Report 98-205

jet boat *Predator*

rock strike

Dart River, Glenorchy

23 March 1998

Abstract

At about 1050 on Monday, 23 March 1998, a commercial jet boat carrying 14 passengers was transiting down the upper Dart River. While negotiating a right hand bend in the river, the driver reduced power as he turned the boat hard left around a rock in midstream. When he re-applied power the engine stalled. Without directional control the driver was unable to prevent the boat striking a large rock on the river bank. The passengers and the driver received minor to serious injuries in the accident. Seven passengers were evacuated by helicopter.

Safety issues identified included the fitting of passenger seat belts and the recording in the boat of the number of passengers carried on each trip.

Predator

Transport Accident Investigation Commission

Marine Accident Report 98-205

Boat Particulars

Type:	Pro Tour commercial jet boat
Class:	Passenger (under 6 m)
Limits:	Lake Wakatipu and Dart River
Allowable occupants:	15 (including driver)
Length:	5.70 m
Built:	In November 1995, in Glenorchy by Neil Rees, Dart River Jetboat Safari Limited
Construction:	Aluminium mono-hull
Propulsion:	One 8200 c.c. 328 kW Chevrolet 502 petrol engine driving a single stage Hamilton 212 jet unit
Normal operating speed:	Up to 60 km/h (35 km/h average for the safari)
Owner/operator:	Dart River Jet Safari Limited
Location:	Upper Dart River, Glenorchy Approximately 300 m up river from Surveyors Flat
Date and time:	Monday, 23 March 1998, at 1050[1]
Persons on board:	Crew: 1 Passengers: 14
Injuries:	Crew: 1 (minor) Passengers: 2 (serious), 11 (minor)
Nature of damage:	Major distortion and impact damage at bow, moderate distortion of passenger seating, and minor scraping on hull.
Inspector-in-Charge:	Captain John Mockett

[1] All times in this report are NZST (UTC + 12 hours) and are expressed in the 24 hour mode

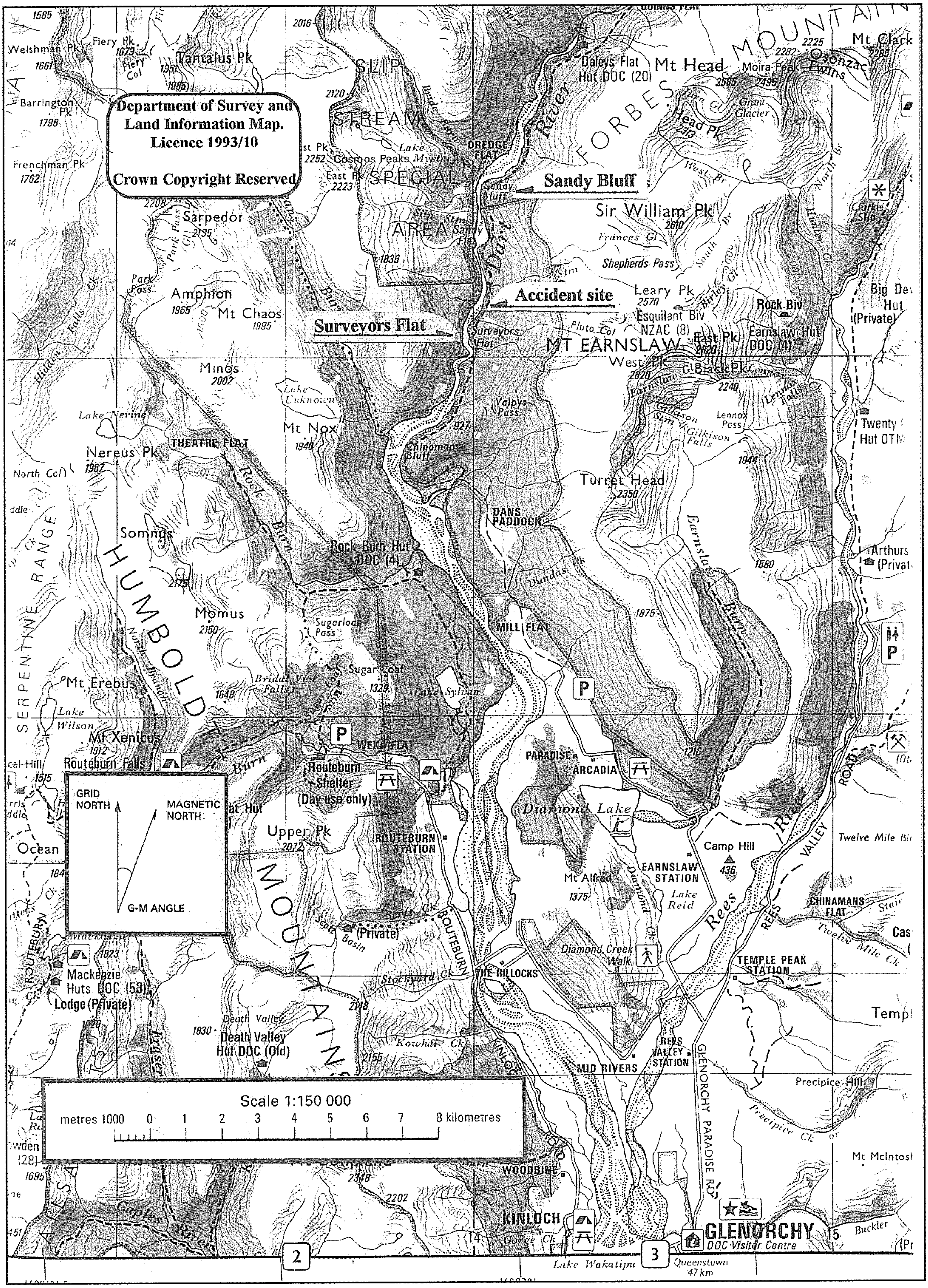

Figure 1
Map of Dart River

1. Factual Information

1.1 History of the trip

1.1.1 A group of passengers met at the Queenstown office of Dart River Jet Safari Limited (Dart River Jet) shortly before 0800 on Monday, 23 March 1998. They boarded a company bus, driven by one of the jet boat drivers, and after other passengers were picked up at various hotels, were driven to Glenorchy.

1.1.2 On arrival at the Dart River Jet base in Glenorchy at about 0900, the passengers were supplied with additional warm clothes, waterproof jackets, gloves and a lifejacket each. They were divided into smaller groups and assigned to four boats. The driver of the bus from Queenstown was to drive the jet boat, *Predator*.

1.1.3 The boats had been prepared and the daily safety inspections completed by the drivers and the mechanic at the base. There were no discrepancies noted on the inspection checksheets. The boats had been taken from the base to the marina where they had been launched and were awaiting the passengers.

1.1.4 The 14 passengers assigned to *Predator* were allocated seats in the boat by the driver. Before leaving the jetty, the driver gave a safety talk to his passengers. The talk outlined the aspects of the river section of the safari, detailed the boat and its safety equipment and explained signals that the driver might give to the passengers during the trip. The driver advised the passengers to remain seated at all times, to keep wholly inside the boat, to steady themselves by holding the rails, to brace themselves with their feet, to ensure that their clothing and lifejacket were properly secured and to tell the driver of any difficulties that they may have.

1.1.5 The convoy of four boats left the Glenorchy marina at about 0915 and proceeded across the northern part of Lake Wakatipu to the mouth of the Dart River. During this time the driver of each boat radioed the base to confirm their departure and the number of passengers on board. The passenger count was recorded at the Glenorchy Base but not in the boats. The drivers of the boats communicated with each other to arrange and agree convoy configuration.

1.1.6 *Predator* was the lead boat and the trip up river followed the normal pattern with several stops at places of interest and particular scenic value, each accompanied by a commentary from the driver. The trip took the boats up river as far as Sandy Bluff. The boats were about five minutes apart while on the river. (See Figure 1)

1.1.7 When *Predator* arrived at the Sandy Bluff turnaround position, the driver gave his passengers a commentary on the features and history of the area. During the stopover two of the other boats arrived.

1.1.8 Before commencing the return trip, the driver of *Predator* advised the passengers that the down river section of the trip would be faster due to the advantage gained by travelling with the river flow and that there would be only one stop. He repeated his warning to the passengers that they must keep wholly inside the boat and to hold on at all times. He also advised them to put away their cameras to leave themselves with both hands free.

1.1.9 The drivers of the boats in the convoy had been communicating their positions relative to each other and the driver of *Predator* knew that the river was clear for him to proceed down to Surveyors Flat, where the driver of the last boat in the convoy had agreed to wait before continuing up river. With the second and third boats still at Sandy Bluff, *Predator* left at about 1040.

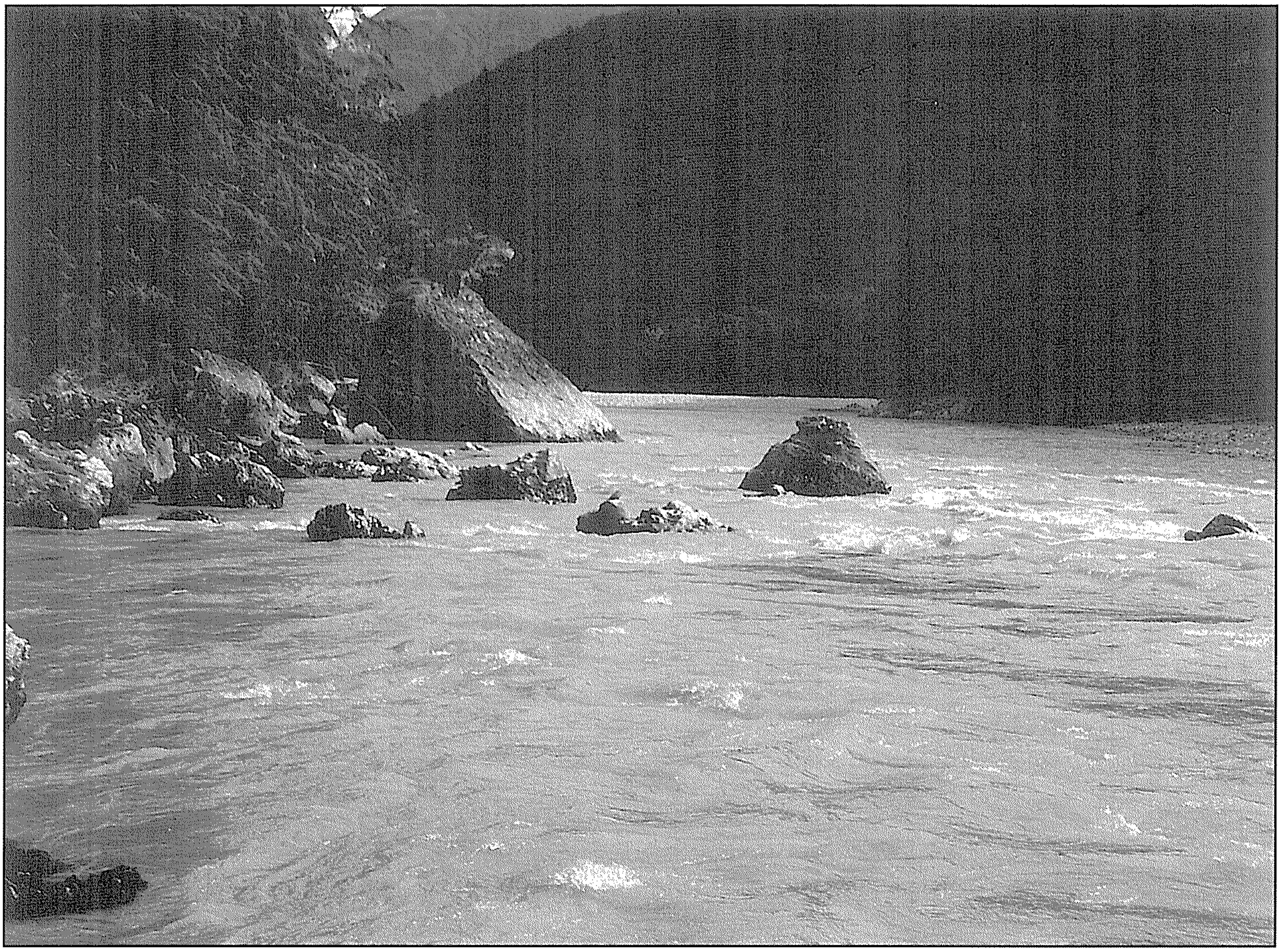

Figure 2
Accident site

1.1.10 About 300 m up river from Surveyors Flat, the driver had to negotiate a right hand bend in the river. The bend involved passages through a series of rocks, some of which were submerged (see Figure 2). The negotiating line had been established for safe passage at times of low river levels and thus avoided any rocks that might be submerged at other times (see Figure 3). The river level on the day of the accident was described by the drivers as "normal".

1.1.11 The driver took *Predator* to the outer extremity of the bend and lined up with a straight passage between several rocks. The flow of the river crossed the passage line so the driver accelerated to about 60 km/h to maintain directional stability. (See Figure 3)

1.1.12 When he reached the end of this short straight run, the driver turned to the left to pass a rock (rock 'A' in Figure 3) and at the same time reduced power to give the required speed for the next manoeuvre. He realised that he had reduced the throttle more than required and re-applied throttle. At this point the engine stalled.

1.1.13 Without engine power the driver lost directional control of *Predator*. As it decelerated the boat came off the plane and continued on the line in which it had been heading when power was lost. *Predator* was heading directly towards a large rock on the river bank (rock 'B' on Figure 3). Just before *Predator* struck the rock the driver called to his passengers to hold on tight .

1.1.14 The passengers were not restrained in their seats and the force of the impact threw them forward and one partially out of the boat. The handrails and the seat backs buckled as they absorbed the energy of the passengers' forward momentum.

1.1.15 The flow of the river pinned *Predator* against the rock and the driver was able to assist the passenger back into the boat and to assess the condition of all the passengers. He first ascertained that all the passengers were still in the boat, that they were all conscious and none had life-threatening injuries. Two of the passengers were trained nurses and assisted the driver in his assessment.

1.1.16 The driver radioed the two boats that were following him down river to advise them of his position and that *Predator* may be an obstruction to them. He then radioed Dart River Jet Glenorchy Base at 1050 and advised them of the accident and that he needed helicopter assistance to evacuate the more seriously injured passengers.

1.1.17 At about 1055 the two following boats went past. One continued on with its trip and the other joined the boat waiting at Surveyors Flat. The drivers of the two boats disembarked their passengers onto the beach at Surveyors Flat, secured one of the boats and proceeded to the accident site in the other.

1.1.18 At this time there was another company boat on the river with a trainee driver under tuition. This boat was directed by the base to proceed to the scene.

1.1.19 The driver of *Predator* re-started the engine but it stopped again shortly afterwards. However, it gave him just sufficient power and time to pull away from the rock and into the downstream flow. *Predator* then drifted in the current and beached on a bar about 100 m down river from the accident site.

1.1.20 Once in this relatively safe position, the driver re-evaluated the condition of the passengers and at 1105 radioed an update to the Glenorchy Base and requested two helicopters be dispatched to evacuate seven passengers. The injuries involved two suspected fractures, two possible concussions and several serious lacerations. He assessed that the remaining seven passengers were able to be evacuated by boat.

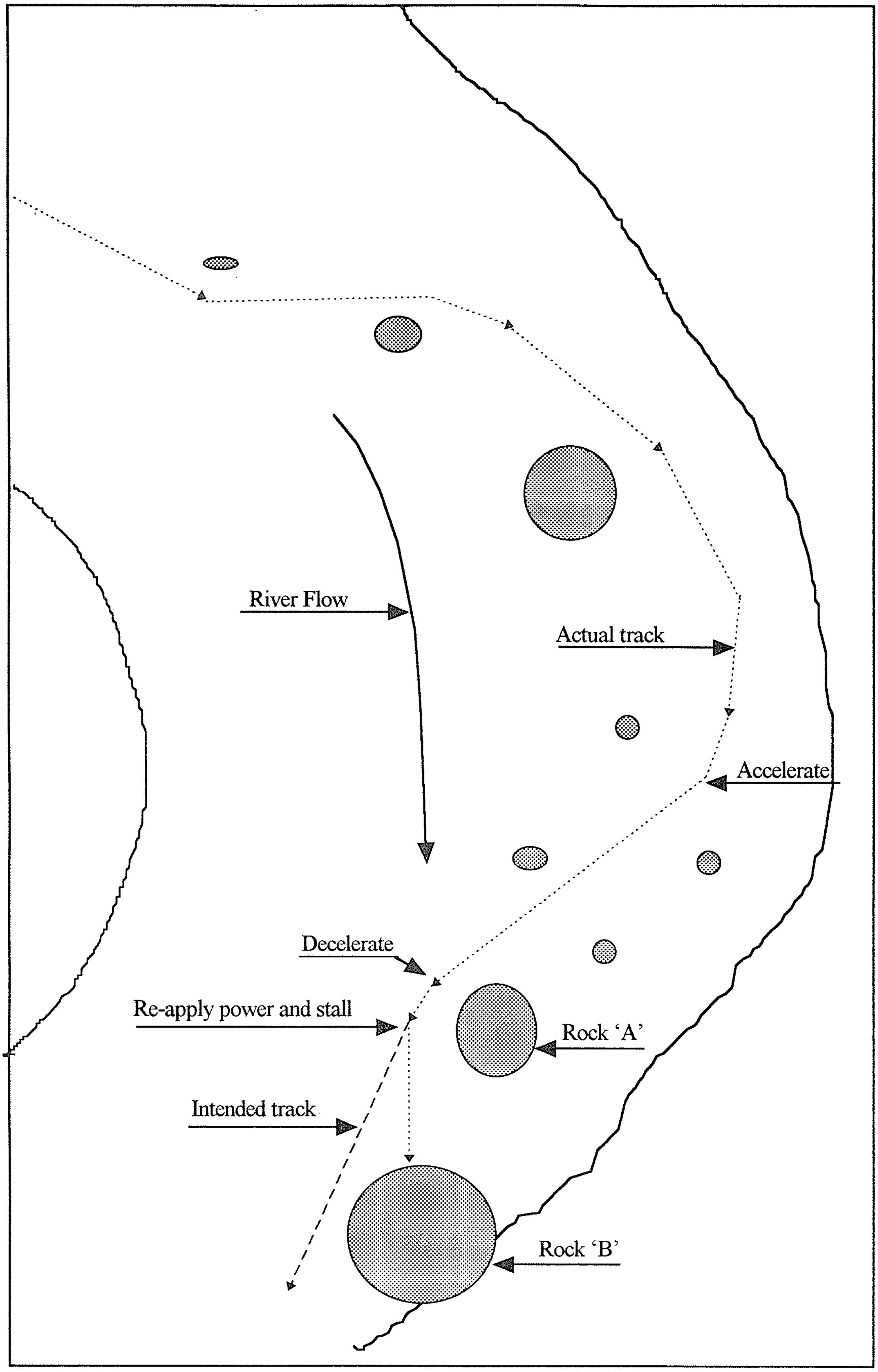

Figure 3
Negotiating line through right hand bend at accident site

1.1.21 The rescue boats transferred everyone to Surveyors Flat from where seven passengers were evacuated to Queenstown Hospital by helicopter. The remaining passengers and the driver of *Predator* were returned by boat to Glenorchy where they were treated at the local medical centre.

1.2 Boat information

1.2.1 *Predator* was a 5.70 m mono-hull jet boat constructed in aluminium. Propulsion was by one 8200 cubic centimetre Chevrolet 502 petrol engine driving a single stage 212 Hamilton water-jet unit. The engine developed a maximum of 328 kW at 4200 revolutions per minute (rpm), which gave a maximum speed of about 75 km/h. The engine was located in a covered compartment behind the passenger seating.

1.2.2 Speed and reverse thrust were achieved by the combination of throttle setting and a cable operated reverse duct[2]. When the reverse duct was fully open, the water efflux was rearwards, thrusting the vessel forward. As the reverse duct was closed, an increasing amount of the water efflux was deflected forward, progressively changing the resultant thrust from ahead to astern. The engine throttle adjustment was independent of the duct setting.

1.2.3 Steering was achieved by a cable operated deflector plate in the jet unit which deflected the water efflux left or right, depending on the direction in which the steering wheel was turned. If a steering cable failed, the water efflux would centre the deflector and the boat would stabilise on a relatively constant heading. If engine power was lost, the boat would drop off the plane rapidly and continue in the direction the bow was pointed regardless of the direction and amount of wheel the driver was applying at the time.

1.2.4 *Predator* was constructed with a deep-vee bow, progressively transforming into a relatively flat bottom stern. Planing strakes were fitted along the hull to reduce side-slipping and improve tracking and turning performance. A flat steel plate was fitted along the keel to reduce damage to the aluminium hull when operating in shallow water.

1.2.5 The boat was built specifically for safari operations on the Dart River. One feature incorporated to combat the potential cold and to encourage passengers to hold on, was the fitting of heated handrails. River water was pumped around the engine where it picked up residual heat prior to being passed through the handrails.

1.2.6 *Predator* had been inspected by the Queenstown Lakes District Council (QLDC) harbourmaster and was licensed by him to carry up to 14 passengers plus the driver.

1.2.7 The engine fitted to *Predator* had been installed new, when the boat had 727 running hours. At the time of the accident *Predator* had logged 1680 running hours. Thus the engine had 953 running hours. The engine checks and services carried out by the company mechanic were documented and were in accordance with the service schedule laid down in the company operations and safety manual.

1.2.8 The engine was originally designed to run on leaded petrol. With the introduction of unleaded 96-octane fuel, engine performance problems were reported within the jet boat industry. Although Dart River Jet did not experience any problems when using unleaded 96-octane fuel they, in common with other operators, converted their boat engines to run on aviation gasoline (Avgas).

1.2.9 At the time of the change from unleaded 96-octane fuel to Avgas 100/130, adjustments to the timing and tuning of the engine were made. No additional mechanical parts were required to be fitted.

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

1.2.10 For a few days prior to the accident, there had been supply problems with Avgas 100/130 and the Dart River Jet fleet temporarily reverted to using unleaded 96-octane fuel. At the time of the accident, *Predator* was running on unleaded 96-octane fuel.

1.2.11 For the short duration that unleaded 96-octane fuel was expected to be used, it was not considered necessary to re-adjust the timing and tuning of the engines. The company mechanics anticipated that some performance may be lost but this would not affect the Dart River Jet operation. None of the company drivers reported any engine problems with any of the boats during the period when unleaded 96-octane fuel was being used.

1.3 Post-accident information

1.3.1 Following the accident, it was established that the impact had moved the engine forward on its mountings and the drive shaft was disengaged from the jet unit. After the impact, the drive shaft was probably only just engaged with the jet unit and finally separated from it during the short engine run when the driver pulled away from the rock.

1.3.2 During an inspection after the accident, the engine started without problem and idled smoothly. The engine was accelerated to 3000 rpm and decelerated quickly. This test was repeated several times and on no occasion did the engine stall. The test was carried out with the drive shaft removed. Throughout the tests the engine sounded normal and free of any mechanical fault.

1.3.3 The spark plugs were removed from the engine and a compression test made to give an indication of the engine condition. There was no discolouration of the spark plugs and all compressions were even.

1.3.4 All of the electrical connections were checked and no faults were found. The distributor was checked and had no faults. The carburettor and fuel filters were uncontaminated and the float levels and operation of the carburettor were correct. The water and oil levels were all normal.

1.3.5 No fault was found in the engine or the accessories which might have caused the engine to stall. Other causes which may have been responsible were considered. Any of these conditions in isolation would be unlikely to have caused the engine to stall but a combination of the three may have done so.

- The throttle setting of *Predator* had been reduced quickly before power was re-applied. When in full-throttle operation, if the throttle setting is returned to idle too quickly it can cause an upset fuel/air mixture to enter the engine which might cause the engine to stall.
- *Predator* was fitted with a flexi-plate rather than a solid flywheel. A solid flywheel is more effective than a flexi plate because it gives the engine more inertia. The additional engine momentum helps stop the engine stalling when it is throttled back to idle speed.
- At the time of the accident, *Predator* was running on unleaded 96-octane fuel but the engine was timed and tuned for Avgas 100/130. Fuel might have been a contributing factor in the stall

    - The idle mixtures and combustion temperatures might have been affected.
    - The engine might have suffered pre-ignition when running on the lower octane fuel.
    - When the throttle was re-applied quickly, the engine might not have been able to respond causing it to stall.

1.3.6 With regard to the need for re-tuning and re-timing of the engine for use with unleaded 96-octane fuel, there was a divergence of opinion among operators, fuel suppliers, engine performance technicians and mechanics whether any change was necessary at all with the two fuels in question being of such similar octane rating.

1.3.7 The passengers spoken to commented that prior to the accident, the driver appeared to have had good control of the boat and had not been driving recklessly. They heard the engine stop just before the accident.

1.4 River and safari information

1.4.1 The Dart River is glacially fed and runs through Mount Aspiring National Park to the northern part of Lake Wakatipu. In the upper reaches the river passes through gorges and rocky areas with a relatively steep gradient. In the lower reaches the gradient reduces and the river widens to become braided with several tributaries within its banks.

1.4.2 On the day of the accident the river level was normal. Due to a period of warm weather, the glacially fed river had been at a moderate level for some time.

1.4.3 Dart River Jet is the only jet boat operator licensed to run trips on the Dart River and the company is limited to 20 boat trips per day. The company runs a fleet of eight boats, five licensed to carry 10 passengers and three licensed to carry 14 passengers. The safari follows a standard route and is usually run with three or four boats in convoy. Passengers generally start their trip in Queenstown but may join in Glenorchy.

1.4.4 The company regard and advertise the service as a “safari” rather than a thrilling adventure ride. The 45 km scenic drive to and from Glenorchy forms an intregal part of the trip. Use is made of jet boats to give added exhilaration to the trip and to enable greater distances to be covered in the time available. The safari ventures about 35 km up the Dart River from Glenorchy. The overall package is a 5.5 hour return trip from Queenstown.

1.4.5 Drivers are trained to inter-relate with their passengers and many stops, with a commentary on each, are woven into the trip. An optional 20 minute bush walk on the down river section is advertised as a highlight of the “wilderness experience”. Also on the down river section, if requested by the passengers, the drivers choose a wide part of the river to demonstrate the capabilities of a jet boat by executing a spin. After the river trip passengers have a meal, often with the driver, at a local lodge before returning to Queenstown.

1.4.6 Drivers are rostered on for five days each week. They generally drive two river trips each day and may also be required to drive the passengers from or to Queenstown. In busy periods it is sometimes necessary for drivers to drive three river trips but they are not then required for driving the road transport.

1.5 Licensing and training information

1.5.1 Drivers were required to undergo training with a minimum of 25 hours driving tuition before being assessed by the QLDC harbourmaster. After successfully passing the test, a candidate had to complete a further 25 hours of probationary driving under the supervision of a licensed driver. On completion of the probationary requirement the driver was authorised by the harbourmaster to drive a commercial jet boat in the specific area in which he had been trained.

1.5.2 Dart River Jet had a full training programme in place. It was not necessary for new entrants to have had any previous boat handling experience. The management of Dart River Jet said they selected new entrants on the basis of attitude, maturity and personality, with any boat handling or mechanical knowledge being secondary considerations.

1.5.3 The Dart River Jet training course schedule was:

Week one	introduction to Dart River Jet Safaris and operational procedures.
Week two	begin stage one river training concentrating on lower section of the river from Glenorchy to Paradise.
Week three	begin advanced control training, including planing turns, spins etc. from Glenorchy to Beansburn Confluence.
Week four	begin gorge training, locating rocks and identifying established negotiating lines.
Week five	begin passenger training (i.e. other staff and friends)
Day 25 (if ready)	proceed with QLDC harbourmaster inspection.
Week six	begin commercial trips with a senior driver on board, slowly increasing loadings. Trainee drives upstream leg only until senior driver is completely satisfied with the trainee's ability.

Each trainee must complete weekly checklists and an individual training log to be presented to the QLDC harbourmaster.

Training weeks two to five account for 25 hours actual instruction each week. At completion of the programme 100 hours training will be achieved.

Weeks seven, eight and nine form a probation period when the trainee driver can operate only when on the river in tandem with other licensed drivers.

1.5.4 During training drivers learnt the established negotiating lines in areas where the river flow is constant, more particularly in the upper gorge section. In the braided lower section of the river, the drivers are taught to "read" the changing nature of the river and identify the best tributary to follow.

1.5.5 Drivers were taught to keep a safe distance off any object, to turn from shallow to deeper water and to always keep the bow of their boat pointing away from any hazard, so that the boat would pass clear in the event of a steering or power failure. However, to keep the bow of a boat always pointing away from obstructions was virtually impossible and drivers had to concentrate their efforts on those hazards immediately in their path.

1.6 Company information

1.6.1 Dart River Jet Safari Limited (Dart River Jet) was a wholly owned and operated subsidiary of Shotover Jet Limited (Shotover Jet). Shotover Jet, established in 1970, was one of the first jet boat companies to operate in the Queenstown area. Shotover Jet acquired Dart River Jet as a going concern in August 1996.

1.6.2 Shotover Jet was ISO 9001 accredited. The operations, procedures and safety manuals for Shotover Jet had been adapted for the Dart River Jet operation but Dart River Jet was not ISO 9001 accredited. The provisions and procedures outlined in the manuals were fully implemented and documented in the Dart River Jet operation. The manuals were subject to internal audit by the Shotover Jet quality office.

1.6.3 The operations manual contained a crisis management plan which detailed initial response, rescue, victim support, required notifications and public relations control.

1.6.4 Shotover Jet appraised the Dart River Jet operation critically and progressively changed the procedures and practices to bring them in line with those followed in the Shotover Jet operation.

1.6.5 A detailed planned maintenance programme for the boats was formulated which stipulated various service requirements at specific running hour intervals. Additionally, daily boat checks were required and any faults had to be reported to the base mechanic for rectification.

1.6.6 When Shotover Jet acquired Dart River Jet, each of the jet boats had a radio fitted, but there were certain areas of the upper reaches of the Dart River from where the boats could not communicate with Glenorchy Base. The equipment in the boats was upgraded from very high frequency (VHF) radios to single side band (SSB) radios in order to utilise frequencies compatible with a repeater antenna that had been set up upriver at Mount Alfred by The Radio Users Community Group. The improvement in the communication was such that the boats could contact Glenorchy Base from any position within the safari route. The company buses were also fitted with similar radios.

1.7 Personnel information

1.7.1 The driver of *Predator* was a seasonal employee and had joined Dart River Jet in early November 1997. He had completed his driving tuition on schedule and passed the harbourmaster's inspection on 5 December 1997. He completed his probationary driving by late December and was authorised by the QLDC harbourmaster as a jet boat driver on Lake Wakatipu and the Dart River.

1.7.2 The driver had no previous boating experience but the management and training drivers reported that he had shown a good aptitude for handling jet boats and his training had been completed to the satisfaction of all concerned. He had demonstrated an outgoing personality and maturity which equipped him well for dealing with a group of passengers over the period of each safari.

1.7.3 The driver was a qualified and experienced first-aider.

1.7.4 Drivers were rostered on duty for five days each week. The driver of *Predator* had worked the previous four days. The day before the accident he had made only one river trip, as most of the operation on that day was cancelled due to poor weather. Operations had been cancelled on one other of his rostered days. On each of the other two days he had driven two river trips and one road trip.

1.7.5 The driver had been to a function on Friday, 20 March but had a late start rostered on the Saturday. His off-duty time on Saturday and Sunday had been spent mostly at home.

1.7.6 The manager of Dart River Jet had been a jet boat driver for five years with Shotover Jet prior to being taken into the operations team at Shotover. He became manager of Dart River Jet when Shotover Jet acquired the company. He trained and became a licensed driver for the Dart River area. In addition to his managerial duties he often drove trips to keep himself current with the river and to build a rapport with his staff. He had been part of the team involved in the training of the driver of *Predator*.

2. Analysis

2.1 The driver training programme at Dart River Jet gave potential drivers tuition hours and experience over and above the minima required by the QLDC harbourmaster. The programme was designed to afford a trainee steady progress through the acquisition of driving and inter-personal skills required for the particular operation of the company.

2.2 The driver of *Predator* had completed his training to the satisfaction of Dart River Jet management and had passed his test by the QLDC harbourmaster without problem. His probationary hours had been completed by late December 1997. At the time of the accident he had been driving unsupervised for three months.

2.3 Although authorised to drive alone, and having done so for three months, the driver would still be regarded as being new. He was considered by the management to have a good aptitude for jet boating but opinion within the industry suggests that it takes up to a year for drivers to become fully competent and be able manoeuvre their boat naturally.

2.4 The driver of *Predator* was on the fifth day of his roster. Considering the hours that he had worked in the days leading up to the accident, fatigue is not considered to have been a contributory factor in the accident.

2.5 River conditions were good on the day of the accident and had been at or about the same level for several days. At the accident site the direction of the river flow and the negotiating line remained the same whether the river level was high or low. The driver would have driven substantially the same line on each occasion that he transited down river.

2.6 Having successfully negotiated the majority of the right hand bend of the river, the driver reduced power when turning left at the end of a high speed straight run. Reducing the throttle too much while in a tight left turn would have caused the boat to begin to come off the plane and the foot of the bow to dig in and turn the boat further to the left, which resulted in *Predator* pointing directly towards the large rock on the river bank.

2.7 When he realised that he had throttled off too much, the driver tried to re-apply power. The reduction and reapplication of power in quick succession may have caused the engine to stall. The loss of power and the heading of *Predator* at that time are considered to be contributory factors in the accident.

2.8 The post accident inspection of *Predator* ruled out any faults in the engine or accessories that may have caused the engine to stall. The engine was fitted with a flexi plate rather than a solid flywheel. The flexi plate fitted to the engine may have contributed to the engine stall in conjunction with other factors. It is common for high performance jet boat engines to have flexi plates fitted as this allows greater acceleration, which increases the thrill aspect of the ride for the passengers. Because Dart River Jet put emphasis on the safari nature of their trips, rather than the thrill aspect, it would have been more appropriate for solid flywheels to have been used.

2.9 In common with the majority of jet boat operators, Dart River Jet ran their fleet on Avgas 100/130 with the engines tuned and timed for that fuel. The company's reversion to the use of 96-octane fuel without adjusting the tuning or timing, may have been a factor in the engine stall.

2.10 An engine tuned and timed for Avgas will run satisfactorily on 96-octane fuel but performance levels may be reduced. While the fuel/air mixture at idle speed, combustion temperatures and compression ratios may have been affected by the use of 96-octane fuel, tests carried out on *Predator* after its return to operation have been unable to replicate the stalling of the engine.

2.11 In the aftermath of an accident such as this, an immediate concern is to account for all the occupants of the boat. In this case, the driver was able to assist his passengers and other company boats were first on the scene. The number of passengers involved was known by the driver and, through the Glenorchy Base was known by the drivers of the rescue boats. Had any other party been first at the scene and the driver been incapacitated, there would have been no indication in the boat as to the number of persons to be accounted for.

2.12 The injuries sustained by the occupants of *Predator* were consistent with them being thrown forward by the impact. It is probable that the injuries would have been less severe had the passengers been restrained by lap belts.

3. Findings

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

3.1 *Predator* met the requirements of the QLDC and was appropriately loaded on the accident trip.

3.2 The driver of *Predator* was authorised by the QLDC harbourmaster to operate unsupervised on Dart River.

3.3 The driver of *Predator* was still at an early stage of his commercial jet boat career and still learning through on-going experience.

3.4 The driver decelerated more than required for his attempted manoeuvre, which caused the boat to turn further to the left than anticipated and head towards a rock.

3.5 The accident was caused by the engine stalling which left the driver without directional control while the boat was pointing towards the rock.

3.6 No reason was established as a cause of the engine stall, but it may have resulted from a combination of the following:

- rapid deceleration from high power,
- limited engine inertia because a solid flywheel was not fitted,
- the use of unleaded 96-octane fuel in an engine set up for Avgas 100/130.

3.7 The extent of the occupants' injuries would probably have been reduced had they been restrained by quick-release lap belts.

4. Safety Actions

4.1 Subsequent to the accident, the following actions have been taken by Dart River Jet Safari Limited:

- a dashpot has been fitted to the carburettor on *Predator* so that when the throttle is released the rpm will reduce quickly to about 1500 rpm and thereafter at a slower rate to the idle speed of about 1000 rpm. Once the performance of *Predator* has been evaluated, the other boats in the fleet will be fitted with dashpots, unless any detrimental effects are found,

- in each boat where a flexi plate was fitted to the engine, the flexi plate has been replaced by a solid flywheel,

- a company policy has been put into place that should Avgas not be available for any reason then operations will be suspended until such time as it becomes available. The engines will not be run on 96-octane fuel,

- to assist with the supply of Avgas, the company is subsidising the installation of a larger holding tank in Glenorchy.

4.2 As a result of a previous investigation, the Commission has made safety recommendations to the Director of Maritime Safety and the chairman of the Commercial Jet Boat Association that the number of passengers carried on each trip should be recorded at the base (as Dart River Jet does) and on the boat before the boat departs, to assist rescue services in accounting for all boat occupants in the event of a mishap.

4.2.1 In response to the safety recommendation, the Director of Maritime Safety indicated that the recording of passenger numbers will be included as a requirement of the safe operational plan in Part 80 of the maritime rules.

4.3 As a result of a previous investigation, the Commission made recommendations to the Director of Maritime Safety and the chairman of the Commercial Jet Boat Association that jet boats be fitted with quick release lap belts.

4.3.1 In response to the safety recommendation, the Director of Maritime Safety indicated that before incorporating this provision into the rules the Safety Authority would consult with the industry in relation to:

- other operational safety issues that may arise; and
- the costs involved.

4.3.2 On 26 August 1998 the Director of Maritime Safety responded as follows:

> We have studied in detail the outcomes of investigated accidents of commercial jet boats over the past 12 years and surveyed existing boats to assess the implications of retro-fitting them with . . . lap belts.
>
> It has been ascertained that the fitting of lap seat belts would require the replacement of seating within existing boats. These being presently inadequate to sustain the loads placed on them by any restraint of passengers seated on them. We also remain concerned about the implications of having passengers restrained in a boat should it sink. It was noted that 20 per cent of the accidents recorded eventuated in the boat sinking, often very rapidly.

> Injuries which have occurred as the result of the investigated accidents and where passenger restraint may have prevented or lessened such injuries have been analysed in some detail. It was noted that many of the serious upper body injuries would not have been mitigated by the fitting of lap belts.
>
> A full benefit/cost analysis has been undertaken in respect of the fitting of lap seat belts. Assumptions were made for the 12 year period that lower body injuries were eliminated and upper body injuries were reduced by 20 per cent. Costs included the retro-fitting of adequate seating and the purchase and fitting of lap belts to an average 12 passenger boat. If any drownings were to occur over that period as a result of using lap belts the costs exceed the benefits. If no drownings were to occur the benefits are still not significant.
>
> We therefore do not propose to implement the recommendation concerning the fitting of quick-release lap seat belts but we are concerned to follow up alternative means of ensuring passenger safety in respect of impact accidents.
>
> As the result of our study and discussions with the industry we believe that the incidence of impact accidents can be reduced and improvements can be made to the seating and passenger area of commercial jet boats which would reduce injuries resulting from such accidents. We are implementing several amendments to the 'Code of Practice' to facilitate this and the New Zealand Commercial Jet Boat Association are encouraging their members to re-evaluate their boats arrangements in this respect.

4.3.3 In response, the chairman of the Commercial Jet Boat Association advised that the recommendation would be considered at the annual general meeting of the Association on 11 July 1998.

4.3.4 On 30 July 1998, the chairman advised that the recommendation had been discussed at the annual general meeting. The meeting agreed unanimously that the implementation of this recommendation may place passengers at risk in a jetboat sinking/highside/fire situation, and is not practical.

> A major factor in all these situations would be disorientation of passengers, only thinking of trying to escape from the hull and forgetting to undo their seatbelt.

The meeting also agreed unanimously that:

> the Association/TAIC/MSA should look at the following to improve passenger safety in commercial jetboats:
>
> 1. Passenger compartment should be user friendly, i.e. padding in all areas, no sharp seat front edges, no sharp hand rail supports, legs of passengers at the proper angle so passengers can brace themselves, feet/legs cannot go under seat frames/drivers seat, dash area in front seating area properly designed etc.
>
> 2. Driver training, jetboat companies should have a more stringent assessment system (i.e. Police check, etc.) in place, and develop a more intensive training programme ensuring drivers are fully aware of their responsibilities, etc.

To ensure that [1 and 2 above] are implemented as soon as practical, the Association has contracted the Queenstown Harbourmaster to audit all its members by 30 November 1998.

4.4 In view of the safety actions taken by Dart River Jet Safari Limited, and the Commission's previous safety recommendations, which also relate to this accident, no new safety recommendations have been made.

Approved for publication 5 August 1998

Hon. W P Jeffries
Chief Commissioner

Glossary of marine abbreviations and terms

aft	rear of the vessel
beam	width of a vessel
bilge	space for the collection of surplus liquid
bridge	structure from where a vessel is navigated and directed
bulkhead	nautical term for wall
cable	0.1 of a nautical mile
chart datum	zero height referred to on a marine chart
command	take over-all responsibility for the vessel
conduct	in control of the vessel
conning	another term for "has conduct" or "in control"
deckhead	nautical term for ceiling
dog	cleat or device for securing water-tight openings
draught	depth of the vessel in the water
EPIRB	emergency position indicating radio beacon
even keel	draught forward equals the draught aft
freeboard	distance from the waterline to the deck edge
free surface	effect where liquids are free to flow within its compartment
focsle	forecastle (raised structure on the bow of a vessel)
GM	metacentric height (measure of a vessel's statical stability)
GoM	fluid metacentric height (taking account the effect of free surface)
GPS	global positioning system
heel	angle of tilt caused by external forces
hove-to	when a vessel is slowed or stopped and lying at an angle to the sea which affords the safest and most comfortable ride
Hz	hertz (cycles)
IMO	International Maritime Organisation
ISO	International Standards Organisation
kW	kilowatt
list	angle of tilt caused by internal distribution of weights
m	metres
MSA	Maritime Safety Authority
NRCC	National Rescue Co-ordination Centre
point	measure of direction (one point = 11¼ degrees of arc)
press	force a tank to overflow by using a pump

SAR	Search and rescue
SOLAS	Safety Of Life At Sea convention
sounding	measure of the depth of a liquid
SSB	single-side-band radio
statical stability	measure of a vessel's stability in still water
supernumerary	non-fare-paying passenger
telegraph	device used to relay engine commands from bridge to engine room
ullage	distance from the top of a tank to the surface of the liquid in the tank
VHF	very high frequency
windlass	winch used to raise a vessels anchor