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

MARINE INVESTIGATION REPORT
M99W0078

STRIKING

TUG *SHEENA M* AND CHIP BARGE *RIVTOW 901*

CPR MISSION RAILWAY BRIDGE, FRASER RIVER
MISSION, BRITISH COLUMBIA
2 JUNE 1999

Canada

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

Marine Investigation Report

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Report Number M99W0078

Summary

On 2 June 1999 at about 0045 local time, the loaded chip barge *Rivtow 901*, under tow of the tug *Sheena M*, struck the Canadian Pacific Railway Mission Railway Bridge which spans the Fraser River at Mission, British Columbia.

The striking caused considerable damage to the protection pier and swing span of the bridge. Rail traffic over the bridge was interrupted until 30 June 1999.

Marine traffic through the swing span was suspended until the same date when it was made available on a limited basis. Unrestricted maritime use of the swing span was not available until 26 July 1999.

Ce rapport est également disponible en français.

Factual Information

Particulars of the Vessels

	Sheena M	***Rivtow 901***
Official Number	800064	371293
Port of Registry	Vancouver, British Columbia (B.C.)	Vancouver, B.C.
Flag	Canada	Canada
Type	Tugboat	Wood Chip Barge
Gross Tonnage	9.99[1]	860
Length	10.21 m	54.86 m
Draught	F: 0.90 m A: 2.60 m	F: 1.65 m A: 2.30 m
Built	1981, Port Alberni, B.C.	1976, Vancouver, B.C.
Propulsion	Diesel, 2 x 300 bhp	Non self-propelled
Cargo	N/A	2,100 tonnes, wood chips
Crew	2 Members	None
Owner(s)	Bayside Towing Ltd. Mission, B.C.	Rivtow Marine Ltd. Vancouver, B.C.

Description of the Vessels

Tug Sheena M

The *Sheena M* is a steel tug with the superstructure forward and a towing winch located on the centre line of the main deck behind the superstructure. Two diesel engines driving two reversible propellers constitute the propulsion system which is entirely controlled from the wheelhouse.

The towing winch on the *Sheena M* is situated on the after deck, approximately one-third of the vessel's length from the stern. The drum of the towing winch contains approximately 180 m of 250 mm diameter tow wire connected to two 220 mm diameter towing bridles, each approximately 13 m in length. The towing winch is fitted with an electric-hydraulic abort system that can be activated remotely from three locations on the vessel.

Chip Barge Rivtow 901

The *Rivtow 901* is a barge of all-welded steel construction designed for the on-deck carriage of wood chips in bulk. Steel bulwarks, 4.7 m high, set in from the port and starboard sides of the barge form an open-topped cargo box with a smooth inboard face supported by exterior steel stanchions.

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[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.

Description of Canadian Pacific Railway (CPR) Mission Railway Bridge

Constructed in 1909, the Canadian Pacific Railway (CPR) Mission Railway Bridge spans the Fraser River at Mission, B.C. Supported by 13 concrete piers, the bridge is approximately 533 m long. The swing span with a vertical clearance of 4.9 m above Higher High Water Large Tide (HHWLT) when closed is fitted atop a circular concrete pier, the 10th from the north bank of the river. This concrete pier is protected by a treated wood pile, timber and wood sheathed protection pier extending upstream approximately 46 m and downstream, approximately 46 m from the concrete pier. The protection pier is tapered at the up-river and down-river ends. The navigable portions of the north and south channels are approximately 30 m wide. At night a fixed white light is displayed on piers 9 and 11 as well as at the up-river and down-river ends of the protection pier.

Marine traffic with low air draught requirements such as log tows, loaded and unloaded gravel barges, use the channel beneath the fixed span between piers 5 and 6 for navigation. The swing span north and south channels are used mainly for wood chip barge traffic and other marine traffic that cannot navigate under the rail bridge between piers 5 and 6.

A bridge tender maintains an office on the shore at the north end of the bridge and is on duty around the clock. The bridge tender may be contacted by telephone and also monitors a VHF radio. When requested to open the bridge for marine traffic, the tender walks the trestle to a control booth situated on the swing span. The tender must remain on the swing span while the bridge is in the open position.

History of the Voyage

At 1745[2] on the evening of 1 June 1999, a relief master and deckhand set out by water taxi from Port Hammond, on the Fraser River, to relieve the crew of the tug *Sheena M* in the vicinity of Port Coquitlam, B.C. After a brief handover, the relief crew took over and the previous crew departed in the same water taxi. Neither the master nor deckhand is a full-time employee of the operator and, as such, is not employed on a regularly scheduled basis. However, they had received advance notice of this work and were reportedly well rested.

The tug *Sheena M* was upbound on the Fraser River, towing one empty chip barge. The master had been told by the tug owner to deliver the chip barge to the Meeker Cedar mill in Mission, B.C., exchange it for a loaded chip barge at the same mill, and then return down-river to await orders, the most likely destination suggested was Annacis Island, on the Fraser River.

Aboard the *Sheena M* all equipment was reported to be in good working order. The moon was full on May 30, the sky was clear and bright, visibility good. There was no appreciable wind. As part of the handover, the master had been informed that the gauge reading at Mission was 15.09 feet (4.6 m). This represents the height of the river level above chart datum.

The 20-mile passage up the river was uneventful. Using a cellular telephone at approximately 2245, the master of the *Sheena M* gave the bridge tender on the CPR Mission Railway Bridge at Mission advance notice of the intentions of the *Sheena M* with an expected time of arrival (ETA) of 2330 at the bridge. The bridge tender advised the master that he was monitoring very

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[2] All times are Pacific daylight time (PDT) (co-ordinated universal time (UTC) minus seven hours) unless otherwise noted.

high frequency radio-telephone (VHF R/T) radio channel 80 and requested 20 minutes notice for opening the span. Adhering to the bridge tender's instructions, the *Sheena M* arrived at the bridge at the given time and made the upstream passage through the south draw without event, arriving at the Meeker Cedar mill at approximately 2345 (see Figure 1).

The Meeker Cedar mill is situated on the north bank of the Fraser River approximately 500 m

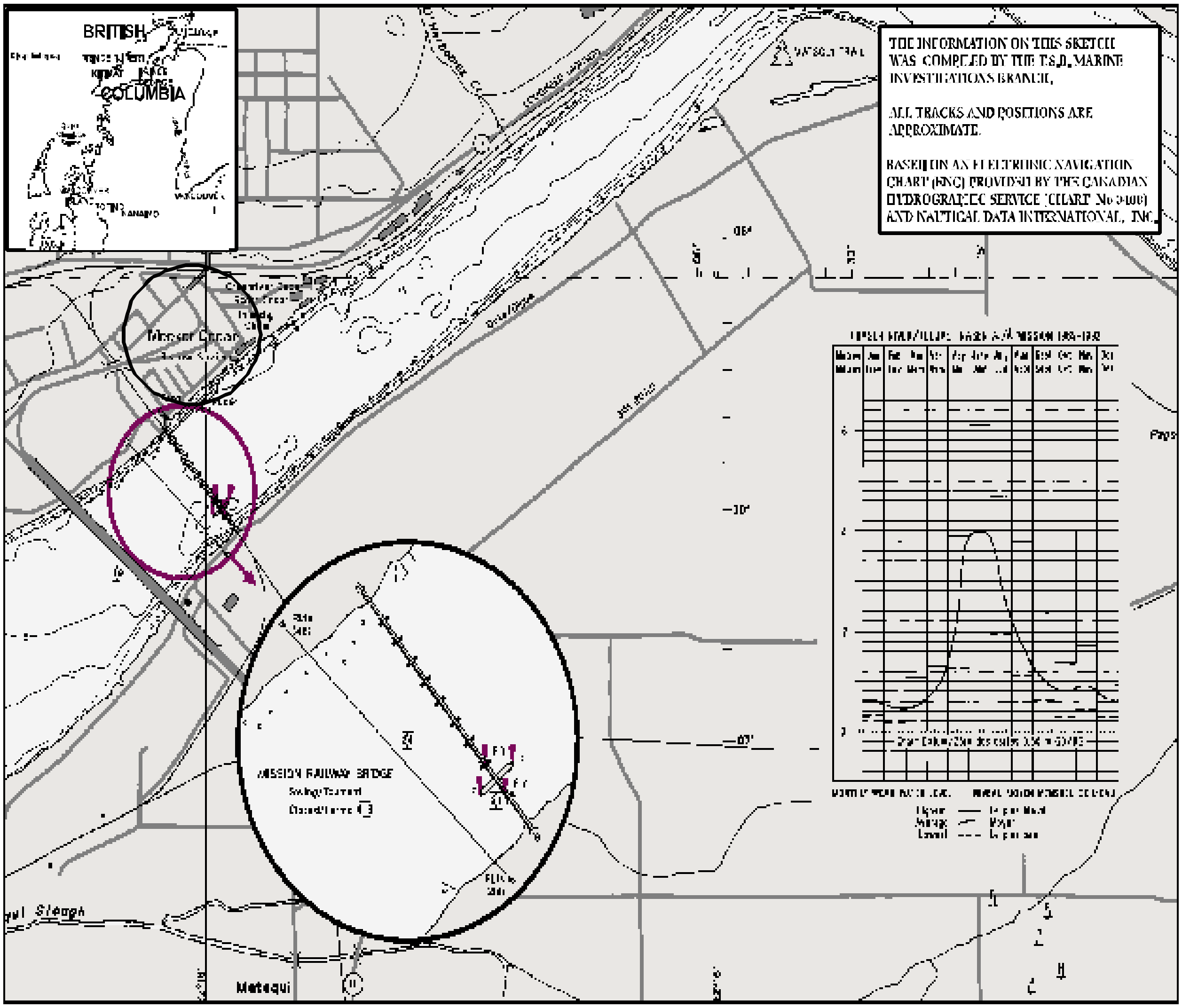

Figure 1. Map showing the location of the CPR Mission Railway Bridge.

upstream of the CPR Mission Railway Bridge. Upon arrival at Mission the crew of the *Sheena M* secured the empty chip barge to a dolphin adjacent to the mill. They then took the chip barge *Rivtow 901*, loaded with approximately 2,100 tonnes of wood chips, from under the loading chute at the mill to a position approximately 100 m upstream on the same bank, securing it to a dolphin. Re-connecting to the empty barge they had brought with them, it was manoeuvred into position under the loading chute and secured. Upon completion they returned to the *Rivtow 901* and, after attaching their tow line and bridle, began their preparations for the passage down river. Approximate time of their departure from Mission, with the loaded chip barge in tow, was 0020 on June 2. On departure the master of the *Sheena M* again contacted the CPR Mission Railway Bridge tender, giving an ETA of 20 minutes at the bridge.

Proceeding upstream, stemming the current, the *Sheena M* and her tow crossed the Fraser River, using the lights of a mill on the north bank upstream of Meeker Cedar as reference before commencing a turn downstream toward the bridge. This reference point equates to an approximate sailing distance from the point of departure (near the mill) of 1000 m and is upstream from the bridge, a distance of approximately 1400 m.

The master turned the *Sheena M* to port. When both tug and tow were heading downstream the master used a minimum throttle in order to maintain bare steerageway as he followed the south bank of the river toward the south draw of the bridge. The master's intention was to keep both tug and tow away from the main flow of the river, remaining as close to the south bank as possible.

As the *Sheena M* made her approach to the bridge the master was alone in the wheelhouse. The deckhand was standing by the winch controls on the after deck ready to respond to instruction from the master; the port wheelhouse door was open to facilitate communication. Both master and deckhand later reported that the lights on the CPR Mission Railway Bridge marking the navigable passages were dimly lit and difficult to discern. The master of the *Sheena M* reported that the shackle connecting the towing wire to the bridle was approximately 3.7 m abaft the stern. Combined with the bridles this gave an approximate distance of 15 m between the tug and barge. With the *Rivtow 901* following the *Sheena M* so closely the master had no difficulty seeing the barge, given the brightness of the night. The master made full use of the helm, supplemented by short bursts of throttle, in his effort to keep the *Rivtow 901* tracking astern of the *Sheena M*.

As the *Sheena M* closed on the south draw of the CPR Mission Railway Bridge, the master became aware of an increase in the strength of the current setting toward mid-channel. This had the effect of setting the barge further away from shore than the tug. Realizing he was committed to making the transit of the bridge, he redoubled his efforts, using both helm and throttle, in his attempt to achieve safe passage through the bridge.

The *Sheena M* did not make contact with the bridge structure. However, the master suspected, by the feel of the tow transmitted to the tug through the tow wire, that the barge had made contact with the bridge structure. When the barge made contact, the progress of both vessels was momentarily arrested before continuing through the draw. The deckhand on the stern of the *Sheena M* reported that he heard first the sound of wood breaking, followed by the sound of metal working against metal. The time was approximately 0045 on the morning of June 2.

The master used VHF 80 to call the bridge tender, asking if he was all right. Upon receiving an affirmative response he advised the bridge tender that the tug would return to pick him up. The *Sheena M* with the *Rivtow 901* in tow continued through the draw and proceeded to a location on the north bank, approximately 1000 m downstream from the bridge, known as the Herman grounds, to secure the barge. At approximately 0050 the master of the *Sheena M* called the vessel owner by cellular telephone, informing him of events.

The damage sustained by the bridge was significant. Since the bridge tender must remain on the swing span when it opens, he was now isolated on that span with the fear that the structure might topple into the river at any moment, carrying him with it. Not being content to await the return of the *Sheena M*, the bridge tender contacted the water taxi service, whose base of operations is at Mission, adjacent to the bridge, with the request that he be immediately removed from the span.

With the *Rivtow 901* secured to a log boom at the Herman grounds at approximately 0100, the *Sheena M* was then free to return to the bridge to pick up the bridge tender. When the *Sheena M* was informed by the bridge tender that a water taxi was expected, the tug then travelled upstream through the north draw and returned downstream through the south draw. During her passage through the south draw her mast became fouled by an overhead cable. Moments afterward the mast carried way. This low-voltage overhead cable has an advertised vertical clearance of 21 m above chart datum, but when the bridge was struck, the cable supports were displaced resulting in a reduced vertical clearance of the cable. The *Sheena M* continued downstream through the draw and, through use of her spotlight, was able to provide illumination when the bridge tender was picked up by the water taxi.

After the bridge tender was safely recovered, the *Sheena M* returned to the *Rivtow 901* in order to inspect her for damage. The barge was lying on an even keel and seemed to be watertight with no apparent damage to her hull. At 0130, after satisfying himself that the watertight integrity of the *Rivtow 901* was not impaired, the master of the *Sheena M* decided to resume towing the barge down river to Annacis Island tie-up. The barge was secured to her lay-by berth at Annacis Island at 0530 ready for passage to her discharge berth on Vancouver Island.

Injuries to Persons

No one was injured.

Damage

Damage to the Vessel

Damage to the tug was minimal. The low-voltage overhead cable spanning the draw was designed to provide an advertised clearance of 21 m above chart datum. This became dislodged when the bridge was struck resulting in a significant reduction of clearance. The tug's main mast, fitted with navigation lights and radio antennae, became fouled in this cable after the accident and was carried away (see Figure 2).

Figure 2. The tug *Sheena M* without mast.

Damage to the Barge

The most significant damage was to the upper edge of the steel box-wall on the starboard side which was fractured and set-in over a length of approximately 6 m at a point immediately forward of the barge's mid-length (see Figure 3). Lesser damage was sustained by the vertical stiffeners welded to the external face of the box-wall. These were damaged to varying degrees, ranging from paint scuffs to, in the case of one stiffener, sufficient deformation to require replacement. The barge's hull remained intact. Only a small amount of the wood chip cargo was spilled onto the bridge or into the river.

Figure 3. The chip barge *Rivtow 901* with damaged starboard box-wall under repairs.

Damage to the Bridge

The upstream portion of the bridge protection pier was significantly damaged. As a result of the impact by the barge, the nose of the squared timber (upper) portions of the protection pier was deflected to the north. Without this protection, the swing span was dislodged from its pedestal by the barge impact and deflected approximately 4 m to the west.

Figure 4. Damaged nose of protection pier deflected to north.

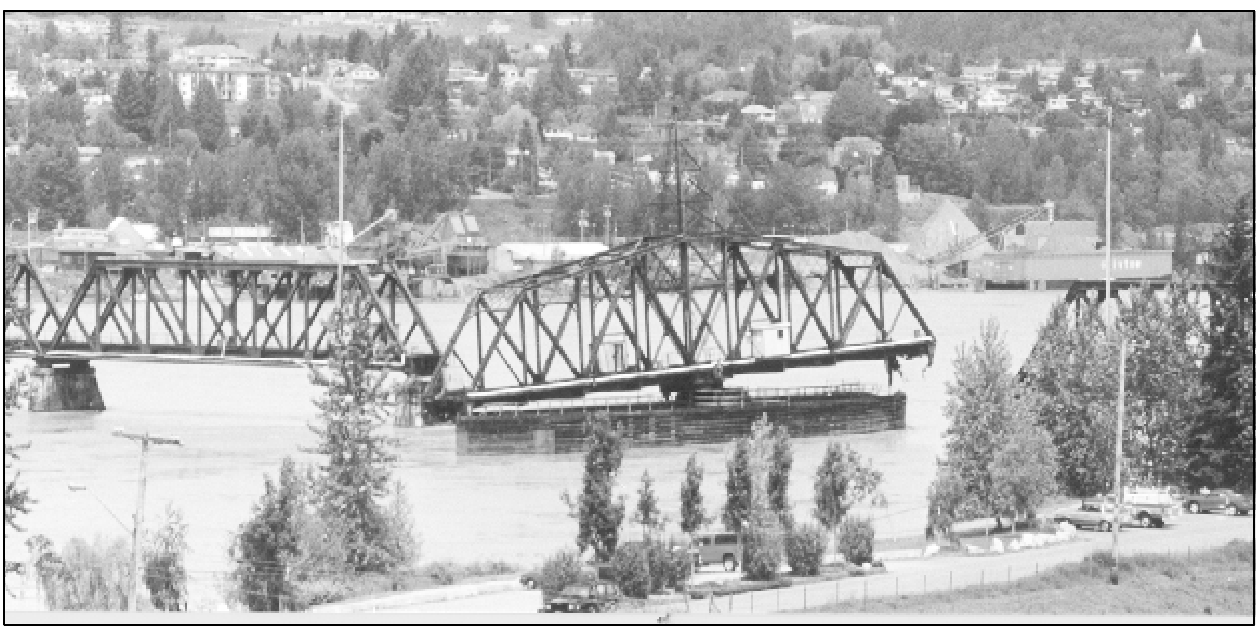

Figure 5. Damaged CPR Mission Railway Bridge at Mission, B.C., viewed from south shore of Fraser River. Meeker Cedar mill in background with a chip barge at loading facility.

Damage to the Environment

There was no environmental damage as a result of the striking.

Certification

Vessels

The Sheena M

The tug was built in B.C. in 1981, twin screwed and rated at 600 (brake horse power) bhp. Its gross tonnage of 9.99 is below the 10-tonne threshold above which requires Transport Canada inspection and certification. However, they must still be operated in compliance with all Regulations applicable to vessels in her trade.

The *Sheena M* conforms with Fraser River industry norms in terms of size and power. All equipment at the time of the accident was reported to be in good working order. The vessel was acquired by her current owner in 1998 for use primarily on the Fraser River.

The Rivtow 901

As an unmanned barge built before 1 September 1977, and not carrying pollutants, the *Rivtow 901* is not subject to inspection by Transport Canada, Marine Safety.

Personnel

The master of the *Sheena M* holds a Master Home Trade 350 Ton Certificate of Competency issued by Transport Canada in 1970 and re-issued, with STCW[3] endorsement in February 1992. This certificate was valid at the time of the occurrence.

The deckhand held no certification nor was he required to do so.

Personnel History

The master's towing experience dates from 1958, all on west coast waters and the Fraser River. His first command was in 1964. Between 1958 and 1968 he sailed almost exclusively on this section of the Fraser River, during which time he estimates having made several hundred transits of the CPR Mission Railway Bridge. More recently he has been employed in towing construction materials on the coast. His last previous transit of the CPR Mission Railway Bridge was in 1990, but not during freshet[4] (see Current Information).

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[3] *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978.*

[4] Refers to a rush of fresh water flowing into sea or flood of river from heavy rain or melted snow.

Communications

A Vessel Traffic Services (VTS) scheme, with mandatory Calling-in-Points (CIP), is in place near the mouth of the Fraser River. The section of the river in the vicinity of Mission, B.C., is outside that zone. In order to co-ordinate bridge openings, mariners first establish contact with the bridge tender by telephone then update their progress by means of VHF radio-telephone.

Weather and Current Information

Weather on Scene

Weather conditions were fine and clear with little wind and calm seas in the sheltered waters of the Fraser River.

Current Information

Fraser River at Mission, B.C.

In the late spring each year the Fraser River experiences freshet. During freshet the volume of water flowing through the Fraser River estuary increases from its winter low by a factor of 10. As the river level rises, the volume of water flowing past a given point increases significantly. In the spring of 1999, a combination of increased snow-pack inland combined with above average temperatures resulted in a freshet significantly above the norm.

Throughout any given day the actual water levels can vary for a variety of reasons such as diurnal tidal effect, air temperature, and resultant rate of snow-melt. At the time of the accident the water level at Mission was closer to 4.5 m above chart datum. This equates to an approximate discharge rate of 7950 cubic metres per second (cms). By calculation this discharge rate can be expressed as a mean surface velocity, bank to bank, of 1.3 metres per second (m/s) or approximately 2.5 knots. Environment Canada hydrologists caution that the figure given is a mean, and particular sections of an unobstructed river might have a surface velocity of 1.7 m/s or 3.3 knots. When the normal flow of a river is obstructed by a bridge structure and the flow of water is guided through specific channels, surface velocities can increase appreciably above those for an unobstructed river.

Environment Canada maintains a river level gauge at Mission. Daily readings from this gauge are available to interested parties via a toll-free telephone number. Due to the run-off from melting inland snows in April, the river level begins its annual rise from low winter levels. The rate at which the river rises increases throughout May, reaching its highest level in June and remaining up until the end of July or middle of August. At Mission, since 1962, the monthly mean water level for June is 4.0 m above chart datum. The highest recorded water level in the same period was 6.1 m.

The Fraser River is affected by the tide as far upstream as Chilliwack.

Analysis

Safety on Fraser River

The loaded chip barge *Rivtow 901*, under tow of the tug *Sheena M* struck the CPR Mission Railway Bridge at night in calm weather, with good visibility. The accident occurred during the down-stream transit 75 minutes after the successful completion of an up-stream transit of the same bridge.

The master of the *Sheena M* has over 40 years experience in the B.C. towing industry, 10 years of which were spent exclusively on this section of the Fraser River. In the past decade his experience has not been with chip barges nor has it included this section of the river. While he was familiar with the annual Fraser River freshet, his most recent direct experience on this section of the river was more than 10 years ago.

Downstream from Mission, the lower section of the Fraser River bears a higher concentration of marine activity. Bridges spanning the lower section of the river have sustained a higher incidence of damage as a result of being struck. In the past 25 years, more than 50 strikes of bridge structures by vessels or barges have been reported to the TSB. As a consequence, the Fraser River Port Authority (Fraser Port), in conjunction with its marine community, have developed Standard Operating Procedures (SOP) for vessels transiting bridges within their jurisdiction in order to minimize the incidence of damage. The CPR Mission Railway Bridge at Mission is approximately 13 miles upstream of the eastern boundary of Fraser Port placing it outside Fraser Port's jurisdiction. At the time of the accident, vessels transiting that bridge were governed by the general terms of the *Navigable Waters Protection Act*, and not subject to any specific SOPs.

Although the navigation lighting on the CPR Mission Railway Bridge was operative at the time of the accident, this was not, in itself, a contributing factor. However, investigation has revealed that lighting inconsistencies exist between bridges and structures on the Fraser River. While the *Navigable Waters Bridges Regulations* and the *Navigable Waters Works Regulations*, both pursuant to the *Navigable Waters Protection Act*, govern the colour and placement of the navigation lighting on bridges and "lawful works" in navigable waters, they are silent as to the intensity of these lights.

Marine Communications and Traffic Centre (MCTS) at Victoria provides Vessel Traffic Services (VTS) for the lower Fraser River only. The nearest (traffic) CIP to the CPR Mission Railway Bridge is at New Westminster, 28 miles down river.

Operation of Tug/Barge in Spring

Stemming a current, a vessel can often remain both stationary in a waterway and retain directional control by judicious use of rudder(s), together with adjusting the throttle setting to match the current.

Travelling with the current, there must be sufficient water flow past the rudder(s), in order to maintain directional control. As a result, to approach an equivalent level of control, a vessel must develop a greater speed over the bottom than it would in still water.

The master of the *Sheena M*, through experience, was well aware of this. He travelled 1400 m upstream of the bridge before turning in order to be able to line up the tug and tow sufficiently for safe passage through the bridge. His attention was focussed on keeping both vessels as close to shore, in the reduced current, as water depth permitted. From his conning position, he knew that the current was setting the tow further away from shore than the tug. While taking this into consideration, he was also aware that he ran the risk of increasing his speed over the bottom above the minimum desired for a safe transit of the bridge.

Planning is an essential element of successful passage making. However, local marine industry practice on the Fraser River does not generally include the four stages of passage planning —appraisal, planning, execution, and monitoring—as a formalized process. As a consequence, an abort point, the last position where the passage could be abandoned safely, had not been pre-established.

The high forward box-wall of the *Rivtow 901* obscured the attitude of the barge and made it difficult to determine its aspect relative to the tug. Including a significant following current into the equation resulted in events unfolding far more rapidly than they had during the upstream passage. The unfamiliar lights of the CPR Mission Railway Bridge did not provide a clear point of reference for the master of the *Sheena M* as the tug made her approach at a speed enhanced by the current.

Although the master was aware that the *Rivtow 901* was tracking in deeper water than the tug, the darkness and high forward box-wall of the barge obscured its relative attitude. This, in the mind of the master, combined with the fact that his attention was focussed for the most part on the bridge ahead caused him to realize that events had begun to deviate from his intended plan.

Although never formally established, in the mind of the master, the abort point had been passed. Once committed to transiting the bridge, no other option remained.

In the event that the tug and tow would not have cleared the draw, the master would have had to rely on the bridge's protection pier to absorb the impact of the barge, then guide it safely through. The protection pier has dimensions greater than the open span of the bridge it is designed to protect.

Sequence of Damage Sustained

Due to the height of the river (4.6 m above chart datum), at the time of the accident approximately 2 m of the upper squared timber portion of the protection pier was visible above the river surface. When the upper portion of the protection pier was struck by the barge, metal strapping and bolts, which connect with the wooden piles, distorted or sheared. Other bolts remained intact but were pulled bodily from position. The upper portion of the protection pier broke away from the pilings and was deflected to the north allowing the box-wall of the chip barge to make contact with the swing span of the railway bridge. The barge struck the swing span with a force sufficient to shift the span almost 4 m from its pedestal. Until it was stabilized several days after the accident, there was concern that the swing span might topple into the river.

Findings as to Causes and Contributing Factors

1. The master misjudged the full effects of the strong freshet when navigating downstream.

2. The master did not detect the onset of a loss of control of the tow due to being unfamiliar with the lights marking the navigable passage at the bridge and the configuration of the tow of the barge.

3. Although the master of the tug had experience in other geographical areas, he did not have recent experience of transiting this section of the river during freshet.

4. A predetermined passage plan had not been elaborated nor had a predetermined abort position been formally determined.

Findings as to Risk

1. Unlike similar bridges on the lower Fraser River, there were no Standard Operating Procedures governing the safe transit of this bridge by marine traffic.

2. The location of the railway bridge controls obliges the bridge tender to remain on the swing span to operate it which exposes him to considerable risk in the event of a vessel striking and bridge damage.

Other Findings

1. The master was aware that while not yet at its maximum rate of flow for the year, in terms of both height above chart datum and rate of discharge, the Fraser River was significantly above annual levels and had an unusually large freshet.

Safety Action

Action Taken

Following the accident, the bridge was repaired and the upstream portions of its protection pier were repaired and enhanced. In the damaged section, wooden piles were replaced by a combination of steel pipes and “H” beams. The nose of the protection pier was extended approximately 10 m further upstream by the addition of a wooden-sheathed, triangular-shaped steel structure made from 915-mm diameter pipes driven into the river bed. CPR, in its four-year capital program, is budgeting for similar improvements to the downstream portions of the protection pier.

The *Navigable Waters Bridges Regulations* made pursuant to the *Navigable Waters Protection Act*, govern bridge lighting. These *Regulations* are silent as to the colour and nominal range of lights prescribed. After the CPR Mission Railway Bridge re-opened, investigators from the Transportation Safety Board (TSB) viewed bridges spanning the Fraser River after dark in order to assess lighting. It has been determined that bridge lighting on the Fraser River is inconsistent with respect to nominal range. While the lighting on the CPR Mission Railway Bridge is considered appropriate, the TSB has issued a Marine Safety Advisory on these inconsistencies to the Navigable Waters Protection Division of the Canadian Coast Guard.

Figure 1 of this report incorporates a section of the Canadian Hydrographic Service (CHS) chart (i.e., CHS 3488) for this section of the Fraser River. This chart indicates the CPR Mission Railway Bridge is supported by 10 piers when, in fact, the bridge has 13 supports. Since reconstruction the protection pier extends an additional 10 m upstream. The chart also indicates the bridge displays 2 white lights and 2 yellow lights. The bridge now displays 10 white lights and 4 red lights. The TSB has brought these changes to the attention of the CHS. Upon confirmation, they will issue a Notice to Mariners advising the marine community of these changes.

Rail traffic through the Fraser Canyon over the CPR Mission Railway Bridge has increased dramatically recently. As a result of this accident and in response to concerns over potential conflicts between rail and marine traffic, in April 2000, the Navigable Waters Protection Division of the Canadian Coast Guard, in consultation with stakeholders, developed Standard Operating Procedures (SOP) for vessels transiting the CPR Mission Railway Bridge. These SOPs detail formal calling-in points (CIP) and procedures to the bridge tender, from each direction, for bridge transits which require the span to be opened.

Additionally, in order to enhance the safety of personnel, CPR has investigated methods of operating the bridge without the need for the bridge tender to be present on the moveable portion of the span. To date, a solution has not proven economically feasible.

This report concludes the Transportation Safety Board’s investigation into this occurrence. Consequently, the Board authorized the release of this report on 5 March 2002.

Appendix A **S** *Glossary*

bhp	brake horse power
CIP	calling-in point(s)
cms	cubic metre(s) per second
CPR	Canadian Pacific Railway
ETA	expected time of arrival
HHWLT	higher high water large tide
IMO	International Maritime Organization
m	metre(s)
MCTS	Marine Communications and Traffic Services
mm	millimetre(s)
m/s	metre(s) per second
PDT	Pacific daylight time
SI	International System (of units)
SOP	Standard Operating Procedure(s)
STCW	*International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978*
UTC	coordinated universal time
VHF R/T	very high frequency radio-telephone
VTS	Vessel Traffic Services