC. It is also noted that the Saint Lawrence Seaway Development Corporation, an American government corporation responsible for the operation of the Seaway within the territorial limits of the United States, has, since 1992, participated in or hosted annual vessel-related emergency exercises involving their local, state and federal agencies.

During the 1999-2000 navigation season there were 3141 vessel transits through the Welland Canal, including petroleum and chemical product carriers. Vessel-related emergencies occurring in close proximity to populated areas situated along the Seaway, including the Welland Canal, may pose a risk to the safety of the population in those areas. Consequently, such emergencies present unique challenges for responders in which a coordinated and integrated response among responding agencies is necessary. No major vessel-related emergency response exercise involving other agencies has been conducted within the Welland Canal. Given that risks associated with an improperly coordinated response are higher than that associated with a fully-coordinated response, the Board therefore, recommends that:

> The St. Lawrence Seaway Management Corporation conduct, in collaboration with the other appropriate authorities and organizations, exercises to respond to vessel-related emergencies which may be

> encountered within the Seaway, including the Welland Canal, in order to evaluate the preparedness for responding to a major vessel-related emergency.

M02-03

Following commercialization of the Seaway in which SLSMC is responsible for Canadian operations, there has been little, if any, oversight provided by TC to ensure that emergency plans, training and exercises were in place and adequate to respond to vessel-related emergencies. Although the Corporation is responsible for Seaway operations, TC retains regulatory authority and is responsible to ensure that arrangements are in place for dealing with vessel-related emergencies within the Seaway. The Board therefore recommends that:

> The Department of Transport ensure that overall preparedness is appropriate for responding to vessel-related emergencies within the Seaway.

M02-04

4.2.3 *Bridge Defences Against Inadvertent Lowering*

A 1982 study by TC, titled *Vulnerability of Bridges in Canadian Waters*, recognized that lift span or swing bridges over narrow waterways are statistically more prone to collision with vessels. The study reported, *inter alia*, that:

> In considering the bridge characteristics, it is necessary to look at the operational aspects as well as the physical and structural factors, all of which must be viewed in the context of the total bridge environment.

The operation of any SLSMC lift bridge involves close interaction between the operator, TCC personnel, the bridge, and its equipment; and, that diligence and situational awareness of the bridge operator be uncompromised. However this investigation has identified deficiencies involving the performance of the bridge operator, and management oversight associated with the operation of Bridge 11 on the night of the occurrence. These deficiencies included the following:

- the SLSMC regime in place for monitoring the medical fitness of employees, particularly those in safety-sensitive positions, was less than adequate;
- safety-sensitive positions were not identified or defined within SLSMC and the monitoring system in place was inadequate to ensure that individuals occupying those positions were competent and fit for duty;

- bridge operators spent a significant amount of time working alone, and there was little opportunity for management to ensure that they can consistently perform their job functions in an appropriate and safe manner; and

- it is likely that the bridge operator's performance was impaired at the time of the occurrence.

In the circumstances which existed at Bridge 11 on the evening of the occurrence, a bridge operator working alone did not represent an adequate defence against the inadvertent lowering of the lift span on to passing vessels. Suitable backup arrangements are therefore essential to prevent the bridge from being lowered inadvertently.

A consultant, hired by SLSMC to review potential physical defences against premature closing of bridges, indicated that such technical arrangements are not in widespread use throughout North America. TSB notes that, whereas Welland Canal bridges operated from a remote location are extensively monitored by video cameras, the camera monitoring of Bridge 11 was not adequate to allow TCC personnel to effectively monitor the bridge environment. Additionally, TSB has determined that infrared technology, to detect the presence of vessels in the proximity of bridges, is in use on some lift bridges under the jurisdiction of the United States Coast Guard.

As a result of this occurrence, SLSMC has restructured its operations and created additional supervisory positions, implemented procedural changes requiring shift supervisors to visit each bridge on every shift, and modified communication procedures between bridge operators and vessels. Additionally, a long term program has been initiated to automate bridges in the Welland Canal area. The Board is encouraged; measures taken by SLSMC are positive steps towards correcting procedural and supervisory deficiencies noted in the report. The Board notes however that, in the absence of effective backup monitoring systems, the competence of the bridge operator continues to be the sole line of defence against the inadvertent lowering of the span onto a vessel. The Board therefore recommends that:

> The St. Lawrence Seaway Management Corporation ensure that physical and administrative defences are in place to ensure that Seaway bridges are prevented from coming into contact with transiting vessels.

M02-05

4.3 Safety Concerns

4.3.1 Accessibility of Fire Control Plans

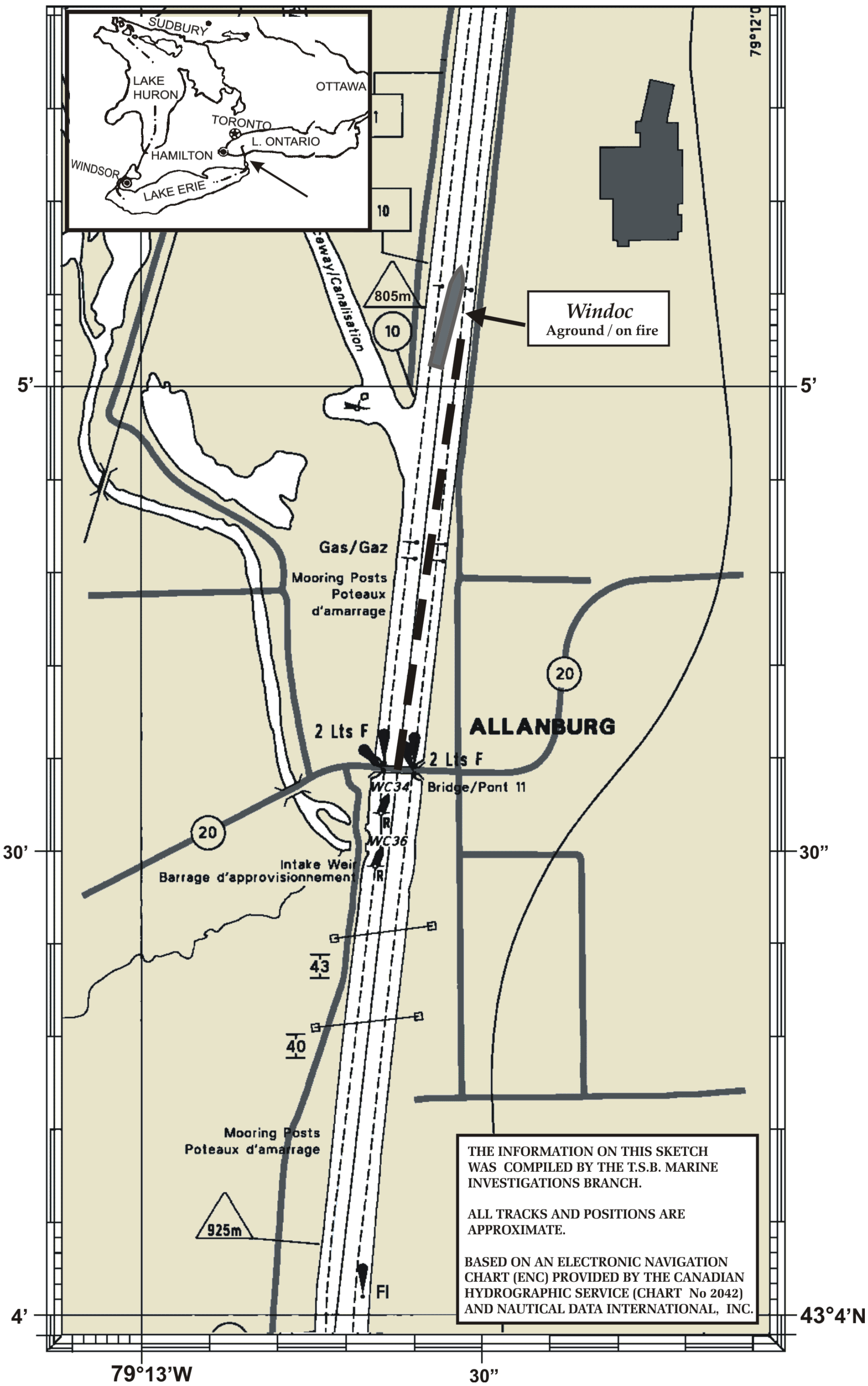
Without readily available fire plans, shore-based fire departments, whose knowledge of the shipboard environment may already be limited, do not have access to information on the disposition of the vessel's fire fighting equipment. The Board notes that TC is conducting a review of the *Fire Detection and Extinguishing Equipment Regulations*. However, the Board is concerned that, in the interim, without a requirement for such plans to be stored in a location outside the deckhouse on Canadian non-convention vessels, inaccessibility of the ship's fire control plans may continue to hinder the firefighting capability of municipal fire departments, thereby increasing the risk of personnel injury and damage to property.

4.3.2 Installation of Sprinkler Systems

Examination of the sprinkler system on the *Windoc* subsequent to the occurrence indicated that pipework had been secured to wooden structures. Once the fire destroyed the wooden components of the accommodation, the unsupported sprinkler pipework collapsed, rendering it unserviceable. Subsequent to two fatal fires involving Canadian vessels in 1979 and 1981, many older Canadian flag vessels were retrofitted with such sprinkler systems throughout their accommodation structures. The Board is therefore concerned that, such other older vessels may have retrofitted sprinkler systems attached to combustible internal structures, in a manner similar to the *Windoc*, and that exposure of such systems to fires may negate their effectiveness.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 30 October 2002.

Appendix A: Sketch of the Occurrence Area



Appendix B: Glossary

A	aft
CAFC	Canadian Association of Fire Chiefs
CCG	Canadian Coast Guard
dBA	decibel(s) A scale
DSM IV	*Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*
EC	Environment Canada
EDT	eastern daylight time
F	forward
IAPA	Industrial Accident Prevention Association
IMO	International Maritime Organization
km	kilometre
kW	kilowatt
m	metre
M	nautical mile
MCTS	Marine Communication and Traffic Services
MoE	Ministry of the Environment (Ontario)
MSA	Marine Safety Advisory
MSC	Maritime Safety Committee
N	north
nm	nautical miles
NTSB	National Transportation Safety Board (United States)
SAC	Spill Action Centre
SI	International System (of units)
SLSA	St. Lawrence Seaway Authority
SLSMC	St. Lawrence Seaway Management Corporation
SLSMD	Saint Lawrence Seaway Development Corporation
SOLAS	*International Convention for the Safety of Life at Sea*
TC	Transport Canada
TCC	Traffic Control Centre
TSB	Transportation Safety Board of Canada
VHF	very high frequency
W	west
°	degree
'	minute
"	second