Report 09-203, jet boat, *DRJS-11* grounding and subsequent rollover Dart River, near Glenorchy, 20 February 2009

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.

Report 09-203

jet boat
DRJS-11

grounding and subsequent rollover

Dart River, near Glenorchy

20 February 2009

Photograph courtesy of Dart River Jet Safaris Limited

DRJS-11

Executive Summary

Momentary driver distraction led to a tourist jet boat striking and overturning on a midstream gravel bank in the Dart River, near Glenorchy, at about 1545 on 20 February 2009. The driver and 3 of the 18 passengers suffered injuries, while the boat received minor damage to its hull and moderate damage to its canopy.

The jet boat was on the plane down-river towards Lake Wakatipu when the experienced driver pointed out a flock of geese taking flight to passengers. The driver then realised the boat was heading too close to a gravel bank, but his attempted course correction came too late to avoid the grounding, which he tried to manage with adjustments to helm and throttle. However, the boat rolled slowly onto its port side and slid along the bank on its side for a short time before coming to rest on its canopy.

The occupants escaped by kicking out windows as directed by the driver, with most exiting onto the bank. Two passengers exited into the river, where one became soaked in petrol running out of a tank vent. The post accident handling of the situation by the driver and company was well coordinated.

Safety issues identified in the investigation included: the potential difficulty of removing the canopy in a deep-water situation or if the boat were inverted; the passengers' inability to hear the entire pre-trip safety brief; the poorly marked emergency exit windows; and the fuel vent's design, allowing fuel to leak out from the upturned boat and above the exit windows.

The Transport Accident Investigation Commission has made recommendations to the Director of Maritime New Zealand: to encourage proper recognition of driver distraction in jet boat operations; regarding the marking of emergency exits from enclosed boats; and regarding the design and placement of fuel vents.

(Note: this executive summary condenses content to highlight key points to readers and does so in simpler English and with less technical precision than the remainder of the report to ensure its accessibility to a non-expert reader. Expert readers should refer to and rely on the body of the full report.)

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Abbreviations

°	degree(s)
Cumec(s)	cubic metre(s) per second
DRJ Safaris	Dart River Jet Safaris Limited
DRJS-11	*Dart River Jet Safaris 11*
Km/h	kilometre(s) per hour
m	metre(s)
mm	millimetre(s)
UTC	universal co-ordinated time
VHF	very high frequency

Glossary

chine	the join between the bottom and the side of a boat
code one	major injury accident

Data Summary

Vessel particulars:

Name:	*DRJS-11*
Type:	commercial jet boat
Class:	marine craft used in adventure tourism
Limits:	Dart River
Length:	7 metres (m)
Breadth:	2.6 m
Built:	December 2004 for Dart Wilderness Adventures
Propulsion:	2 x Mercruiser 377-cubic-inch, electronic fuel-injected petrol engines, each developing 235 kilowatts, each driving a Hamilton 212 jet unit
Service speed:	about 70 kilometres per hour
Owner/operator:	Ngai Tahu Tourism Limited
Allowable occupants:	one crew and up to 24 passengers

Date and time:	20 February 2009 at about 1545[1]
Location:	Dart River, near Glenorchy
Persons on board:	crew: one passengers: 18
Injuries:	crew: one minor passengers: one serious, 3 minor plus minor bruising
Damage:	minor scrapes to hull of boat; polycarbonate canopy partially crushed and windows shattered towards the front of the cabin.
Investigator-in-charge:	Captain Iain Hill

[1] Times in this report are New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

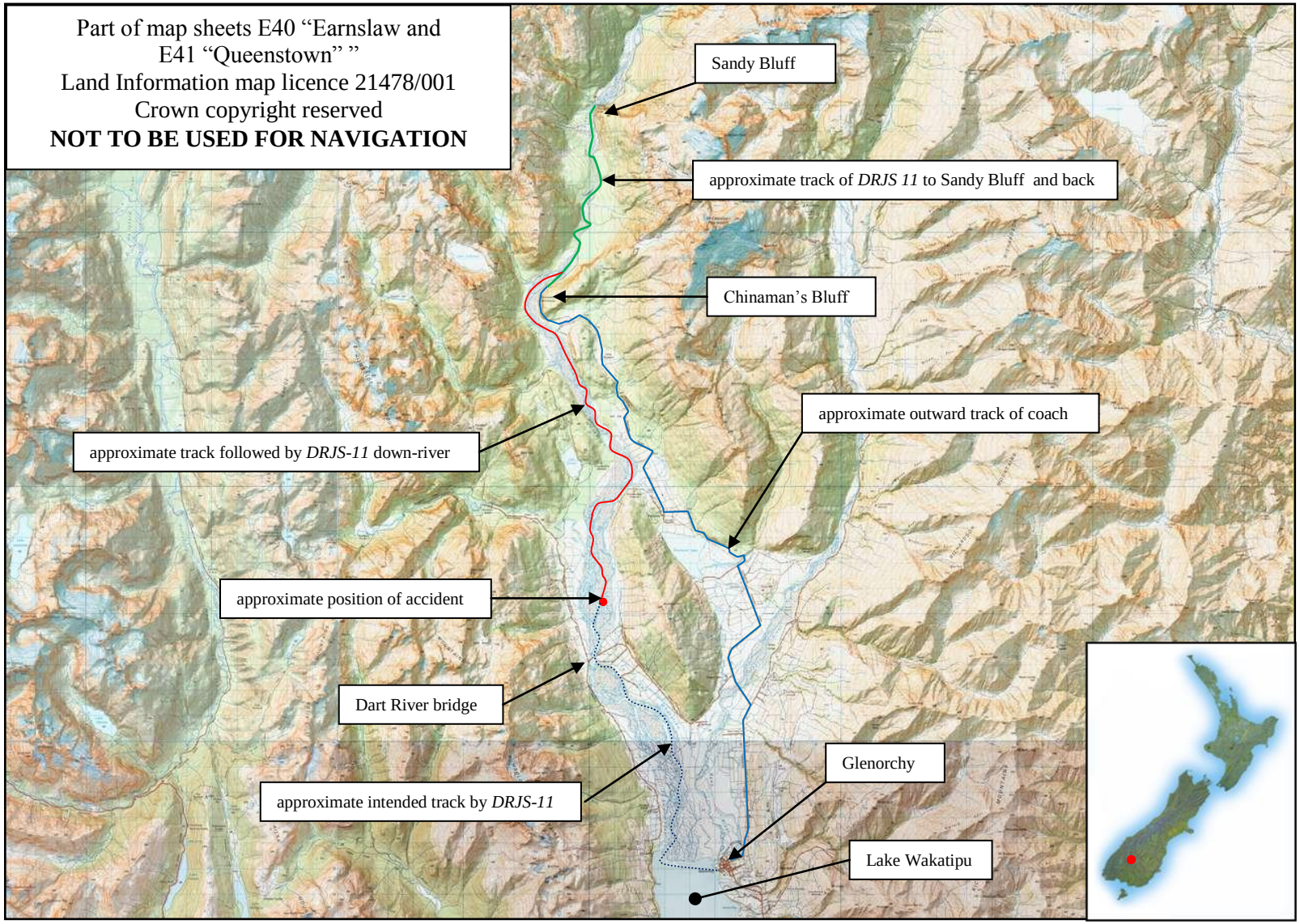


Figure 1
General area of the accident

1 Factual Information

1.1 Narrative

Events leading up to the accident

1.1.1 At about 1200 on 20 February 2009, 9 adult passengers were picked up by the Dart River Jet Safaris Limited (DRJ Safaris) transfer coach in Queenstown for transport to DRJ Safaris' base in Glenorchy, at the northern head of Lake Wakatipu. The transfer was part of a wilderness safari package booked through various agents on behalf of DRJ Safaris.

1.1.2 On arrival at the DRJ Safaris' base in Glenorchy, the 9 passengers were joined by 9 other passengers who had made their way independently to the base office. Of these 18 passengers, 2 were from New Zealand; the remaining 16 were overseas visitors, 10 from the United Kingdom, 4 from the United States of America, one from Australia and one from Eire. After booking in for the wilderness safari, the passengers were given a short talk about the possibility of getting wet, the ride being "a bit bumpy" and the length of the bush walk that was part of the trip. All the passengers were then issued with splash coats as they boarded the 4-wheel-drive coach for the outward journey through the Dart River Valley. Once the coach arrived at Chinaman's Bluff car park, the passengers disembarked and were taken on a short walk through the woods to the bank of the Dart River where a jet boat, *Dart River Jet Safaris 11* (*DRJS-11*), had arrived for the next part of their trip.

1.1.3 On the river bank the jet boat driver and coach driver issued the passengers with life jackets and ensured that they were correctly fitted, and once this was done the jet boat driver seated the passengers for the correct balance and trim of the jet boat. Once they were seated, the jet boat driver gave his safety briefing before lowering the canopy and starting off upriver. All of the passengers later recalled a safety briefing being given, but none could remember the full briefing; they all appeared to remember different parts of the briefing given.

1.1.4 The driver then drove the boat up to Nox's Hole (see Figure 2), where he completed a 360-degree (°) spin, after which he checked on the welfare of the passengers and made sure that they were bracing themselves correctly.

1.1.5 The driver then drove *DRJS-11* upstream passing the Beans Burn entrance and on to Pyramid Rock, anticipating that he would have to stop about 200 m above Pyramid Rock as the river level had been low. As he passed Pyramid Rock he noticed that the river level had risen and he could see a clear way through. He continued up the river, making a positioning radio call on the boat's very high frequency (VHF) transceiver as he passed Waterfall and through Cathedrals until he reached Sandy Bluff, where he stopped to give a commentary.

1.1.6 The driver of *DRJS-11* then started the return journey, completing a 360° spin at Waterfall and continuing down to Nox's Hole, where he completed another 360° spin then went back upstream to attempt to enter Beans Burn. However, owing to the river level he was unable to enter the tributary, so he turned the boat and returned to Nox's Hole, where he stopped again to give another commentary.

1.1.7 He then continued down-stream (see Figure 5) through The Narrows and past Paradise where he did a 360° spin, and then to the entrance to the Routeburn, where he completed another 360° spin before entering the Routeburn to stop and give another commentary. At this point he also contacted DRJ Safaris' base by VHF to ascertain the state of Lake Wakatipu in case he had to disembark the passengers at the Dart River Bridge because of the roughness of the lake. He then advised the passengers that they would be crossing the lake and it could be "a little bit bumpy". After making a positioning radio call he proceeded downriver from the Routeburn.

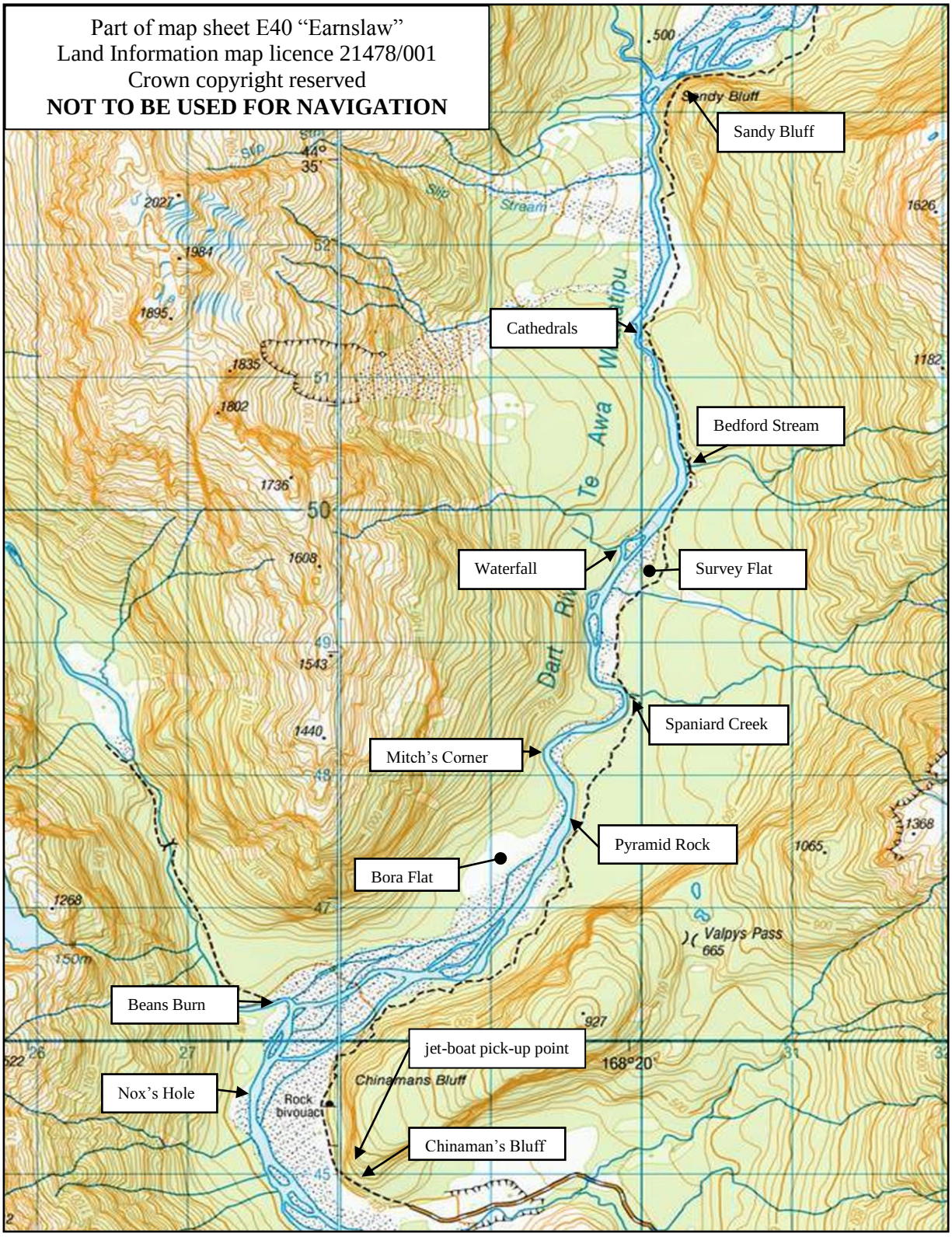


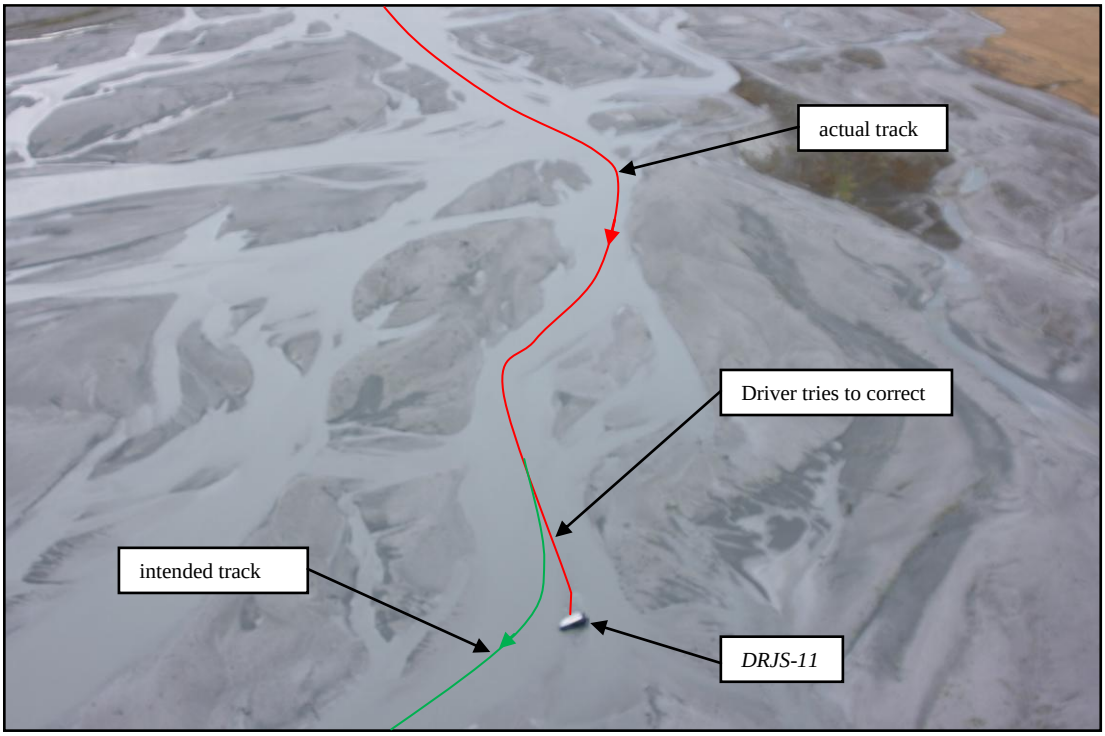
Figure 2
Map of the area above Chinaman's Bluff

1.1.8 The driver of *DRJS-11* got the boat up onto the plane and headed down river towards the lake. On the way down, a passenger sitting close to the driver began asking questions about the vegetation and bird life. The driver was responding to his questions. The boat had just made a left-hand turn to follow the main channel when he noticed a flock of geese taking flight to the right of the boat. He pointed these out to the interested passenger, and when he looked ahead again he noticed the boat had drifted left of his intended track. He turned the wheel to the right

to regain his line but he immediately realised that his correction had been too late to clear the gravel bank, so he centred the wheel and took his foot off the throttle pedal. He said he heard the keel rubbing on gravel and as the boat slowed it rolled slowly over to port, sliding for a period on its port side before rolling over and coming to rest upside down on the roll bar and canopy.

The rescue

1.1.9 When the boat came to rest upside down the driver made a "code one" emergency call on the boat's VHF radio, shut off both propulsion motors and shouted out for the passengers to "kick the windows", which was heard by some of the passengers; other passengers also shouted to others to kick the windows out. After the windows had been kicked out the passengers started to crawl out of the boat through the canopy windows. The majority of the passengers exited the boat on the starboard side, onto the gravel bank, but 2 of the passengers exited on the port side into the river. One of the passengers who exited on the port side of the boat was drenched with petrol over his back. The petrol was draining out of the boat's fuel tank through a vent positioned on the boat's side near to one of the escape windows.



Unannotated photograph courtesy of DRJ Safaris

Figure 3
Track of *DRJS-11*

1.1.10 At about 1545, a staff member at DRJ Safaris' base in Glenorchy received the code one emergency call. The staff member followed the procedures in the emergency management plan (Dart River Safaris Limited, 2008), calling the emergency services, DRJ Safaris' initial response team and DRJ Safaris' emergency management team.

1.1.11 At about 1550, the initial response team departed from the Glenorchy marina in 2 jet boats, *DRJS-7* and *DRJS-2*, with an emergency kit, blankets, towels and tool kits. At about 1557, the operations base team called the harbourmaster and the Police to inform them of the situation.

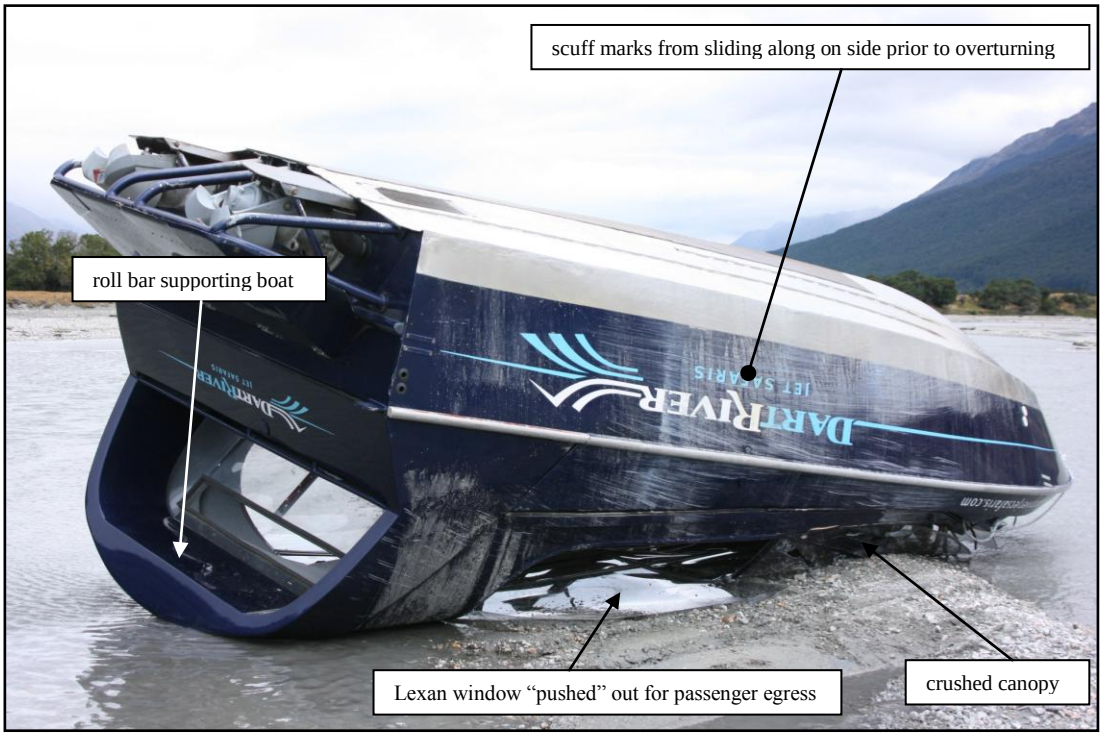
1.1.12 When all the passengers had exited the boat and had grouped on the gravel bank, the driver took a head count and did an initial assessment of the condition of the passengers, using his handheld VHF radio to transmit the information to DRJ Safaris' base. He then re-entered the upturned boat and smelling petrol isolated all the electrical equipment on the boat before exiting again.

1.1.13 The driver advised everybody to not light cigarettes or use a naked flame because of the petrol fumes. He then helped the passenger who had been doused with petrol to remove his upper clothing and washed him down.

1.1.14 The driver then led the group across 2 small channels to the left bank of the river. By this time the driver could hear the sound of an approaching jet boat. Two jet boats, *DRJS-7* and *DRJS-2*, appeared around the downriver bend and made their way to as close to the passengers as was possible. The driver then led the passengers downriver to where the 2 jet boats had beached.

1.1.15 The drivers and other occupant of the 2 rescue boats unloaded the emergency kit from one of the jet boats and set up a forward base to administer first aid and give whatever help they could to the passengers. They then loaded them onto the 2 rescue boats and transported them back to the Dart River Bridge.

1.1.16 On arrival at the bridge the passengers were loaded onto a DRJ Safaris' bus, where they were assessed by a paramedic. Two female passengers who were thought to have injured shoulders were then transferred to a waiting ambulance and taken to Queenstown Hospital. The remainder of the passengers were transported to DRJ Safaris' base at Glenorchy, where they were given warm drinks and snacks before being debriefed by DRJ Safaris' staff about the accident. The male passenger who had been drenched in petrol was taken to the local Glenorchy Lodge, where he was able to shower before changing into fresh clothes. The passengers were then transported back to Queenstown by DRJ Safaris' coach.

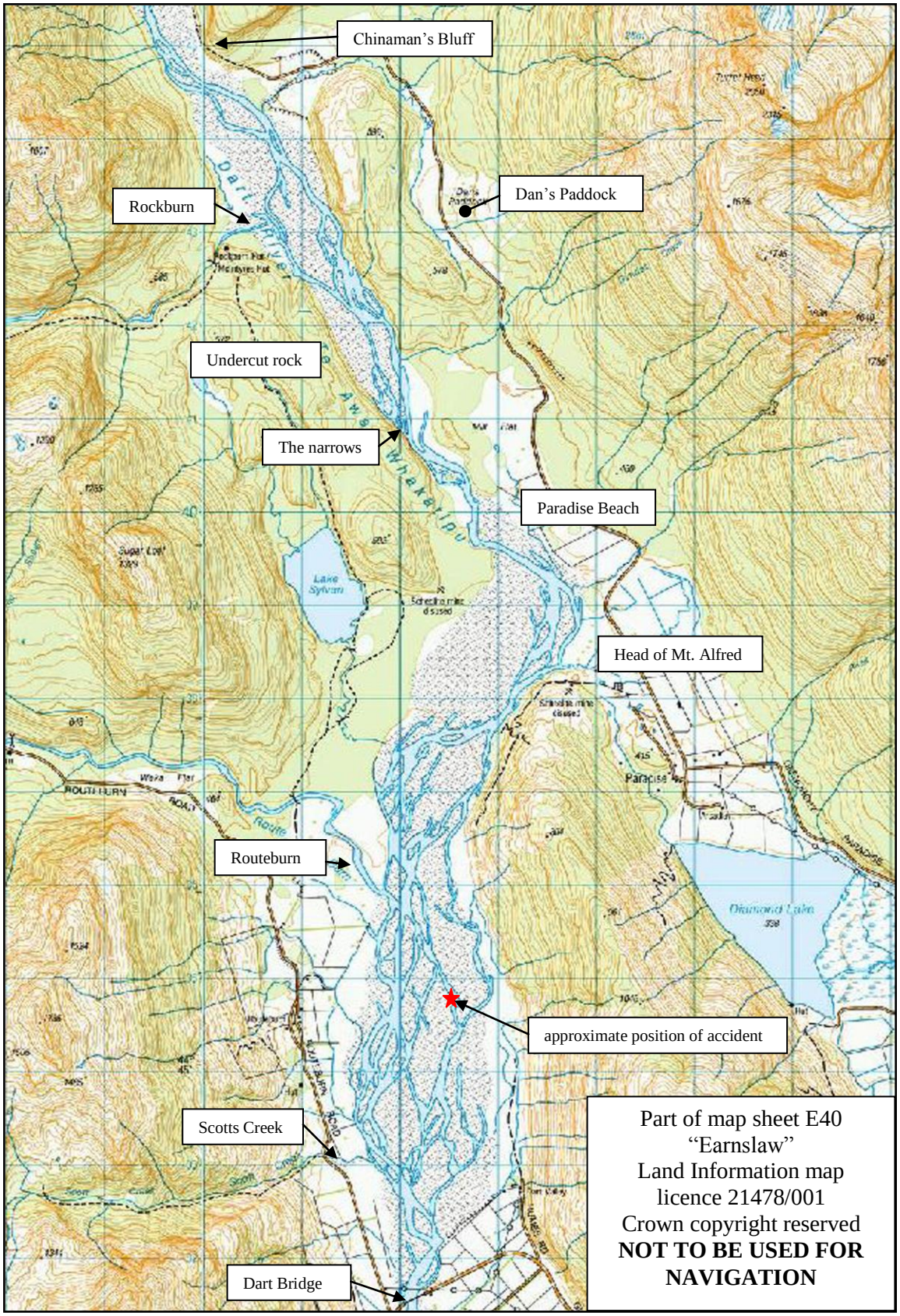


Photograph courtesy of DRJ Safaris

Figure 4
***DRJS-11* at the accident site, still inverted**

1.2 Vessel information

1.2.1 *DRJS-11* was a purpose built in 2004 by 3D-Marine Development of Glenorchy for the tourist industry as a commercial passenger-carrying jetboat. The boat was of aluminium construction and was 7 m overall in length. It was powered by 2 Mercruiser 377 engines, each driving



***Fig*ure 5**
Map of the area Chinaman's Bluff to Dart Bridge

a Hamilton 212 jet unit that gave an operational speed of about 70 km/h. It was capable of carrying 24 passengers and one driver.

1.2.2 *DRJS-11* was designed as a front loading, fully air-conditioned boat with a hydraulically operated canopy constructed out of polycarbonate resin thermoplastic. Since being acquired by DRJ Safaris in 2006, the air-conditioning system had been removed and the cabin, which was open at the stern under the roll bar, was naturally ventilated. The canopy on *DRJS-11* could be hydraulically raised and lowered to allow passenger access to the interior. The canopy could also be removed, in a workshop, to allow the boat to operate without it. The canopy was designed to be jettisoned manually in the event of an emergency. To jettison the canopy the driver was required to operate a control that released hydraulic pressure, allowing passengers in the outboard rear seats to pull on wires that released the canopy securing latches. The canopy was also fitted with an emergency escape window on either side that could be pushed out in the event of an emergency. The emergency escape windows were not clearly marked, nor had the driver instructed passengers seated at those locations on what to do in an emergency.

1.2.3 The hull was designed with an almost flat bottom aft transforming to a shallow vee forward. This form of hull generates hydrodynamic lift as it is driven through the water, rising up on the plane when sufficient thrust is applied through the jet units. The large flat area towards the stern makes it easier for the boat to remain on the plane at lower speeds, thus maintaining a shallow draught and making it ideal for operating in shallow or braided rivers. The draught at a normal operating speed of 70 km/h was about 100 millimetres (mm).

1.2.4 The shallow operating draught when on the plane allowed the driver to follow or access shallow sections of the river, choosing deeper sections or "holes" in which to stop in when required.

1.2.5 Steering a jet boat was achieved by altering the angle of the jet nozzle through a wire and pulley arrangement between the steering wheel at the front and the jet nozzles at the back. In a twin jet installation, the nozzles were rigidly connected so that they turned together. Moving the jet nozzles to either side altered the direction of thrust to the fore-and-aft line of the boat, pushing the stern across and changing the direction in which the boat was pointing. Depending on the tightness of a turn, the direction in which the boat was pointing would differ from the actual direction of travel owing to the boat side-slipping in the turn. The amount of side-slip would depend on the profile of the underwater section of the hull. Planing strakes were often fitted to cause the hull to "grip" the water better and reduce side-slip. Generally, the more planing strakes fitted, the more directionally stable the boat would be.

1.2.6 Some planing strakes were fitted to the hull of *DRJS-11* to improve directional stability. These features also facilitated the driver performing spins, or what has been traditionally called "Hamilton turns", performed to enhance the excitement of the trip for the passengers.

1.2.7 Following the accident *DRJS-11* was taken to a secure facility and underwent a thorough examination by Maritime New Zealand's Adventure Jet Boat Safety Auditor under the direction of the Transport Accident Investigation Commission.

1.2.8 Apart from extensive damage to the canopy, and superficial damage to the hull and roll structure, the boat was intact. All of the control cables and linkages to the jet unit nozzles and reverse buckets were intact and a full range of movement was possible for all components. The engines were not operated, but the driver stated that he had not noticed any mechanical malfunction with the boat leading up to and at the time of the accident.

1.2.9 Following the examination, questions were raised by Maritime New Zealand as to the possibility of the canopy affecting boat stability and contributing to the rollover. DRJ Safaris engaged a naval architect to analyse the stability of DRJS-11 for a dry rollover. The naval architect found that:

- after computer modelling the boat from the design package, carried out experimental analysis on the boat's vertical centre of gravity and transverse centre of gravity when

the boat's hull was rotated about the chine, and determined the minimum static angle of inclination that should result in the rotation of the boat back towards the keel during a grounding scenario. He analysed the vessel's data in 5 different departure conditions

- because there were no standards, rules or guidelines against which the results could be measured, it was impossible to determine analytically the fitness for purpose of the boat going forward. However, the naval architect noted that no specific areas of concern arose that led him to believe that the boat was "in any way significantly or otherwise inferior in standards of safety to that of any other boat of the river jet boat type"
- from his experimental analysis that the removal of the canopy caused a lowering in the centre of gravity of around 50 mm, which was in his opinion "unlikely to reduce the risk of dry rolling to such an extent so as to override the additional safety afforded by retaining unsecured passengers within the vessel confines when the canopy is in place"
- was not able to calculate the dynamic stability of the boat when it grounded at an undetermined speed while moving sideways (Marine Vehicle Solutions Limited, 2009).

Unannotated photograph courtesy of Maritime New Zealand

Figure 6
Port side of *DRJS-11* showing vent from which fuel flowed when the boat was inverted

1.3 Personnel information

1.3.1 The driver of *DRJS-11* was a 35 year old male who had started jet boat driving in 2005, and in that same year qualified as a commercial jet boat driver in accordance with the standards of Maritime Rules Part 80, Marine Craft Used for Adventure Tourism (New Zealand Government, 1998). He had been driving jet boats for DRJ Safaris during the summer seasons since 2005 and had recorded about 2400 hours of commercial driving, all of it on the Dart River. He had been trained in accordance with DRJ Safaris operational training manual.

1.3.2 The driver had undergone peer reviews at 3-monthly intervals while working for DRJ Safaris. The 2 most recent reviews had taken place on 15 October 2008, when he returned to work for the summer season, and on 14 January 2009. He had been audited for competency in driving on 4 February 2009 and found to be "very good and driving well" (Shotover Jet Group, 2004).

1.3.3 The driver was a volunteer fireman in Queenstown and had worked as a ski patroller during the winter months since 2000. The driver had completed St. John training in Adventure Tourism First Aid and in Pre Hospital Emergency Care.

1.4 Injuries

1.4.1 Several of the passengers sustained injuries

- one passenger was treated at Queenstown Hospital for a broken collarbone
- one passenger was treated at Queenstown Hospital for burns resulting from skin contact with petroleum spirit
- 2 passengers were treated at Queenstown Hospital for bruising
- several passengers were treated for mild hypothermia at the DRS Safaris' base in Glenorchy.

1.5 Weather and river conditions

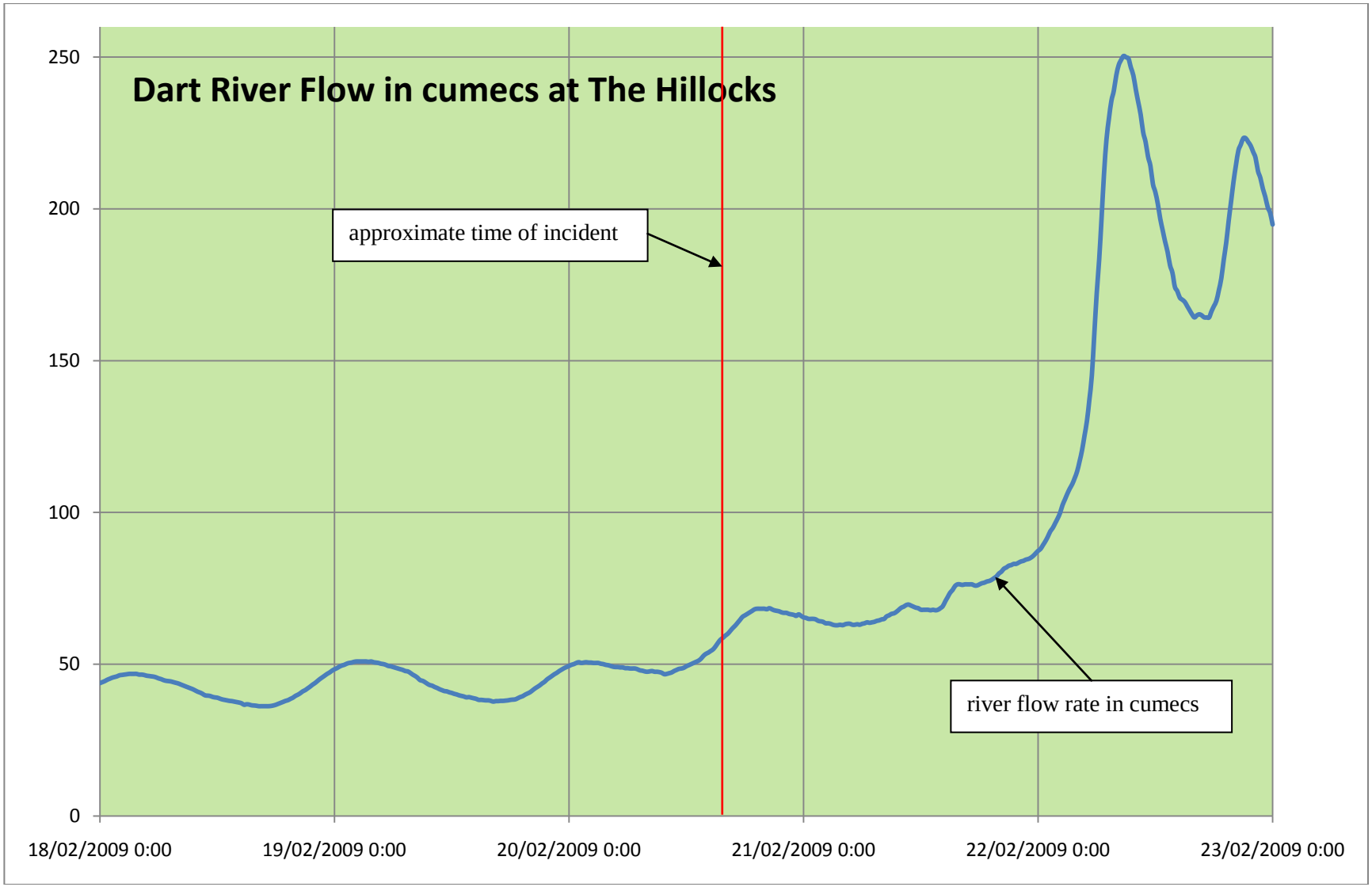
1.5.1 The weather at the time of the accident was reported as being overcast with a cold wind. It had been raining during the early morning and the morning trip had been cancelled. The passengers for the accident trip had been contacted, where possible, to enquire if they wished to rebook.

1.5.2 The Dart River flows into Lake Wakatipu and is fed by melt waters from glaciers and also water runoff from the steep mountain slopes through which the river flows. The amount of water flowing down the river is influenced by the amount of precipitation that has fallen in the headwaters and the amount of sunshine and ambient temperature to which the surrounding snow and ice fields are subjected.

1.5.3 The gradient of the lower reaches of the Dart River is less than that of the upper reaches, which causes the river to slow and widen and, depending on the river level, branch out into several tributaries or braids within its banks, creating what is commonly referred to as a braided river.

1.5.4 As the river flow slows, much of the gravel and silt it carries in suspension is deposited on the river bed, forming new banks and changing the nature of the river. The main channel of flow can change dramatically in a short space of time. Drivers of jet boats operating on braided rivers such as the Dart River need constantly to "read" the water ahead to judge the best tributary to follow. Consequently the route a driver takes can vary from trip to trip or between going upstream and coming downstream, especially in the periods of rapidly changing flow after heavy rains.

1.5.5 Figure 7 shows the water flow of the Dart River as recorded by the Otago Regional Council at its monitoring station at "The Hillocks" (Otago Regional Council, 2010) close to the Dart River Bridge for the 5 day period encompassing the day of the accident.



Data courtesy of Otago Regional Council

Figure 7
Dart River flow in cubic metres per second (cumecs) at The Hillocks

1.6 Organisational and management information

1.6.1 *DRJS-11* was owned by DRJ Safaris. DRJ Safaris had been formed in 1988 and was acquired by Shotover Jet Limited in 1996. In 2004, Ngai Tahu Holdings Corporation, which had been a major shareholder in the Shotover Jet Limited group for several years, became the 100 % owners under the Ngai Tahu Tourism Limited brand. In late 2006, Ngai Tahu Tourism Limited acquired Dart Wilderness Adventures, the other commercial jet boat operator on the Dart River which gave Ngai Tahu Tourism Limited resource consent for 26 jet boat trips per day on the Dart River. (Dart River Jet Safaris Limited, 2009)

1.6.2 DRJ Safaris at the time of the accident operated 8 boats with 9 drivers and in 2008 carried more than 20 000 passengers (Dart River Jet Safaris, 2010).

1.6.3 On 11 February 1999, Maritime Rules Part 80 Marine Craft used for Adventure Tourism (New Zealand Government, 1998) came into force. Appendix 1 of Maritime Rules Part 80 contained the Code of Practice for the Safety of Jet Boats Operating on Rivers. DRJ Safaris had developed its safe operational plan (Dart River Jet Safaris Limited, 2009) based on the requirements of the rule.

1.6.4 DRJ Safaris held a certificate of compliance for commercial jet boats operating on rivers, issued on 30 October 2008 by Maritime New Zealand, which was valid until 30 October 2009. A condition of this certificate was that the boats named on the certificate, including *DRJS-11*, had to have been inspected and the owner's safe operational plan approved by Maritime New Zealand. The jet boat operation had been audited on 24 October 2008 by a Maritime New Zealand authorised person and found in accordance with the Code of Practice for the Safety of Jet Boats Operating on Rivers (New Zealand Government, 1998).

1.6.5 Section 1 of the code contained the requirements for the design and construction of jet boats operating on rivers; Section 2 covered machinery installations and Section 9 covered safe operation, including the safe operational plan.

1.6.6 Section 5 of the safe operational plan was the driver's training manual. This laid out the basis of the training system, which included the minimum 50 hours driving training specified in Maritime Rules Part 80 and the additional DRJ Safaris-required training, which increased the minimum training to about 120 hours, for new drivers, including allied safety and operational training.

1.6.7 The safe operational plan laid out instructions for the use of the radio communications equipment carried on board, including protocols, call-in points and procedures; it also contained details of emergency procedures to be followed and the designated emergency codes one, 2 and 3. Code one emergency meant a major injury accident.

1.6.8 The safe operational plan contained advice on all aspects of the operation, the parts relevant to the accident are noted below:

> 2.1. Before departing on any ride, the driver must brief passengers on the safety features of the boat and its equipment. Attention should be drawn to the fact that all passengers should familiarize themselves with the safety boarding card provided in the boat. The driver should ensure that he/she has had confirmation from all passengers in the boat that they understand all areas of the safety briefing.
>
> 2.1.3 Where spins, Hamilton turns or other like manoeuvres are undertaken during the ride, passengers must be made aware of this before departure and warned by hand signal and voice when necessary.
>
> 2.6.1 All boat drivers must check the Daily Hazard log and sign off if hazard is present.

2.6.2 Check with HBD [head boat driver]and with the River Map for any alterations to daily procedures.

2.6.3 The HBD has the responsibility to communicate with drivers unfamiliar with river conditions on a daily basis.

2.6.4 All boat drivers must ensure they drive in the main flow of the river, or only channels marked OPEN on the base map.

2.6.5 A detailed river map is provided denoting the approved channels and needs to be checked daily. This is to assist less experienced drivers and drivers returning from days off.

2 Analysis

The accident

2.1 There was nothing unusual about the trip made on the day. The weather conditions were reasonable, and although the river level had been low for the previous few days, it was still acceptable for commercial jet boating, and the channels the driver intended to follow at the time of the grounding had sufficient water to allow the safe passage of *DJRS-11*. The river level was rising, which meant the driver could take the jet boat as far upriver as the resource consent allowed. Although the river water was not clear, owing to the schist suspended in it, the driver had been trained to "read" the water ahead and to take more care in these conditions.

2.2 There were no reported problems with the performance of *DRJS-11* on the day, and nothing obvious was revealed in the post-accident inspection of the boat that could have affected its performance. The driver made no mention that he had had any problems with the performance or handling of the boat during the trip.

2.3 Had *DRJS-11* been travelling in a straight line with no helm applied, the boat would likely have simply grounded on the shingle bar and come to a stop, or possibly travelled over it and back into the river channel. With the boat being in a shallow right turn however, the boat would have had a left-hand sideways component to its direction of travel relative to the boat's heading. When the bottom of the boat touched the shingle bar it is likely that the planing strakes and/or chine caught and resisted the side-slip component of travel, creating a capsizing moment. The driver's last-second attempt to align the heading of the boat with its direction of travel would have reduced the capsizing moment enough to result in the slow roll-over, as opposed to the quicker faster flip described in other jet boat accidents previously investigated.

2.4 With the boat decelerating on contact with the shingle bar and turning slowly over to port, there would have been a tendency for the passengers seated on the right side of the boat to slide down to the low side as the boat rolled, rather than being thrown clear as has been shown in other accidents to be the tendency when the speed of the rollover has been greater. In these latter cases the centrifugal forces prevented the passengers sliding down to the low side and instead they were ejected from the craft as it rolled, with those on the port or down side remaining and being trapped under the boat. In this case the canopy prevented the right side passengers from being ejected from the boat and the roll bar across the stern allowed sufficient occupiable space under the boat for the passengers to escape; some unaided and others with the assistance of others who had already escaped.

2.5 Although the canopy on *DRJS-11* had been designed so that it could be jettisoned in the case of emergency, this process would not have been easy to accomplish with passengers who had received only rudimentary verbal training in the process. Had the passengers been further stressed in the event of an emergency it is unlikely that the canopy could have been effectively removed. The effective removal of the canopy required 4 separate actions.

- the driver had to activate an obscured control next to their seat to release hydraulic pressure to the canopy lifting rams
- the driver had to release the 2 securing mechanisms at the front of the canopy
- the driver had to instruct the passengers near the rear to pull the release mechanisms
- 2 different passengers were required to actually pull the release mechanisms.

2.6 If the driver were incapacitated during an event it is highly unlikely that the removal of the canopy would be successful, because they were pivotal to the task

2.7 There are 2 obvious scenarios where removal of the canopy might not succeed: one as in this case where the boat came to a stop upside down; and the second had *DRJS-11* overturned in deep water, on Lake Wakatipu for example. For each example it is unlikely that there would have been enough warning to jettison the canopy before the rollover occurred. Once inverted, the water pressure on the outside of the canopy would have rendered any attempt at removal difficult. The occupants could have effectively been trapped in the upturned boat if removal of the canopy had been the only means of escape.

2.8 For the reasons given above, the most effective means of escaping from *DRJS-11* when it was inverted was through the "kick-out" windows on each side of the canopy, yet these were not marked as escape routes, nor had the passengers been briefed on how to use them in an emergency. In this case the driver was able to instruct the passengers what to do when the accident occurred, but had he been incapacitated the passengers might have had some difficulty escaping the boat in a hurry.

2.9 Fire within an upturned jet boat would be an identifiable risk. With 2 petrol engines operating at high speeds, the fuel and ignition sources would be present within the engine compartment in the event of some kind of disruption to components. In this case fuel leaking from the fuel tank vents was an added risk, albeit it was leaking outside the passenger compartment. Once the side windows had been kicked out however, petrol fumes could have entered the passenger space. The positioning of the fuel tank vents over the escape route was unfortunate in this respect, and also because passengers had to pass through the leaking fuel in order to exit.

2.10 Had the driver had easy access to a quick-acting means to isolate the boat's electrical power and fuel systems, including the fuel venting arrangements as soon as he was able after the roll-over and before exiting the boat, he would have been able to:

- reduce the risk to the passengers of the possibility of a fire from the leaking fuel and an electrical ignition source
- prevent fuel leaking from the tank vents,
- reduce the risk to himself from having to re-enter the upturned boat to isolate electrical equipment.

2.11 The naval architect commissioned to assess the effect of the canopy on boat stability concluded that it had little effect, and based on that finding concluded that the canopy had not affected the boat's fitness for purpose. While this statement might be true with regard to stability and the susceptibility of the boat to rolling, other considerations such as means of escape need to be considered before making a conclusive finding.

Human factor considerations

2.12 The driver of *DRJS-11* was an experienced driver who had a good driving record and was considered by his employers as being risk averse. He was not suffering from illness or fatigue. Since 1995, the Commission has investigated 20 occurrences and published 17 reports involving commercial jet boats, the most recent being in 2008. Of these 20 occurrences, 3 involved high-speed rollovers: one in 1997 – Marine Occurrence 97-211, one in 1998 –Marine Occurrence 98-213 and one in 2008 – Marine Occurrence 08-207. After the earlier occurrences the Commission made safety recommendations covering the fitment of rollover bars on jet boats

operating on braided river systems and the need for accurate recording of passenger numbers on boats to assist emergency services. These 3 rollover accidents resulted in one fatality and, 5 serious injuries and 3 minor injuries. Together with this accident, that makes one fatality, 5 serious and 5 minor injuries in a period of just over 11 years.

2.13 All 4 rollover events (including this one) were caused more by human factors than by design or maintenance issues. The Commission commented in report 08-207 that no matter how reliable the jet boats are mechanically, there will always be an inherent risk of an accident of this type occurring when jet boats travel at planing speed, down braided rivers, where the correct path to follow along an ever-changing river is reliant on the skill and judgement of the driver. The report also commented that faster speeds in relation to the river bed will be a factor. Travelling up river should allow more reaction time on the part of the driver because the boat is travelling against the river flow at a lower speed across the ground. Travelling down river, however, requires a shorter reaction time on the part of the driver because the boat is travelling with the river flow with a higher ground speed. All 4 of these rollover events described above occurred when travelling downstream.

2.14 In this case the Commission considers that driver distraction was a contributing factor. The driver was being asked questions by one of the nearby passengers and was responding to those questions during a period when his boat was travelling down river at high speed, when all his concentration should have been focused on following his lines and reading the water ahead. His noticing and pointing out to the passenger a flock of geese taking flight to the right of his intended path immediately prior to the rollover was evidence of this.

2.15 Driver distraction should be a foreseeable risk with this type of operation. It should be documented in company procedures and discussed during driver training. Passengers should be made aware during the safety briefing not to converse with the driver except in case of emergency while the boat is at planing speed, for example, and there should possibly be a sign reinforcing this point on the dashboard, similar to what is often found in other public transport vehicles. Commentary and interaction with the driver should be limited to times when the boat is stopped or travelling at low speed. A safety recommendation has been made to the Director of Maritime New Zealand to address this safety issue across the jet boat industry.

2.16 Earlier recommendations on the fitting of roll bars to commercial jet boats operating on braided rivers were made in acknowledgement that the risk of rollover will always be present and that both the likelihood and the consequences could be high, as has been proven in this case. The dilemma the industry faces is what else can be done to mitigate the risk and how much the travelling public should be told of those risks before deciding to undertake the activity. As stated in Marine Occurrence Report 08-207 (ibid), some guidance will be required from the regulator on that issue, because there will be a competing interest in how much to tell the prospective customers at the risk of losing patronage in what has become a multi-million-dollar tourist activity.

2.17 As stated in Marine Occurrence Report 08-207 (ibid) the New Zealand Government has recently launched a major review of adventure tourism in New Zealand. Maritime New Zealand is participating in that review, so a recommendation has been made to the Director of Maritime New Zealand to have this safety issue addressed.

The safety briefing

2.18 Giving the safety briefing to the passengers poses some challenges for the boat driver. The briefing must be heard over the ambient noise, including that of the engines. Passengers seated closer to the driver are more likely to hear the briefing, putting those in the back row at a disadvantage. Keeping the attention of the passengers on the person giving the safety briefing is a problem shared by all industries where safety briefings have to be given. Non English speaking passengers pose an additional challenge for drivers, although in this case they all spoke English as their first language. There was some feedback from passengers that not all of them heard the full safety briefing, although they all heard and remembered certain parts of it.

2.19 Whether the passengers understood the safety briefing or not did not contribute to or directly affect the outcome of this accident; nevertheless, the fact that giving a meaningful safety briefing is still posing a challenge to operators is a concern. An effective safety briefing should be achievable if all passengers are provided with a briefing card and the driver takes the time to engage with the passengers meaningfully, rather than performing the briefing in a robotic fashion without taking time to gauge their comprehension.

2.20 As mentioned above, covering the best way to evacuate the boat in an emergency and including a caution about conversing with the driver would have been useful additions to the safety briefing.

The rescue

2.21 As the occupants exited from the boat they did what they could do to assist those still inside to escape from under the boat. The driver was one of the last to exit the upturned boat, and after doing a head count he returned to the upturned boat to switch off all the equipment, as he could smell petrol. His actions, along with advising the passengers to not light cigarettes ,were that of someone in control in spite of the accident. The aerial for the inbuilt radio was a whip aerial located on the forward port side, just in front of where the driver sat. The aerial survived the accident, and because of the way *DRJS-11*came to rest the aerial was elevated up out of the water and not grounded. Thus the driver was able to use the inbuilt radio to contact DRJ Safaris' base before exiting the boat. After leaving the boat he was still able to communicate with DRJ Safaris' base using his handheld waterproof VHF transceiver. Communications during this event worked as designed and resulted in a timely first response

2.22 Once the radio call had been received by DRJ Safaris at its base office in Glenorchy, it alerted the emergency services and implemented its own emergency response. Rescue services went as closely as they could to the scene of the accident at a point agreed with DRJ Safaris. DRJ Safaris then used its jet boats to transfer the passengers to this agreed point. The driver had assessed the general condition of the passengers and relayed this back to the base, so it was known at that point with reasonable certainty that they were not dealing with a life-threatening situation. The choice to send jet boats pre-loaded with emergency response equipment, rather than calling for helicopter assistance, was therefore a reasonable response.

3 Findings

Findings are listed in order of development, not in order of priority

3.1 The jet boat *DRJS-11* rolled after making contact with a shingle bank when the driver lost his driving line while travelling at planing speed down river.

3.2 The driver momentarily lost his driving line when he became distracted by conversing and interacting with the passengers seated near him.

3.3 There were no company instructions for dealing with the safety issue of driver distraction during high-speed jet boat operations that required a high degree of concentration by the driver, particularly when travelling down river.

3.4 The roll bar and canopy collectively provided sufficient occupiable space beneath the jet boat for the passengers and driver to escape once it had come to rest upside down.

3.5 Ejecting the canopy in the event of roll-over was not a viable response to enable passengers to escape from the passenger compartment. The emergency egress windows on the side of the canopy not being clearly marked and not referred to in the safety briefing could have compromised the evacuation of passengers from their compartment under different circumstances.

3.6 The canopy had a marginal effect on the stability of the boat during a dry roll-over event in comparison with the other dynamic forces involved when jet boats strike shingle bars at high planing speeds.

3.7 The fuel tank vents did not prevent the uncontrolled escape of fuel in the event of an accident and were sited in the area designed for emergency egress from the boat.

3.8 The risk to passengers and drivers in the event of an emergency in commercial jet boat operations could be reduced with the fitting of an easily-accessible, quick-activating mechanism that isolates electrical power and fuel systems, including fuel venting arrangements.

3.9 Although, in this case, the delivery of the pre-trip safety briefing did not affect the outcome of the accident, enhancements in the way safety briefings are conducted by the operator are needed if passengers are going to be fully briefed in the future.

3.10 The emergency response to the accident was efficient and well coordinated.

4 Safety Actions

4.1 After the accident DRJ Safaris:

- stood the driver down from driving immediately. On completion of an internal investigation the driver started a re-induction process and was reviewed on several occasions by the head boat driver/operations manager before a final independent check by an external experienced jet boat driver. The driver was rostered back on commercial trips in May 2009
- contracted Marine Vehicle Solutions Limited to undertake an independent evaluation of *DRJS-11* to analyse it's stability for a dry roll over
- decided not to repair or use the *DRJS-11* canopy again in its existing design
- reviewed and modified the DRJ Safaris' safe operating procedures with the following additions:
    - that the driver's primary responsibility at all times is the safety and welfare of their passengers
    - that the driver should ensure to the best of their ability that the boat is positioned accurately in the flow at all times, particularly when the boat is in motion
    - that during the safety briefing drivers are to advise passengers that they will be focusing on the river environment during the trip and unless they have a safety concern or emergency they should not attempt to engage with the driver while the boat is in motion
    - that the driver should not engage with passengers who are not in the front seats at any time while the boat is in motion, other than for the purposes of passenger welfare or safety reasons
    - that if an action or event occurs that could distract the driver's focus, i.e. passenger in distress, passenger attempting to distract them, any need to add or remove items of clothing, they should stop the boat to attend to it.
- modified the driver's training manual and processes to reflect the importance of drivers focusing on the river environment fully at all times and avoiding distractions, particularly while the boat is in motion
- were investigating practical options to stop fuel from pouring from the fuel breather system and will be implemented if considered practicable to do so.

5 Previous Safety Recommendations

5.1 On 25 February 2010 safety recommendations were made to the Director of Maritime New Zealand in Marine Occurrence Report 08-207 (Transport Accident Investigation Commission, 2010) to:

> address the safety issue whereby in the event of an accident or incident, the emergency back-up radios are not capable of being used for communicating with either the rescue authorities or the boat's home base. (001/10)
>
> bring this report to the attention of the reviewers of adventure tourism in New Zealand, and ask them to consider how to deal with informing potential commercial jet boat passengers of the risks inherent with the activity. (002/10)
>
> address with the commercial jet boat industry that in spite of the requirements under Maritime Rules Part 80 and other safety initiatives taken by Maritime New Zealand:
>
> that the issue of delivering meaningful pre-trip safety briefings to passengers, particularly where understanding of the English language is still an issue. (003/10)
>
> that the issue of accounting for passengers when multiple boats are involved during emergency response still remains. (004/10)

6 Safety Recommendations

Safety recommendations are listed in order of development, not in order of priority

6.1 On 19 May 2010 it was recommended to the Director of Maritime New Zealand that she address the following safety issues:

6.1.1 That distraction of jet boat drivers when driving at high speeds that require a high degree of concentration had not been identified as a risk to the operation and was the main factor contributing to this accident. This could be an issue to address across the industry. (011/10)

6.1.2 There was no means of preventing the uncontrolled escape of fuel from the fuel tank vents when the boat was inverted and these vents were located above the emergency exit from the passenger compartment. (012/10)

6.1.3 That in the event of an emergency on board a commercially operated jet boat there was no easily-accessible quick-acting means to isolate electrical power and fuel systems including fuel venting arrangements. This could be an issue to address across the industry. (013/10)

6.1.4 That this jet boat fitted with a canopy did not have the path of emergency exit from the passenger compartment clearly marked and explained to the passengers during the safety briefing. (014/10)

6.2 On 29 April 2010 the Director of Maritime New Zealand replied to the safety recommendations:

Please note we agree with and accept three of your safety recommendations as follows:

6.1.1 The distraction of jet boat drivers when driving at high speeds that require a high degree of concentration had not been identified as a risk to the operation and was the main factor contributing to this accident. This could be an issue to address across the industry. (011/10)

This hazard will be identified to operators during routine liaison visits, which will also assist MNZ to determine the scale of the problem across the sector. Operators' management of the hazard will be monitored and assessed during subsequent audits. MNZ will then assess whether further action, such as a Safety Bulletin, is necessary.

6.1.2 There was no means of preventing the uncontrolled escape of fuel from the fuel tank vents when the boat was inverted and these vents were located above the emergency exit from the passenger compartment. (012/10)

MNZ is following up with Dart River Safaris Ltd. and their authorised person to determine that changes to the fuel breather system, made since the accident, satisfactorily address this hazard. Only one other New Zealand operator has jet boats with enclosed canopies. In that instance the fuel valves are placed well away from the emergency exits. Any new commercial jet boats with canopies will be inspected prior to commencing operation to ensure this hazard has been addressed.

6.1.4 That this jet boat fitted with a canopy did not have the path of emergency exit from the passenger compartment clearly marked and explained to passengers during the safety briefing. (014/10)

New draft rule Part 82, which is intended to replace the present Part 80, will propose that emergency exits on boats fitted with canopies should be clearly marked as such. The need to identify the exit during safety briefings will be followed up during liaison visits with the two operators who have canopy type boats.

Please note we are unable to accept the following recommendation until further work is undertaken:

6.1.3 That in the event of an emergency on board a commercially operated jet boat there was no easily-accessible quick-acting means to isolate electrical power and fuel systems including fuel venting arrangements. This could be an issue to address across the industry.

We will undertake work to determine the scale of the problem across the sector, including an assessment of whether this is a viable and cost effective option.

Approved on 20 May 2010 for publication

Mr John Marshall QC
Chief Commissioner

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