Report 99-210

commercial jet boat *Helijet 2*

collision with rockface

Kawarau River, Queenstown

20 August 1999

Abstract

On Friday, 20 August 1999 at about 1410, the jet boat *Helijet 2*, with a driver and 8 passengers on board, was proceeding at about 60 km/h past a series of rocky outcrops on the Kawarau River when the driver experienced what he considered to be a lock-up of his steering system as he rounded the last of the outcrops. The driver freed the steering by reducing throttle and moving the steering wheel from side to side. Meanwhile, the boat had entered a cove and the driver turned the boat to avoid a head-on collision with a rockface. The right rear of the boat struck the rockface, the boat slewed to the right and struck the rockface again at the right front of the boat. One of the passengers was severely injured while most of the others received minor injuries.

Safety issues identified in this and other jet boat accident investigations were:

- operational supervision of jet boat operations and standards
- driver training and licensing
- maintenance control
- passenger briefings
- occupant protection in the event of collision.

Safety recommendations were made to the Directors of Kawarau Jet Limited to address the safety issues.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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Photograph courtesy of Kawarau Je

Helijet 2

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List of Abbreviations

GRP	glass reinforced plastic
km/h	kilometres per hour
m	metre(s)
MSA	Maritime Safety Authority
QLDC	Queenstown Lakes District Council
UTC	universal time (co-ordinated)

Glossary

aft	rear of the vessel
ballast	weight, usually sea water, put into a ship to improve stability
bilge	space for the collection of surplus liquid
class	category in classification register
eddy	a circular movement of water causing a small whirlpool

Data Summary

Boat Particulars:

Name:	*Helijet 2*
Type:	commercial jet boat
Class:	passenger (under 6 m)
Limits:	Lake Wakatipu, Shotover River and Kawarau River
Allowable occupants:	driver plus 18 passengers (at driver's discretion)
Length:	5.5 m
Construction:	aluminium monohull with glass reinforced plastic (GRP) topsides
Propulsion:	a single Chevrolet 502 petrol engine driving a series 212 Hamilton jet unit
Normal operating speed:	up to 70 km/h
Operator:	Kawarau Jet Limited
Location:	Kawarau River, Queenstown
Date and time:	Friday, 20 August 1999 at about 1410[1]
Persons on board:	crew: 1 passengers: 8
Injuries:	crew: nil passengers: 1 serious 4 minor
Nature of damage:	substantial to hull at right rear, engine dislodged from mountings and driveshaft fractured
Investigator-in-Charge:	Captain John Mockett

[1] All times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

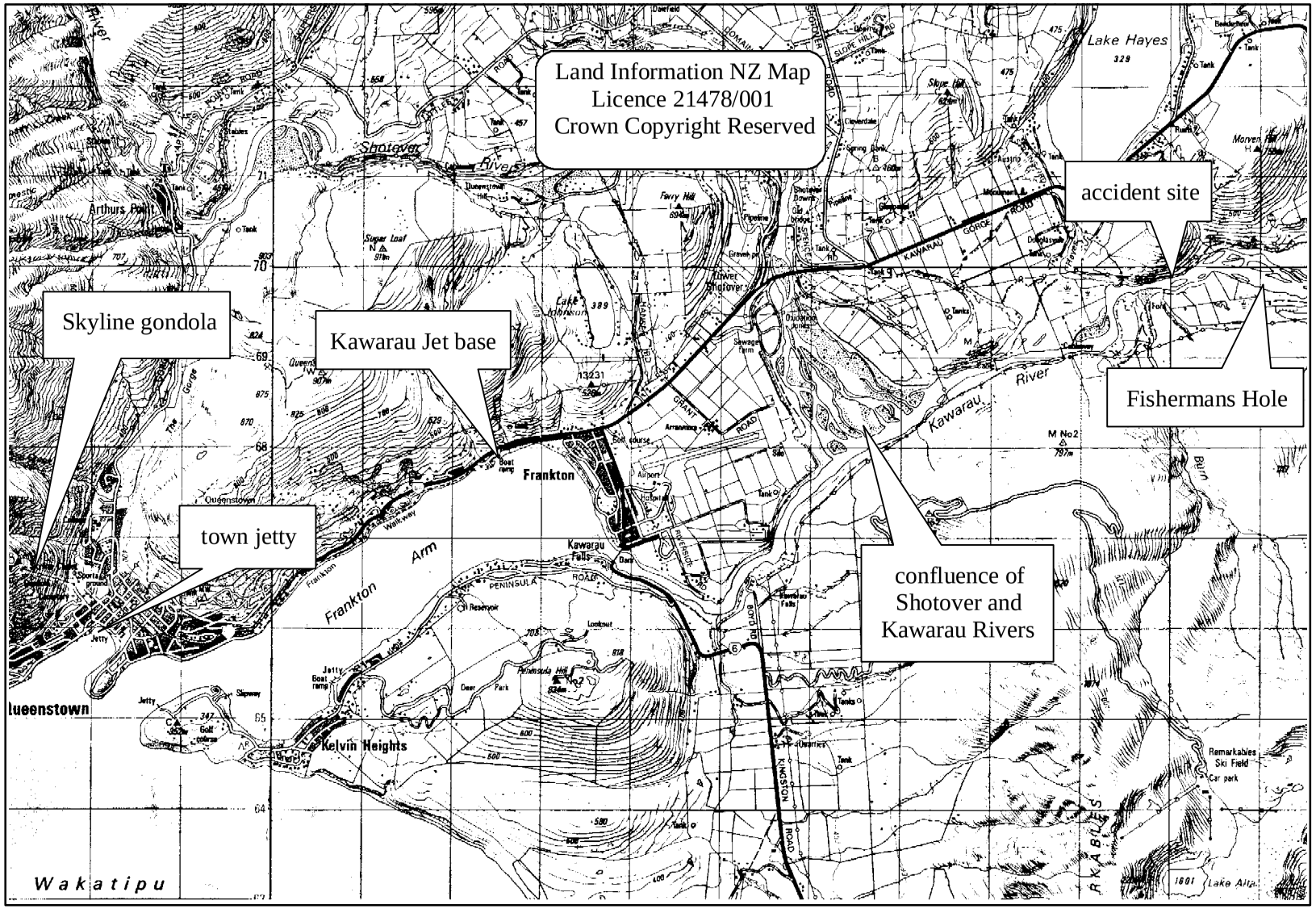

Figure 1
Location map showing key points

1. Factual information

1.1 History of the trip

1.1.1 In Queenstown on Friday, 20 August 1999, a group of 8 tourists booked a Helijet combination package that included a jet boat ride on the Kawarau and Shotover Rivers, a helicopter ride to the Skyline complex and a gondola ride to return to the town. The group consisted of a family of 4, including 2 boys aged 9 and 6, and a party of 4 adults. One of the party of adults was booked only to do the jet boat section of the trip.

1.1.2 The whole group was taken by minibus to the Kawarau Jet base at Frankton marina at about 1345. At the marina they were kitted out with life-jackets and after souvenir photographs had been taken, they boarded the jet boat *Helijet 2* for the first part of the trip. Once the passengers were seated in the boat, more souvenir photographs were taken before the driver manoeuvred the boat out into the Frankton Arm of Lake Wakatipu.

1.1.3 Once clear of the boat ramp, the driver gave a safety briefing, telling the passengers to remain seated and to keep wholly inside the boat, not leaning over the side or putting hands and arms over or close to the side. He explained that this was important because the ride would take the jet boat close to obstructions on the sides of the river.

1.1.4 The driver also explained some hand signals that he would be giving, in particular the signal that he would give when he was about to perform a spin[2], during which the passengers should hold on tightly.

1.1.5 The usual route for the jet boat was from the Frankton Arm, down the Kawarau River and then up the Lower Shotover River. The driver had made an earlier trip and explained to the passengers that the Lower Shotover River was in flood and as a result the ride was more bumpy than usual.

1.1.6 Because of the conditions on the Lower Shotover River, and having 2 children on board, the driver suggested an alternative route of staying on the Kawarau River beyond the confluence with the Shotover River, then back for a short trip into the lower reaches of the Shotover River as far as the bridges, which did not involve the gorges where the waters were more turbulent. The passengers all agreed (see Figure 1).

1.1.7 *Helijet 2* departed at about 1355 and proceeded across Frankton Arm to the head of the Kawarau River. The driver took the boat through a group of small islands, passing close to the shore and overhanging trees before heading down the Kawarau River.

1.1.8 The driver kept *Helijet 2* broadly to the right-hand side of the river, keeping the boat close to objects on the banks of the river to enhance the excitement of the trip for the passengers. This side of the river was mainly low-lying with many overhanging trees. During the downriver trip he performed several spins, stopping each time to check that the passengers were all right. He also stopped at places of interest and told the passengers about the area and its history.

1.1.9 The driver took *Helijet 2* downriver as far as a wide section known as Fishermans Hole. He turned the boat around and after a short commentary proceeded back up river, again keeping to the right-hand side. This side of the river was more steep and rocky.

[2] A spectacular manoeuvre, unique to jet boats, where the boat is turned at relatively high speed, almost within its own length. Commercial jet boat drivers use the manoeuvre to enhance the degree of excitement of a trip.

1.1.10 Above Fishermans Hole, there was a series of rocky outcrops. Following his normal line, the driver steered *Helijet 2* about 0.5 m off the first outcrop at about 60 km/h. He turned slightly to the right into the cove formed by the first and second outcrops and then steered left to clear the second outcrop, again by about 0.5 m. He repeated this manoeuvre through the cove formed by the second and third outcrops.

1.1.11 When *Helijet 2* cleared the third outcrop the driver turned slightly to the right, intending to repeat the manoeuvre through the third cove. However, when he tried to steer back to the left he found that he could not turn the steering wheel. He immediately reduced the throttle and moved the wheel from side to side to free the steering nozzle (see Figure 2).

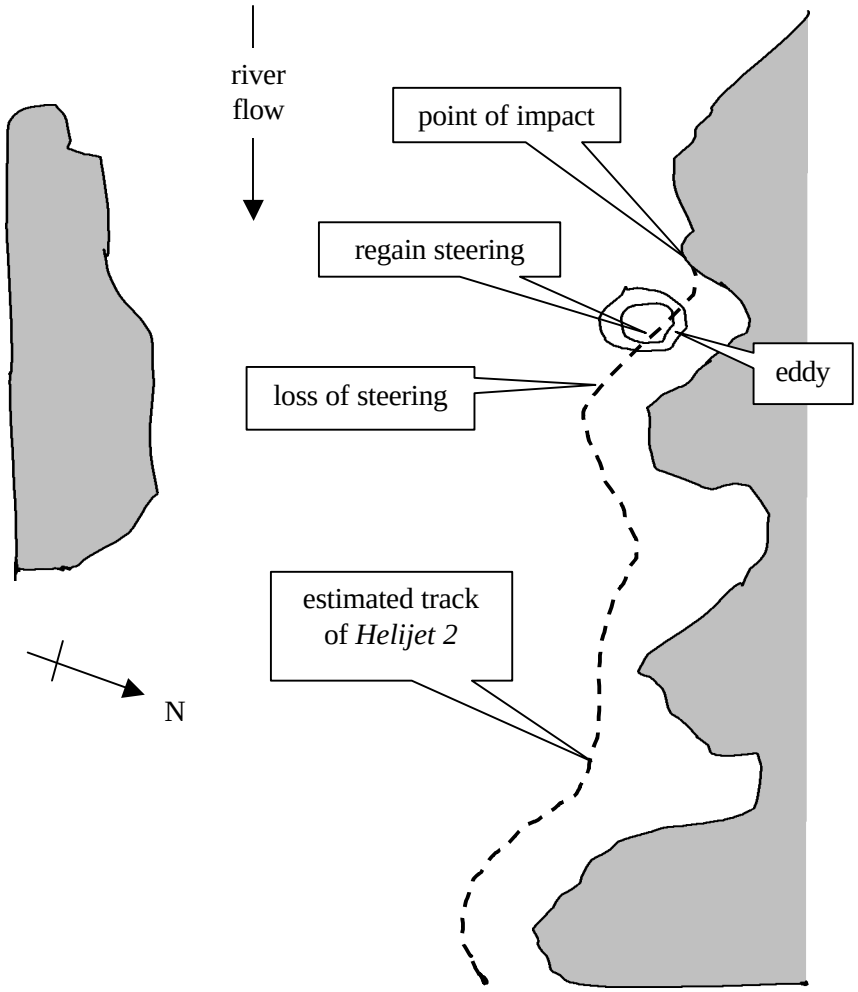

Figure 2
Schematic diagram of accident area
(not to scale)

1.1.12 In the short time the driver took to free the steering, *Helijet 2* had travelled into the cove, was pointing directly at the rockface and was in a current eddy. The driver realised that the boat was going to strike the rockface and although he had already reduced the throttle, he felt that it was too late to apply reverse bucket[3] to stop the boat in the remaining distance.

1.1.13 In order to avoid a head-on collision with the rocks, the driver applied full throttle and steered hard to the left. The boat turned away from the rockface but the right rear of the boat struck the rocks. The impact slowed the boat and swung it back to the right and the right front of the boat also hit the rocks (see Figure 3).

[3] A scoop that is closed into the water efflux to deflect all or some of the water forward.

1.1.14 After the impact, the driver first checked that none of his passengers had been thrown out of the boat and that none had suffered injury requiring immediate attention. *Helijet 2* began taking on water so the driver started the 2 electric bilge pumps. The engine had stopped on impact and the boat was drifting downstream without power.

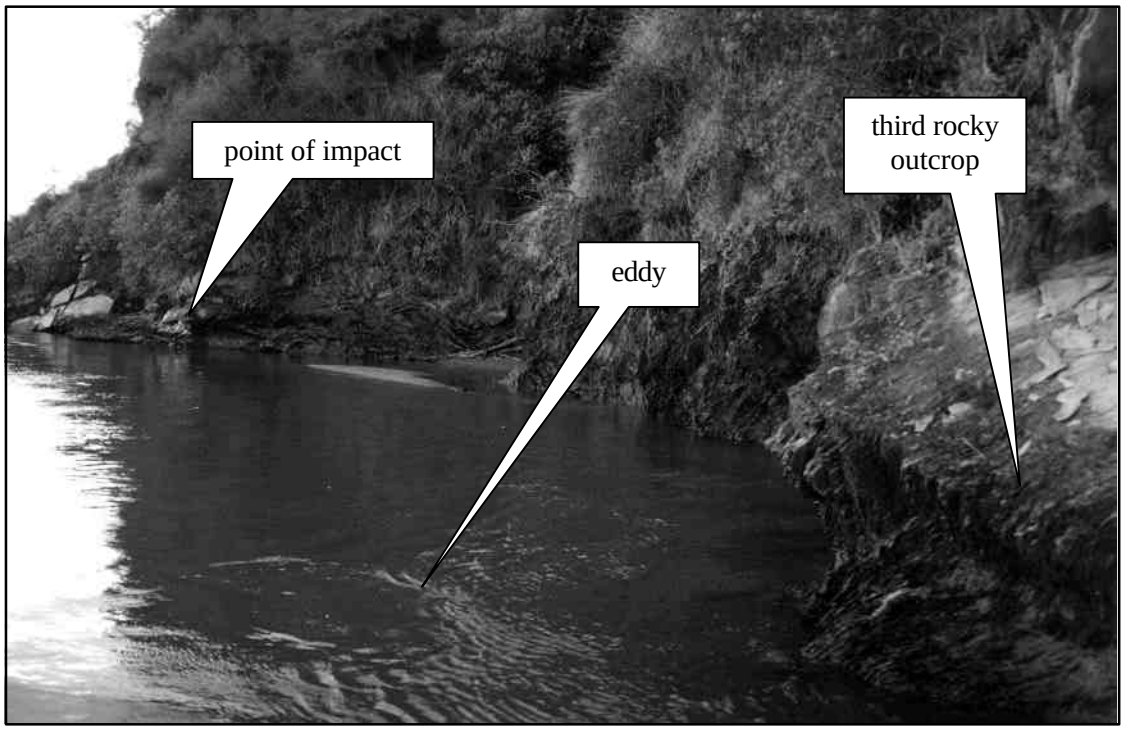

Figure 3
Accident site

1.1.15 The driver took out one of the paddles and he fended the boat off the rocks and tried to paddle the boat clear. He took out the second paddle and passengers assisted him in keeping the boat clear of the rockface while it was being swept downstream in the strong current. Once clear of the rockface they were able to paddle to a shingle bar further downstream.

1.1.16 The driver and one passenger jumped ashore and pulled the boat onto the shingle bar. Other passengers got out of the boat and pulled it clear of the water. The driver assessed the passengers for injuries. There were various cuts and bruises but it was apparent that the mother of the family had a more serious injury to her right leg and she had to be lifted out of the boat.

1.1.17 The driver radioed the Kawarau Jet base personnel to inform them of the accident and to summon assistance. Although his message got through, the return messages were not clear due to static. The driver then radioed Helicopter Line and requested assistance. One of the helicopters was dropping off a group of rafters downriver and after its passengers were disembarked it proceeded to *Helijet 2* to pick up the injured passenger.

1.1.18 The helicopter arrived at the shingle bar about 15 minutes after the accident. The family was evacuated first and taken to the airport, where they were met by one of the owners of Kawarau Jet, who transferred them to the medical centre.

1.1.19 Meanwhile another Kawarau Jet boat was proceeding from the Kawarau Jet base to assist with the recovery of *Helijet 2* and its passengers. Another company boat had been conducting a trip on the river and when its driver overheard the radio calls for assistance he disembarked his passengers on the riverbank and proceeded to *Helijet 2* to assist.

1.1.20 The second company boat arrived at the scene first, to find that the driver and passengers were safely ashore and not in immediate danger. As the helicopter evacuation was already under way, and a rescue boat proceeding to assist, the driver returned to his own passengers to continue with his trip.

1.1.21 The jet boat from the base, with a driver and the other company owner on board, arrived shortly afterwards. They assessed the condition of the remaining passengers and *Helijet 2*. When the helicopter returned, 3 of the remaining passengers were evacuated to the airport. The fourth passenger, who had not wanted to fly, waited while *Helijet 2* was refloated and taken in tow and returned with the boats to the Frankton marina.

1.2 Injuries and damage to the boat

1.2.1 Just prior to the accident, the passengers had been holding on to the handrails and bracing themselves against the motion of the boat as the driver weaved along the rockface. When the driver had difficulties with the steering, the passengers realised that the boat was probably about to collide with the rockface.

1.2.2 The father of the family released his own hold on the handrails in order to hold his sons. He was holding their life-jackets at the back and also put his hand across the face of the boy beside him. When the boat struck the rocks the boy was thrown forward and his father's hand took the force of the impact with the handrail.

1.2.3 The mother of the family held onto the life-jacket of her son sitting next to her but kept one hand on the handrail. The restraint created by both parents holding on to his life-jacket prevented any injury to the boy but the mother was thrown around in the boat, striking her leg between the seat back in front of her and the side of the boat. She was sitting closest to the point of impact on the starboard quarter and broke her right leg below the knee.

1.2.4 The passengers in the other seats were all thrown forward and received various cuts and bruising, mainly from contact with the seat backs and handrails in front of them.

1.2.5 The seating positions and injuries to the occupants are shown in Figure 4 below.

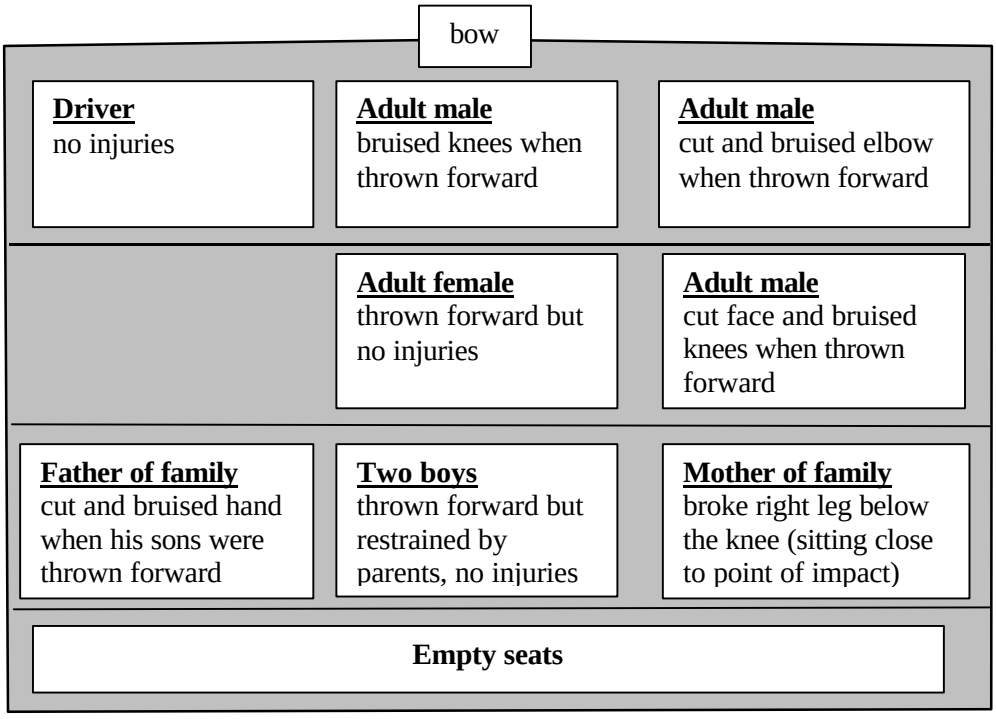

Figure 4
Diagram of boat showing seating position and injuries

1.2.6 *Helijet 2* was inspected after it was recovered from the river. The aluminium hull was heavily indented and punctured at the right rear and dented and scraped at the right front. No other damage was found on the hull. The engine had been dislodged from its mountings and the driveshaft fractured and separated from the jet unit. There was no apparent damage to the steering mechanism.

1.3 Passenger observations

1.3.1 All the passengers commented later that the driver had seemed to be handling the boat competently up to the time of the accident and had shown concern for their well-being, evidenced by his offering to change the route of the trip to give a less bumpy ride, especially with the children on board.

1.3.2 The passenger seated behind and to the right of the driver stated later that the driver had been giving the wheel "a pretty good shake from side to side" just after the boat had entered the third cove. The passenger had not realised the significance of the driver's actions at the time.

1.3.3 For most of the passengers the trip was their first experience on a commercial jet boat ride. Two of them commented later that they had expected the trip to be exhilarating but had in fact found it to be frightening, with the boat passing objects much closer than they thought to be necessary. Those who made the comments felt that before embarking on a trip, they should have been given a more complete description of the trip so that they could better judge their willingness to accept the risks involved.

1.3.4 The passengers all agreed that the driver had given them a safety briefing at the start of the trip but some commented it should have included an instruction to use the footrest to brace against the movement of the boat.

1.3.5 Most of the passengers' injuries were caused by contact with the internal parts of the boat. Having suffered those injuries led to comments that the padding on the seat backs was minimal.

1.4 Driver information

1.4.1 The driver had recreational, but no commercial, boating experience before joining Helijet in September 1998. He had joined Helijet as a mechanic but started training as a driver on 12 November 1998.

1.4.2 He completed 120 hours' on-water training under the supervision of senior drivers. The training was undertaken on Lake Wakatipu and both the Shotover and Kawarau Rivers. As the training progressed the boat was loaded with ballast to simulate having passengers on board to teach the driver the different handling techniques with a loaded boat. Towards the end of the training period the driver made several trips with non-fare-paying passengers.

1.4.3 The driver completed his initial training on 12 April 1999, and then passed a theory and practical test with the Queenstown Lakes District Council (QLDC) harbourmaster to become licensed as a commercial jet boat driver.

1.4.4 On 18 April 1999, he commenced a 25-hour probationary period, during which time he was allowed to carry light passenger loads only and was occasionally accompanied by an observing senior driver. Having completed his initial probationary period to the satisfaction of the senior drivers, he had a further 25-hour probationary period during which he was allowed to carry full passenger loads.

1.4.5 Kawarau Jet Limited acquired the Helijet operation on 1 May 1999, and the driver transferred to Kawarau Jet at that time. The driver did some additional training on the Kawarau Jet boats, which had different handling characteristics than the Helijet boats.

1.4.6 Kawarau Jet soon after fitted planing strakes to the 2 Helijet boats to give them similar handling characteristics to the Kawarau Jet boats, which were more suited to the conditions in the Lower Shotover and Kawarau Rivers.

1.4.7 Kawarau Jet operated 2 boats that were capable of carrying 28 passengers. Before allowing drivers to operate these boats, the company expected the drivers to have about 1000 hours' experience. The driver of *Helijet 2* had not reached that level of experience and was therefore restricted to the smaller boats.

1.4.8 When not driving or touting for passengers at the town wharf, the driver carried out maintenance on the boats at the base in Frankton marina.

1.4.9 The driver was on his second working day after 2 rostered days off. The day before he had driven only one trip: a Kawarau Jet trip from the town jetty, and had spent the remainder of the day selling trips. On the morning of the accident he had started work at 0800 and assisted in preparing the boats. He was then selling at the jetty and completed a Kawarau Jet trip before returning to base to drive the *Helijet 2*.

1.5 Jet boat driver training requirements

1.5.1 At the time the driver was undergoing his training, the draft Maritime Rules Part 80 (Marine Craft Used For Adventure Tourism) had been circulated to the jet boat industry. Part 80 came into force on 11 February 1999.

1.5.2 The draft and subsequent final rule specified that a driver must have not less than 50 hours' experience under the supervision of an experienced driver before driving solo with passengers. The 50 hours must have included a period, acceptable to an authorised person[4], on the river on which the driver was to operate commercially. There was no requirement in the rules for a driver to undergo a probationary driving period following certification, nor any restriction on the size of the boat to be driven.

1.5.3 The QLDC by-laws stipulated that a jet boat driver was to have not less than 25 hours' experience driving under the supervision of a licensed driver who was "approved by the harbourmaster for the particular area of water for which an operating approval was sought". The driver then had to pass a theory and practical test to the satisfaction of the harbourmaster before being allowed to carry fare-paying passengers unsupervised, and a further 25 hours' driving on probation before being issued with a full licence.

1.6 River and weather information

1.6.1 Weather conditions at the time of the accident were good. There was a light wind, no rain and clear visibility, although during the morning there had been a considerable amount of rain.

1.6.2 After long periods of rain, the Shotover and Kawarau Rivers were in flood. This had been the first flood for some time and the rivers were fast flowing with a lot of debris in the water.

1.7 Company information

1.7.1 On 1 May 1999 Kawarau Jet Limited took over the operation of Helijet Limited from another operator and acquired 2 boats on a lease-to-buy contract.

[4] An authorised person is any person who holds a valid certificate of recognition issued under section 41 of the Maritime Transport Act 1994.

1.7.2 The Helijet operation was run as a separate entity from the Kawarau Jet operation although the drivers were interchanged between the boats. At times of low passenger numbers, Kawarau Jet and Helijet boat trips were sometimes combined.

1.7.3 Kawarau Jet Limited was formed in 1961 and was one of the oldest jet boat operations in the Queenstown area. The current owners bought the company in 1987.

1.7.4 In addition to the 2 Helijet boats, the company operated 4 Kawarau Jet boats: two 28-seater and two 13-seater. The company employed 4 permanent drivers and the 2 owners acted as relief drivers when required.

1.7.5 Kawarau Jet maintained a berth at the Queenstown town jetty from where the river trips were run. When not driving, the staff were employed at the jetty touting for passengers.

1.7.6 The company had its own training and operation policy in place before acquiring Helijet Limited. It did not have a policy of formal ongoing review to provide on-board observation of a driver's continued acceptable practices. Periodically one of the owners would observe a boat trip from one of the high vantage points above the river. They would watch for driving lines and techniques and felt that observations made without the knowledge of the driver were more meaningful.

1.7.7 The company had a Safe Operational Plan, which had been put in place shortly before the accident. The plan had been made in consultation with and approved by an authorised person. The plan included a boat maintenance schedule. All the boats were fully inspected at the end of each day and any maintenance required was carried out before the boats were housed for the night. The drivers carried out a shorter inspection before each boat was put onto the water at the start of a day.

1.8 Boat information

1.8.1 *Helijet 2* had a shallow-V bow progressively transforming to a relatively flat bottom stern. The boat was fitted with planing strakes to reduce side-slip in a turn.

1.8.2 *Helijet 2* was capable of seating up to 18 passengers. The driving position was on the front left with a short passenger seat to the right. Behind the driver were rows of bench seats across the full width of the boat. The engine compartment was at the stern.

1.8.3 *Helijet 2* had been inspected by a Maritime Safety Authority (MSA)-authorised person and been deemed fit for use as a commercial jet boat to carry up to 18 passengers.

1.8.4 Propulsion was achieved using a water jet unit driven by an inboard petrol engine. An impeller, housed within the jet unit tailpipe, drew a high volume of water into the tailpipe through a grill-covered intake located in the flat-bottom area near the stern. The water was then ejected at pressure through a restricting nozzle at the aft end of the tailpipe near the surface of the water, producing forward thrust (see Figure 5).

1.8.5 Speed and reverse thrust were achieved by a combination of throttle setting and cable-operated reverse bucket. When the reverse bucket was fully open the water efflux was rearwards, thrusting the boat forwards. As the bucket was closed, an increasing amount of the water jet was deflected forward, progressively changing the resultant thrust from forward to reverse. The engine throttle was operated independently of the bucket.

1.8.6 Steering was achieved by a cable-operated deflector nozzle that moved laterally within a spherical bowl cavity at the aft end of the jet unit, deflecting the water jet left or right depending which way the steering wheel was turned. Steering was thus integrally linked to the propulsion. If propulsion were lost for whatever reason then steering capability was also lost.

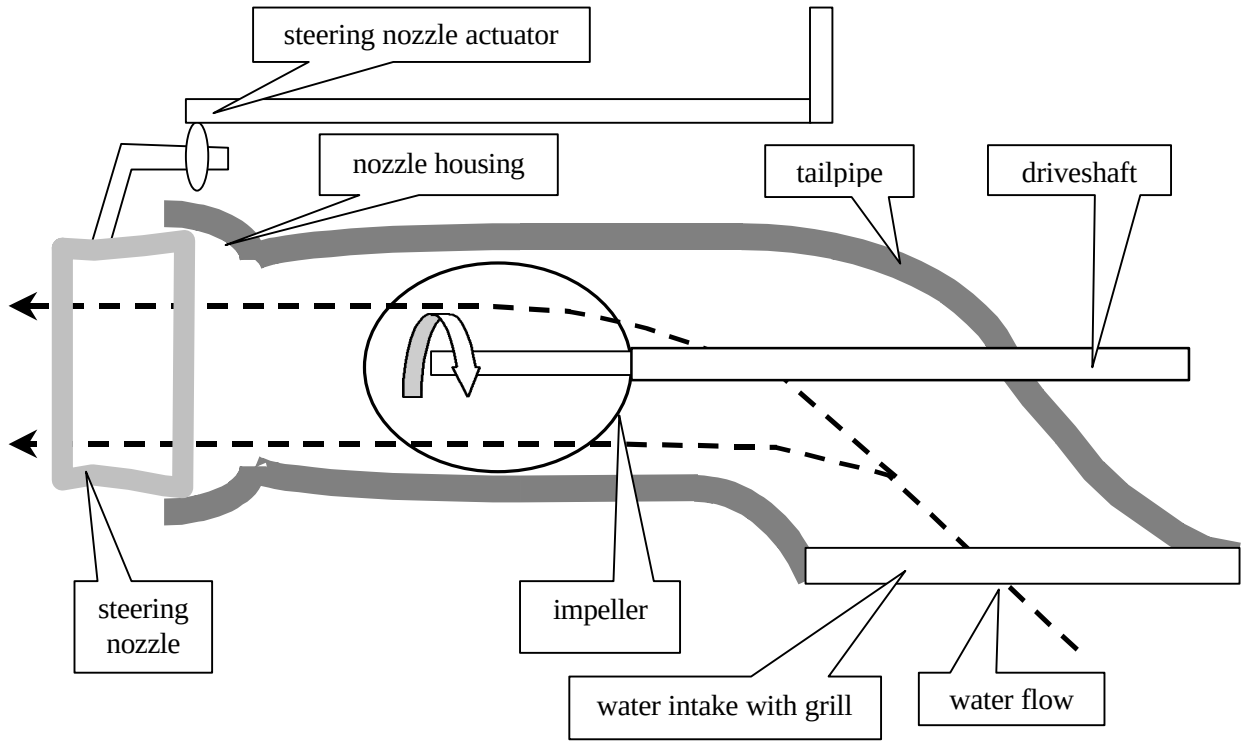

Figure 5
Simplified diagram of jet propulsion and steering

1.8.7 Steering mechanism design had been an ongoing development within the jet boat industry. The *Helijet 2* was fitted with a Hamilton Jet unit. Hamilton Jet Limited stated that the objectives of the steering design were to:

- generate lateral thrust with minimum loss of forward thrust
- provide sufficient lock and lateral thrust for good manoeuvrability
- minimise actuating loads
- function reliably under all conditions.

1.8.8 In about 1958, steering was achieved using a twin deflector "gate" system but operating loads on the steering components were high. It was only moderately efficient and there was a reduction of forward thrust when the water flow was deflected (see A in Figure 6).

1.8.9 The original steering design was used until about 1973, when the deflector pivot points were moved aft. The forces on the steering components were reduced but still considered to be heavy. The water flow passed both sides of the deflector when steering and although the reduction of forward thrust was not significant, the system was not responsive to small movements of the deflector (see B in Figure 6).

1.8.10 In about 1982, the steering design moved away from the gate system and the single conical deflector was introduced. The pivot point of the deflector was positioned to give partially balanced reaction forces, but without a forward seal a backflow and spray were generated when steering and the forward thrust was reduced (see C in Figure 6).

1.8.11 In about 1990, the single ball joint steering nozzle/deflector was introduced. There was a pressure drop within the spherical bowl area and forward thrust was reduced at all times, but there was good steering efficiency and low forces on the steering components. With this design came the possibility of the nozzle jamming within the spherical bowl, caused either by damage to the components or by debris limiting or stopping its movement (see D in Figure 6).

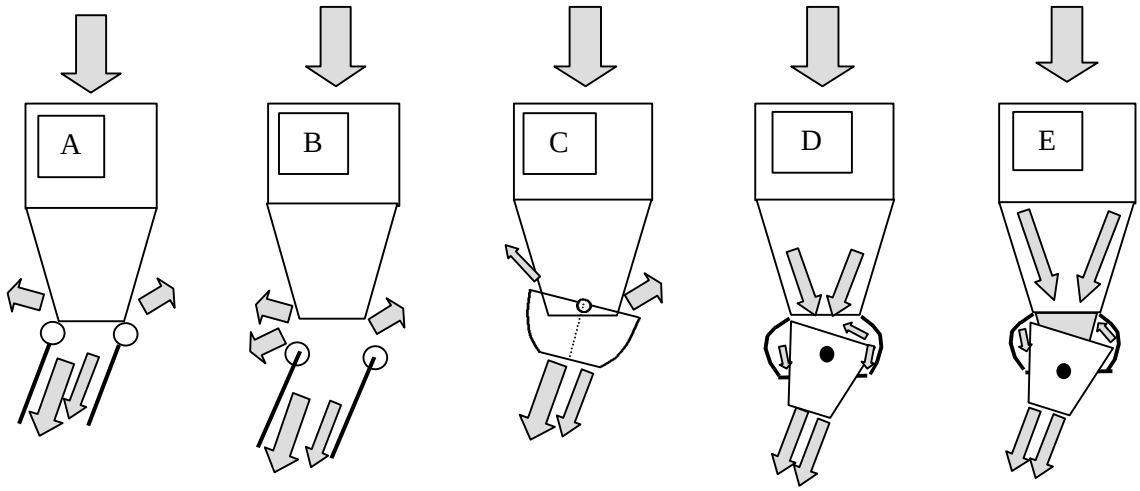

Figure 6
Development stages of Hamilton Jet jet boat steering

1.8.12 In about 1998, the design was further improved by the introduction of an insert extension of the tailpipe into the spherical bowl. The insert directed the water flow to exit aft of the bowl cavity, reducing turbulence and improving efficiency. There was a minimal gap between the insert and the inside surface of the nozzle, reducing energy loss (see E in Figure 6).

1.9 Steering problems

1.9.1 Through the design development of jet boat steering systems, the designers and the industry participants, including Kawarau Jet, worked towards not only improving the efficiency of the unit, but also eliminating or reducing the possibility of the steering jamming in operation.

1.9.2 The early designs were not as efficient as desired and suffered occasional jamming due to the exposure of the components. The introduction of the single ball joint steering nozzle increased steering efficiency but brought with it the increased possibility of the steering jamming.

1.9.3 The nozzle was housed within a spherical bowl with small clearances. Any debris, even small particles, passing through the bowl with the water flow had the potential to build up or lodge between the nozzle and the bowl when steering to one side, resulting in the nozzle being locked on that side.

1.9.4 Drivers were trained to recognise the symptoms of a steering lock-up and the required remedial action. In order to clear the debris, the accepted method was to shake the steering wheel from side to side to dislodge whatever might be trapped between the nozzle and the bowl.

1.9.5 The introduction of the insert in 1998 significantly reduced the possibility of debris entering the spherical bowl. The insert meant that the water flow, and any debris that it may contain, was directed through the bowl and into the mouth of the steering nozzle. The high speed and volume of the water flow when the boat was travelling in deep water at speed left almost no possibility for debris to enter the bowl (see Figure 7).

1.9.6 However, when a boat was manoeuvring in shallow water over sand and fine gravel, stopped in dirty water during driver commentaries or during reversing, it was still possible for small amounts of debris to enter the spherical bowl cavity from aft through the small gap between the inside of the bowl and the steering nozzle.

1.9.7 If debris entered the spherical bowl cavity it was possible for it to be held in there by the turbulence as the boat trip continued, but would more likely be ejected through the steering nozzle. It was, however, possible that debris could become lodged between the steering nozzle and the spherical bowl in much the same way as could happen before the introduction of the inserts (see Figure 7).

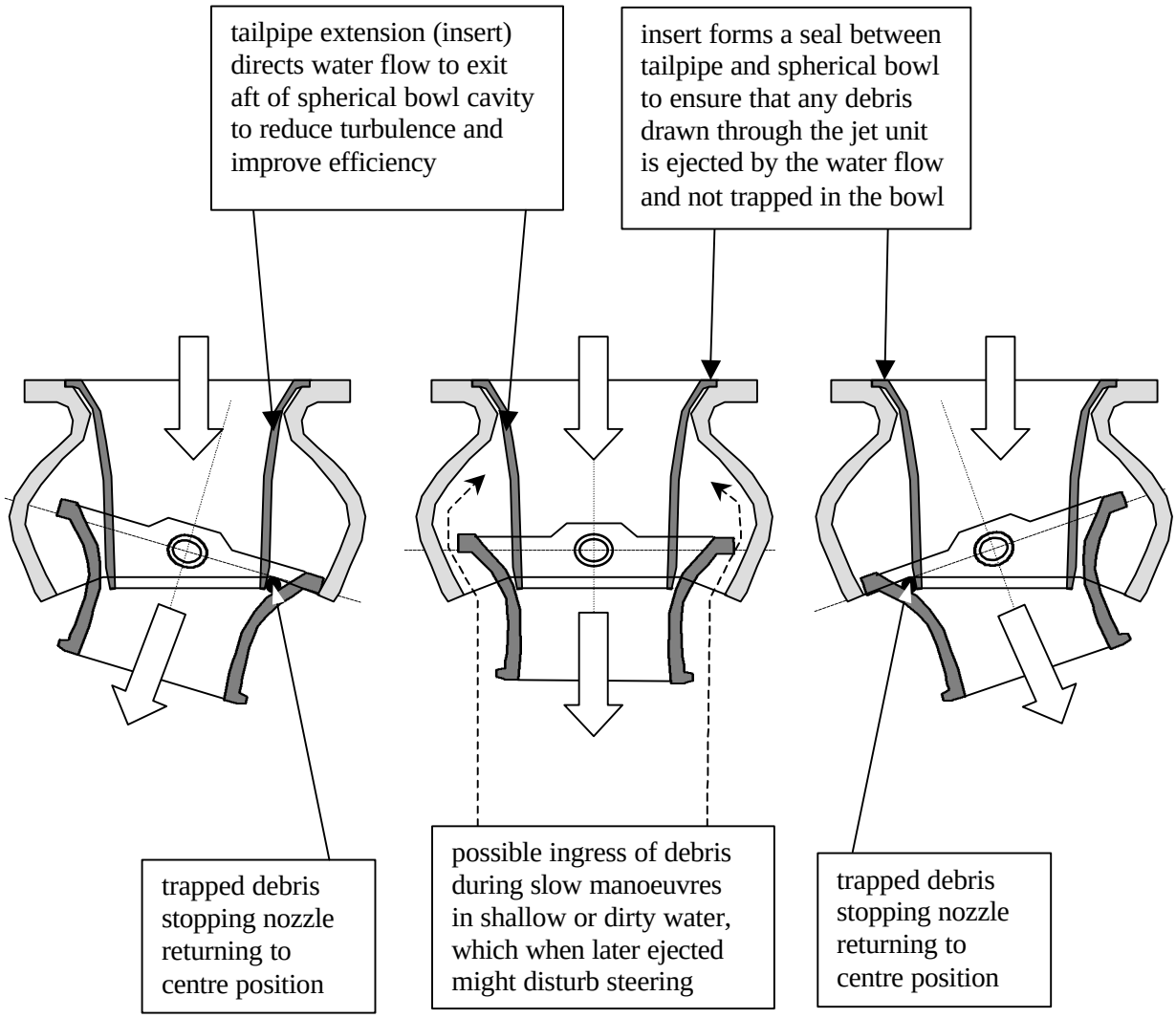

Figure 7
Diagram showing steering nozzle positions and possible effect of debris

1.9.8 After the accident, the steering mechanism on *Helijet 2* was inspected but nothing untoward was found. No telltale marks were found on the steering components that were consistent with hard debris having been present and causing the steering lock reported by the driver.

1.9.9 The steering nozzle of another of the company boats was inspected and an indentation was found on the surface of the insert, indicating that at some time hard debris had entered the spherical bowl and had been trapped, and could have disturbed the steering of that boat in a similar way to that reported by the driver of *Helijet 2* (see Figure 8).

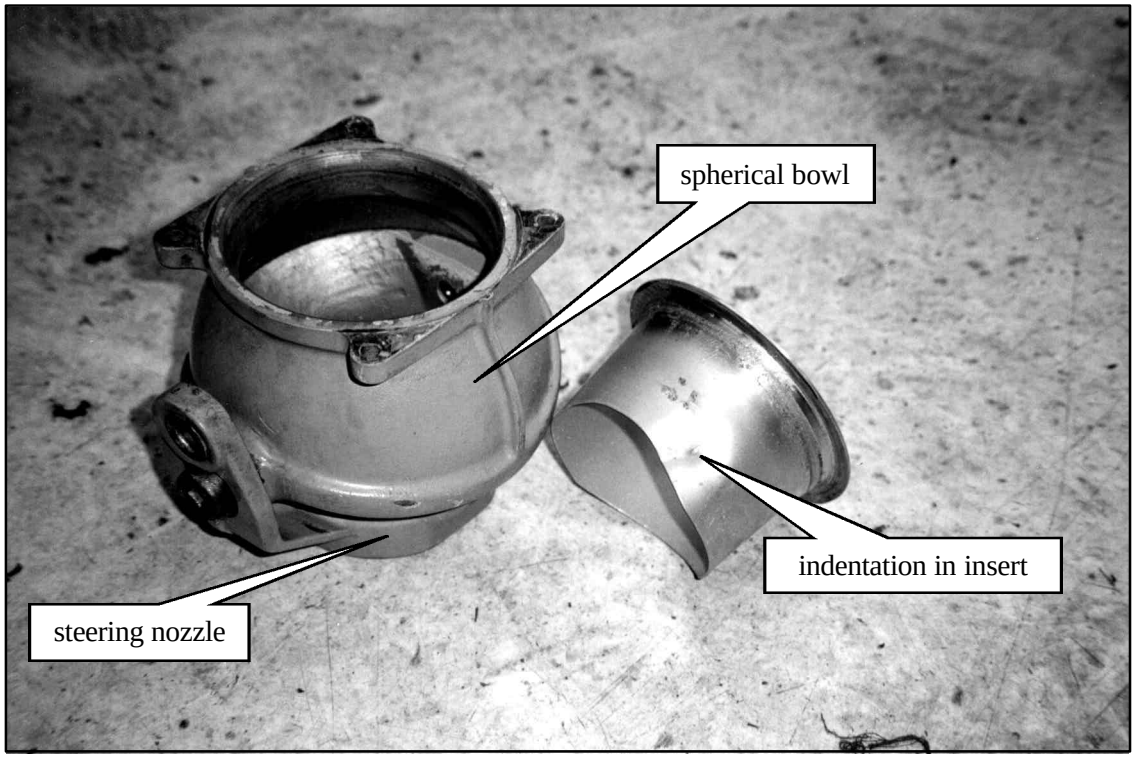

Figure 8
Photograph of steering components with insert from a similar boat

2. Analysis

2.1 The driver of *Helijet 2* had completed his training between November 1998 and April 1999. His training had consisted of 120 hours without passengers plus two 25-hour probationary periods with increasing passenger loads.

2.2 The training given to the driver exceeded the requirements of the then current Maritime Rules and those of the QLDC. His training would have provided a solid base on which to build his experience.

2.3 Kawarau Jet acquired the Helijet operation shortly after the driver commenced solo driving, and he transferred to Kawarau Jet at that time. His new employers appraised his capabilities and were satisfied with his training and performance, although some further training was undertaken to familiarise him with their own boats.

2.4 The cause of the driver losing control of his boat could not be proven. The components of the steering system functioned normally after the accident and no marks were found to indicate that any hard or abrasive debris had been trapped within the system.

2.5 The symptoms described by the driver, where he was steering to the right but was then unable to turn the wheel back to the left, were consistent with a steering lock-up caused by debris lodged between the steering nozzle and the spherical bowl.

2.6 During training, the driver had been taught to recognise and clear such a lock-up by turning the wheel rapidly from side to side to dislodge the debris, a manoeuvre he had previously successfully carried out when faced with a steering lock-up on a different boat. One of the passengers observed him taking such action just before the accident, which confirms the driver's perception of the problem.

2.7 On the day of the accident the Shotover and Kawarau Rivers were in flood and carried more than a usual amount of debris. It would be possible for debris such as paper or plastic to partially choke the water inlet and affect the steering. In such a case the water flow through the jet unit would be restricted, which would cause a reduction of propulsion and a corresponding sluggishness in the steering. It would not however cause the symptoms described by the driver.

2.8 Just before the accident, *Helijet 2* entered an area of turbulence caused by an eddy. Had the water intake picked up aerated water, similar symptoms to an intake blockage could be produced, again not as those described by the driver.

2.9 Steering lock-up was a problem that designers and operators had worked to overcome. The system with the tailpipe extension insert, as fitted on *Helijet 2*, went some way towards reducing the possibility of debris carried by the water flow lodging within the system because the water was ejected straight into the steering nozzle, but it did not eliminate the possibility of debris entering the spherical bowl through the rear of the tailpipe.

2.10 During a typical jet boat ride the drivers demonstrate the boat's ability to manoeuvre in shallow water, usually over the gravel and sand at the edges of the river. The drivers also demonstrate the ability of the boat to perform spins, a thrilling manoeuvre for the passengers. After a spin the boat would be stopped in the water, which was disturbed around it. At several times during a trip drivers stop at points of interest and give the passengers a commentary on local features and history while holding the boat in position with combinations of forward and reverse thrust.

2.11 When manoeuvring in shallow water, stopped in disturbed water or stopped and holding position with reverse thrust in an area of dirty water, it would be possible for debris, either fine gravel or small floating objects, to enter the steering system from aft. Once within the spherical bowl the debris could be held there until the boat continued and would likely be ejected. However, there was the possibility that such debris could become trapped within the bowl and cause a steering lock-up.

2.12 The dent found in the insert of a similar boat does not prove that debris had caused a steering lock-up on *Helijet 2*, but does show that ingress of debris is still possible even with an insert fitted. If debris had lodged in the nozzle of *Helijet 2* it was probably material such as vegetation.

2.13 The driver had driven an earlier trip on the day of the accident but had not travelled down the Kawarau River beyond the confluence with the Shotover River. He knew that the rivers were in flood and conditions were somewhat unusual. When travelling downriver past the accident site the driver would have been concentrating on his driving line on the opposite side of the river to where the accident occurred.

2.14 When travelling along the rockface upstream, it was the first time that day that the driver could closely observe the actual river condition in the accident area. Although he knew the river to be in flood he still traversed the area on his usual line, keeping about half a metre off each rocky outcrop. With the river in flood, it would have been prudent for him to have increased his passing distance off the outcrops.

2.15 When the driver perceived a steering lock-up, his actions in slowing the boat and moving the wheel from side to side were consistent with his training and appropriate for the situation as he thought it to be.

2.16 Once the driver re-established steering, his reactions to avoid a head-on collision with the rockface were quick and appropriate. From the time he turned around the last outcrop to the point of impact, the boat travelled about 35 to 40 m. Even allowing for the reduction in throttle, this equated to an elapsed time of about 2.5 to 3 seconds.

2.17 It was not clear if the eddy within the cove affected the line of travel or speed of the boat, but from the time the driver became confident in his ability to steer, only about one second would have remained before impact. The time and distance remaining were insufficient to achieve a crash stop by applying reverse bucket. Had the driver attempted to stop the boat in this manner, the occupants may have been thrown forward and possibly out of their seats during the violent slowing process, and thrown yet again at the point of probable head-on impact. In that scenario the injuries could have been more severe than they were.

2.18 Most of the occupants of *Helijet 2* were thrown around inside the boat in the impact. They were propelled mainly forward by the sudden deceleration but also sideways by the impact on the right side of the boat.

2.19 The design and construction of the interior of *Helijet 2* offered little protection from injury to the occupants. The seat backs were covered with minimal padding and it was contact with these and the handrails that probably inflicted most injuries. When accidents do occur, the severity of injuries to occupants is often dependent on the design of the boat interior.

2.20 Maritime Rules Part 80 required that jet boats were fitted with footrests against which the occupants could brace themselves and recommended that such footrests be inclined flat plates. *Helijet 2*, constructed before Part 80, had footrests fitted but they consisted of square section bar, under which passengers could place their feet if they were not instructed otherwise. An inclined flat plate footrest would offer better support for the passengers and would be likely to reduce injuries in the event of an accident.

2.21 The commission has investigated 6 previous accidents involving commercial jet boats and has identified a trend in the last 4 accidents that the drivers had less than one year's experience. This accident continued that trend. Although the driver appeared to have reacted appropriately to what he thought was a steering lock-up, a more experienced driver possibly may have not been as close to the rock outcrops in high river conditions with a lot of debris present in the water.

2.22 Jet boating is marine adventure tourism and carries with it a certain degree of inherent risk, but its growing popularity and increased numbers of participants make it vital to keep the risks to a minimum.

2.23 Driver training is an important defence against accidents but, as with many activities, even the most experienced operators can be involved in accidents.

2.24 The training afforded to the driver of *Helijet 2* was above the minimum required by legislation but would have benefited from ongoing review by the senior drivers in the company, particularly if such review was undertaken at times when river conditions were out of the ordinary.

2.25 Having completed his training in April 1999, the driver had four months' experience driving solo with passengers. In other investigations with similarly experienced drivers, the commission has identified a trend where drivers' confidence can grow ahead of their capabilities as they gain experience.

3. Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

3.1 The driver of *Helijet 2* held the required licence for the operation he was conducting.

3.2 The driver of *Helijet 2* had received adequate initial training to enable him to drive solo with passengers on board. The amount of his training had exceeded legislative requirements.

3.3 The driver of *Helijet 2* would have benefited from a formal system of periodic follow-up training and review by the operator, particularly if that training and review were occasionally undertaken during periods of unusual river conditions.

3.4 The river was in flood and rather than follow his usual driving line, it would have been prudent for the driver to have increased his passing distances off obstructions to give himself greater margins in the event of error, accident or mechanical failure.

3.5 *Helijet 2* struck a rocky outcrop when the driver experienced what he described as a steering lock-up and momentarily lost control of his craft.

3.6 The symptoms described by the driver and his remedial actions to free the steering were consistent with a steering lock-up caused by debris within the steering system, but steering lock-up could not be conclusively established as the cause of the accident.

3.7 There was no evidence of mechanical failure having contributed to the momentary loss of control of *Helijet 2*.

3.8 *Helijet 2* was fitted with a Hamilton Jet propulsion and steering unit that incorporated a tailpipe extension insert intended to eliminate the ingress of debris via the jet unit.

3.9 While an insert eliminates the ingress of debris via the jet unit, it was nevertheless feasible that small debris could enter the steering system from aft while the boat was manoeuvring in shallow water or stopped in disturbed water.

3.10 Whether his steering problem was actual or perceived, the driver's remedial actions and actions to avoid a head-on collision with the rockface were timely and appropriate.

3.11 After the accident the driver's actions in keeping the boat off the rockface, beaching it downriver and attending to his passengers' needs were appropriate.

3.12 *Helijet 2* had been inspected by an authorised person and approved for commercial operations.

3.13 The interior design and construction of *Helijet 2* offered little protection to the occupants to minimise injury in the event of a sudden impact accident.

3.14 In view of the work history of the driver of *Helijet 2*, fatigue was not considered to have contributed to the accident.

4. Safety Recommendations

4.1 On 2 June 2000 it was recommended to the Directors of Kawarau Jet Limited that they:

4.1.1 Review the company promotional advertising literature for both Kawarau Jet and Helijet to ensure that prospective customers are made fully aware of the nature of the trip they may be undertaking and the inherent risks involved. (030/00)

4.1.2 Ensure that drivers include in the pre-trip safety briefing that passengers should use the footrests to brace themselves against the motion of the boat. (031/00)

4.1.3 Consider fitting inclined solid plate footrests, similar to those fitted for the front seat passengers, throughout the Helijet boats. (032/00)

4.1.4 Consider enhancing internal features of the Helijet boats to increase the protection afforded to passengers in the event of an accident. (033/00)

4.1.5 Introduce a system of driver review where junior drivers are periodically assessed by a senior driver and senior drivers by their peers. From time to time, such reviews should be undertaken when river conditions are near safe operating limits. (034/00)

4.2 On 12 June 2000 the Directors of Kawarau Jet Limited responded as follows:

4.2.1 Recommendation 030/00
Please refer to our brochure reading …
"Jetboating is an adventure activity with a degree of risk. Even though commercial operations are run within strict safety guidelines, the operator cannot guarantee the absolute safety of the participants or their belongings."

4.2.2 Recommendation 031/00
We enclose a copy of the newly issued Safety Briefing sheet that our drivers run through with our passengers prior to a trip commencing. This sheet was developed with symbols to assist with foreign visitors under the guidance of our local Harbour Master.

4.2.3 Recommendations 032/00 and 033/00
We shall address the modification points with the owners and advise you accordingly. Kawarau Jet is supplied with these boats to carry Helijet passengers under contract.

4.2.4 Recommendation 034/00
We are currently in the process of revising our complete operating manual. We acknowledge the recommendation of periodic assessment and shall include such a programme into our practised procedures.
We aim to have this manual completed by the end of July this year.

Approved for publication 13 June 2000

Hon. W P Jeffries
Chief Commissioner