PREAMBLE

Because the report may initially be read without awareness of location of the geographic area discussed, readers are referred to Appendix A, which gives an overview of the roading network of which the Greenstone-Kinloch Road forms part.

EXECUTIVE SUMMARY

The condition of the Greenstone-Kinloch Road has been examined, locals interviewed and recommendations for improvement proposed, in response to a request from Queenstown Lakes District Council (QLDC).

It is clear that traffic volumes using the road are growing, and more significantly, the proportion of non-locals and the range of vehicle types are increasing.

The main road improvements needed are localised safety and geometry improvements, including

- Local widening of road, including provisional of passing opportunities
- Easing of the steep climb at the Greenstone end, and
- Easing of blind corners in the glades, including removal of a few trees
- Installation of localised guardrailed sections.

Numbers of treatments, locations and extents have not been developed in this report. They are best decided following a survey of the whole road, including locations of obstructing trees, development of a preliminary design for comment by interested parties. Following this, a programme and budget should be prepared.

It is not felt that the motor grading and metalling operation needs change, except that signs warning of the presence of loose gravel should be put out at the Dart River end and retained in place for about two week following grading. Motor grading and remetalling should be confined to periods when the road and available metal is damp.

It is important that improvements to geometry do not lead to a significant increase in travel speeds, and that the resulting speed environment is relatively consistent.

Programming for, and execution of, ongoing maintenance is essential.

Table of Contents

INTRODUCTION

In September 2005, two young children died following a loss of control accident of a vehicle that went off the road and sank into the lake. The children were seat-belted into the vehicle. Their mother (the driver) and an older child managed to escape.

At a hearing, the Coroner indicated that he wished to make recommendations in terms of the road. To that end, a recommendation from Queenstown Lakes District Council (QLDC) was sought.

This report contains requested recommendations to WLDC, and responds to their brief to report on:

- The history of the original construction as a farm track, through to present standard as a low volume gravel road
- The present condition as a low volume gravel road, with regard to pavement materials, shape, surface, and shoulders
- The adequacy of maintenance and maintenance programmes
- Consultation with local community and contractors
- The suitability of the road for its current use, which includes a growing number of tourist service vehicles and private/rental cars
- Recommended initiatives to reduce risk to traffic, and to the Council as owner

1 HISTORY OF GREENSTONE-KINLOCH ROAD

The route has been used for moving stock since the area was first farmed.

Contractor Darrell McGregor built the road in 1982: He had previously widened the horse track at Greenstone in 1957, mainly to stop stock loss into the lake during droving. For this work, plant was landed by the *Earnslaw*.

The 1982 phase of completion of the road and re-widening commenced at the Kinloch end. On this, as well as the earlier occasion, the rock at Greenstone was removed by drilling and blasting.

Figure 1 below shows the outcrop near the jetty, and the 2005 crash site. In the middle of the close-up photo can be seen a section (circled) through a hand-drilled hole in which a charge of gelignite was placed.

Figure 1: Rock Outcrop Formation

An effect of completion of the road was that the Kinloch Lodge, established in 1865, was now able to receive guests by road, as well as by boat. The Lodge, extended since the opening of the road, is shown in the picture below.

Figure 2: Kinloch Lodge

Visitor numbers at the DoC base in Glenorchy have increased significantly in recent years. Some of this increase will include people who will travel a little further beyond the end of a sealed road, in this case, towards Kinloch. Travelling numbers on the road are said to have increased 10-fold in recent years. Recent traffic counts, *albeit taken in the low season*, record an average of 20 vehicles per day, a doubling of the RAMM database estimate of 10.

There are more non-locals than locals driving, and these include recreational hunters, school and university camping trips in shuttle vans.

The heavy traffic season is from Labour Weekend to Easter.

The Coroner's Hearing[1] was told that even large tourist busses were using the road.

2 PRESENT CONDITION OF ROAD

2.1 Road Profile

The road in the vicinity of Greenstone Station was surveyed to assist this report, in May 2006. Figure 3 below shows the climb from Greenstone, the area of commencement of the survey.

Figure 3: View Looking North from Greenstone End

[1] 30 March 2006.

2.1.1 Longitudinal Profile and Width

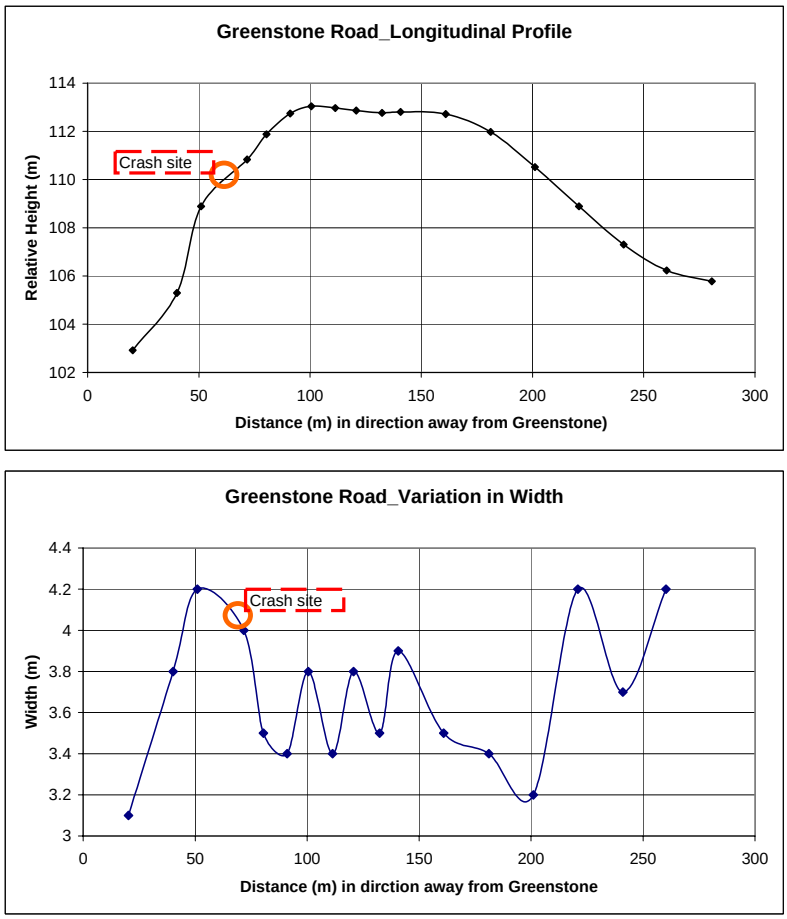

Figure 4: Longitudinal Profile and Width Variation of Road at Greenstone End

The base of the hill (see Figure 4) is 80 m from this marker, and gradients are as high as 1 in 3.

The dotted line shows a potential alteration to vertical alignment (a standard vertical curve) to ease gradients and rates of change of gradient. As drawn, this involves cuts of up to about 2 metres.

At the site of the crash, the road is relatively wide (4.1 m), although this is not a sufficient width for a two lane road.

2.1.2 Transverse Profiled (Cross-sections)

A series of cross sections is shown Appendix B. The crash site is at approximately the 4th cross-section (reading left to right progressively down the page)..

Because of undergrowth, it was not always possible to obtain the slope of the drop to the lake. The undergrowth is capable in parts of cushioning a vehicle moving off the road, and has done so. It is understood that the lake is deepest at the side of the road at the point of the crash, unfortunately.

2.2 Road Surface Condition

2.2.1 At the Time of the Accident

The road was remetalled in July 2005. A significant quantity of metal was required, because the road was down to bedrock in parts. Accordingly, an average thickness of 75 m was programmed for the road. The metal was placed, but not rolled.

The perception of locals was that a loose 150 mm of stone had been placed. This perception is understandable if the free edge of the road (edge near the lake) is considered, because this cannot be compacted by roller or by vehicles.

Photos taken 4 days after the crash (about 6 weeks after metalling) are shown in Figure 5 and indicate that the aggregate was in a reasonable state of compaction in the wheeltracks, but loose on the edges.

Figure 5: The Accident Scene Four Days after Crash (6 Sept 2005)

Sheep has been driven over the road on the day before the accident, and may have loosened the top surface.

2.2.2 At the Time of Visit on 24 May 2006

The photos in Figure 6 show the condition of the road surface material.

Figure 6: Greenstone End of Road in May 2006.

The road surface condition is not out of the ordinary for an unsealed road, with relatively low traffic volumes, as here. It is clear that there is loose metal at the edge of the roadway. However, it is not possible to compact this edge-of-road aggregate.

2.3 Moisture

Unsealed roads provide a most stable surfacing course when the spread material is in a "damp" state, neither too dry nor too wet..

Monthly rainfall in the period July to September 2005 was close to monthly averages for the first two of these months, but well below average in September. This applies to the nearest station (Dart at the Hillocks) as well as to those at Routebourne and at Queenstown. The comparison is summarised in the table below:

Measured and Average Monthly Rainfalls for Various Raingauges[2]

	July			August			September		
Rainfall Station	2005 (mm)	Average (mm)	% Average (%)	2005 (mm)	Average (mm)	% Average (%)	2005 (mm)	Average (mm)	% Average (%)
Dart at the Hillocks	139.0	122.6	113%	139.0	145.8	95%	113.5	196.7	58%
Routeburn Station	184.5	159.0	116%	180.5	176.0	103%	156.3	211.0	74%
Queenstown	52.8	56.6	93%	61.7	60.3	102%	44.6	70.4	63%

Raineffects Limited reports that the winter of 2005 in the area was one of the mildest ever experienced.

The tragedy that has led to this report occurred on 2 September, too early in the month to enable assertion that the road was adversely affected by the relatively low September rainfall.

2.4 Existing Signage

A sign at the northern end of the road (Figure 7) gives a quite stark warning to motorists wishing to continue south.

Figure 7: Warning Sign near Dart River Bridge on Road to Greenstone

3 MAINTENANCE AND MAINTENANCE PROGRAMME

3.1 Surface Course Material

Figure 8 compares the specified maintenance metal with samples taken from the source stockpile for this road at the Dart River Bridge site.

[2] Raineffects Limited: *"Head of Lake Wakatipu Weather Conditions."* A report prepared to assist this study. June 2006.

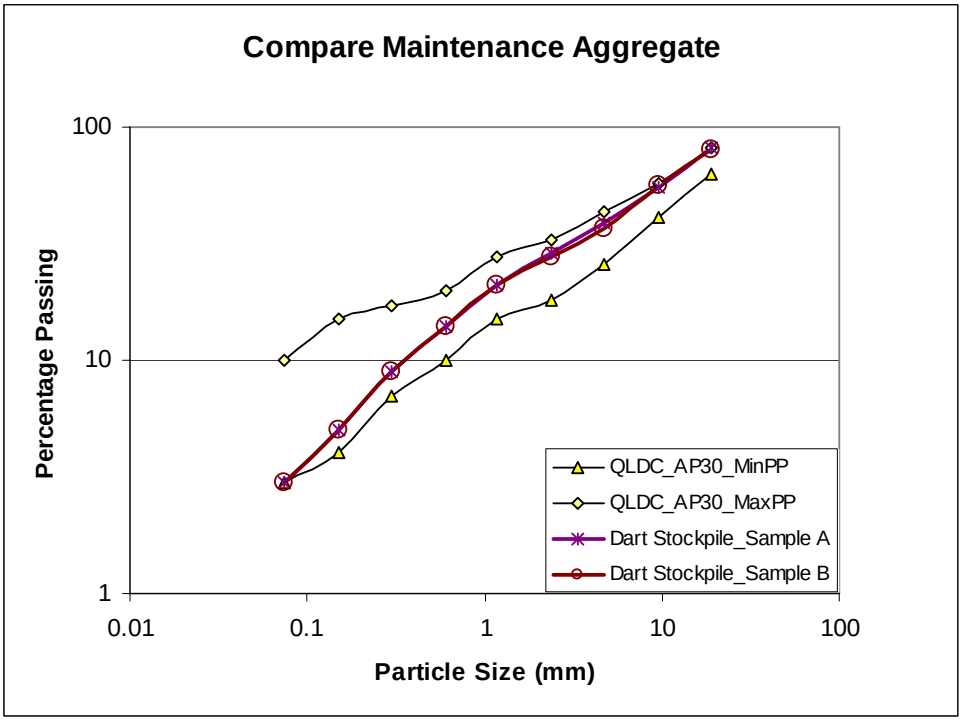

Figure 8: Comparison of Sampled Material with Specification

The stockpile fits comfortably within the prescribed particle size gradation limits. The slope of the curve indicates a material with a smaller concentration of fine material.

Visual inspection of the material suggested the dominance of a coarse sand at the smaller end of particle size. The absence of cohesive clay material means that the metal will be unbound when it is dry, but the well graded nature of it suggests that it should pack together reasonably well. The absence of much silt means that the metal will not weave and rut under trafficking, even when very wet. The material is at its best condition when moist. Such was the case on the date of stockpile and road inspection.

The photos below (Figure 9) show the stockpile of crushed metal from the Dart River.

Figure 9: Stockpile of Maintenance Aggregate at Dart River Bridge Site

4 CONSULTATION WITH COMMUNITY AND CONTRACTOR

4.1 Glenorchy Community Association

On 24 May 2006, members[3] of the Glenorchy Community Association met at the Dart River Bridge. Together, we drove to Greenstone Station, and discussed the road's condition and its future management. The following summarises the views expressed by this Group:

4.1.1 Context of Road in District

Tourism has always been a significant contributor to the economy of the area. Kinloch Lodge was founded in 1865 and tourists would arrive at Elfin Bay by boat.

If farming ceased in the area, things would keep going. Farming is currently marginal: as example, a local property valued at $12 million, grossed just $200,000 in a good year.

"Life stylers" are moving into the area. Essentially, they stay for 6 months and then move back to their other residence.

4.1.2 Traffic Volumes

An increase in traffic volumes has resulted from completion of sealing to Glenorchy in 1992. Nowadays, vehicles include camper vans. There are a lot of single vehicle, non-injury accidents, and nearly all known crashes have involved people from out of town.

There are now significant numbers of busses and mini-busses, and summer school camps. More "non-locals" that local people use the roads, including recreational hunters.

Tourist operators in the area included Backpack Express, Kinloch Lodge and Routebourne Guided Walk.

4.1.3 "Surprises" for Drivers

Sudden Change of Light

The bush glades pose a crash risk, through the sudden change of light, and worse, the dazzling effect of sunlight dancing between trees as the vehicle progresses. Figure 10 shows the sudden change of light (glare) for the driver emerging from the glade: the opposite effect, sudden adjustment to twilight as the driver enters, is more severe.

Figure 10: Natural Lighting Contrast in Glade

Tortuous Alignment and Obstacles

Some beech trees near the road edge have clearly been struck by vehicles, shown by missing bark at point of impact. Figure 11 shows the sudden changes in carriageway alignment with a bank protruding at left. At right, the tree at right of the vehicle has been regularly struck by cars approaching a "blind" corner.

[3] Vince Jones (Chairman), Graham Railton and Stuart and Anne Percy.

Figure 11: Small Sight Distance and Intruding Obstacles

4.1.4 Maintenance Metalling and Motor Grading

The road tends to have loose stones which roll on each other after grading (a "marbly" surface).

When the metal was applied to the road (in July 2005), it was not formally rolled following placement. There was a lot of loose metal. The material applied at this time was unusually thick, and about 150 mm of loose metal resulted. One truck rolled as it was spreading metal on the road.

As a result of progressive metalling, the road surface has gone from a 3-wheel track road to a 2-wheel track (i.e. has become narrower). Heavy application of maintenance metal tends to produce steep shoulders. At places, vertical drops exist at the edge of steep shoulders.

Before the accident, sheep had been drafted along the road.

A stock truck got stuck in loose metal in early February.

There was no evidence that the Contractor inspected the road, prior to gravelling.

Prior to the present contract with Works Infrastructure for road maintenance, Queenstown Lakes' LATE executed the maintenance work. At that time, requests were received directly by the receptionist at Queenstown Lakes' maintenance contract office, and without further inspection, the Contractor came up to attend to the problem.

At this time, after a year under the new contract, response to local requests has improved.

4.1.5 Road Geometry

The climb northbound from the jetty at Greenstone Station is "pretty steep." For southbound traffic, there is a sudden and surprising dip after a crest. Both photos In Figure 12 look south: that at left is on the approach to the steep downgrade (not apparent to the driver at that point) while the right hand photo shows the bend immediately beyond the crest.

Figure 12: Views at Either Side of Crest at Greenstone Station End

In the picture at right, above, it is apparent on site that a vehicle has skidded on the right side of the road. Although not clear in the picture, the vehicle has then turned towards the lake (near the shadow at upper mid section of photo). The involuntary change in direction results from the differential skid resistance between the loose gravel at the bank edge and the traffic-compacted gravel across most of the width.

The group noted that it was quite common for vehicles to hug the bank side of the road as they came south over the crest.

The rock face on the hill side of the road is not generally very high, and is part of a natural terrace. It would not therefore be difficult to widen the road by cutting back this face.

Weeds and brush at the roadway edge has to be controlled to hep road users identify the edge. Bracken is intruding. Periodically, this was treated by mulching. Currently, a small mower is used instead: this equipment is not clearing high enough. It would be better to use spray[4]. Figure 13 shows general views of encroachment.

Figure 13: Encroaching Brush on Sides of Road

Often the bracken is capable of securing an errant vehicle, but there are critical locations where this does not happen.

Figure 14 shows the imprint of a vehicle that has left the road.

Figure 14: Imprint of Straying Vehicle on Roadside Scrub

[4] Du Pont's "*Answer*" was cited as a suitable herbicide. It also deals with tutu, a poisoning hazard to stock.

In places on the lake side, the road has no verge. The person in the photo at right, in Figure 15, is indicating one such drop-out.

Figure 15: Absence of Verge at Lakeside Edge of Road

Maintenance metal at this unsupported edge is loose, where not bound by vegetation: two comparisons are shown in Figure 16.

Figure 16: Unsupported Metal at Road Lakeside Edge

4.2 History of Road Construction

Darrell McGregor built the road in 1982. He had previously widened the horsetrack at Greenstone (shipping his gear up) in 1957. In the completion of the road and re-widening, he commenced at the Kinloch end. On both occasions the rock at Greenstone was removed by drilling and blasting.

He built the approaches to the Dart River Bridge which was opened in 1974.

To his knowledge, the only deep lake edge is near the jetty.

At some locations, the uphill side is not terraced (i.e. is shear). The drop to the lake is generally also sheer.

The Dart River metal takes a long time to settle down (i.e to densify under traffic compaction alone).

4.3 Alistair Haig (Works Infrastructure) and Tony Adams (Fulton Hogan)

Mr Haig is the Operations Manager for Works Infrastructure. He has been responsible for the maintenance operation on the QLDC network for the past two years. He is very familiar with the area, and used to grade the road to Glenorchy. Tony Adams manages the Fulton Hogan office in Alexandra.

4.3.1 Road Width

In the past, the stock was free ranging, and kept the verges clear of brush. Now Works has to come in with a verge mower.

The rock uphill side of the road near the crash site is generally not high, and widening looks quite straightforward. Blasting of rock would be required.

4.3.2 Traffic

The Greenstone-Kinloch road is "coming of age," in Alistair Haig's terms: there is a return daily school bus to Glenorchy, and Council wants the road gritted in winter on a daily basis – more like an urban road. The short wheel-base stock trucks of old have been replaced by longer three-axle truck and trailer units. One got stuck late last year.

The seal extension programme has encouraged people to travel further. People will travel a short distance beyond end of seal onto an unsealed road, and attractions like "Lord of the Rings" sites add to the usage. Priory Road has been seal extended in the past year.

4.3.3 Maintenance Metalling

The Maintenance Metalling is a Lump Sum item in Works' contract but was subject to separate public tender for supply. Contractor Fulton Hogan won this supply contract. Works is the nominated initiator of supply according to a schedule in the contract. Mr Haig requests crushed metal in economic quantities and locations from Fulton Hogan on a programmed basis, through Fulton Hogan's Mr Tony Adams in Alexandra.

Prior to gravelling in July 2005, some of the road was down to bedrock. An average thickness of 75 mm was ordered. Tony Adams advises that thickness is normally controlled by instructing the truck driver to discharge his load between two painted stones. He says that there has been rolling of applied metal in the area in previous years, but without the accompaniment of a water cart.

The gravel for the Greenstone Kinloch is sourced from the Dart River, and crushed. There are a range of minerals present, including schist with its tendency to emerge as slivers, and hard chunkier siliceous product.

The material has a high content of coarse sand. Accordingly, it does not bind well in summer, but nor is it dusty. In a damp state, binding is reasonable.

Alistair Haig believes that the scree-sourced aggregate is better than that sourced from the river.

5 ROAD SURFACING AGGREGATE AND PROCEDURES

Although the aggregate applied to the road is not ideal (clay-bound aggregate is not known to be available in the area), the road surface is not inconsistent with many unsealed roads in New Zealand.

Unsealed roads constitute about 40% of the public road network and have significantly less skid resistance than a sealed road. It is important that the driver have space in which to decelerate/brake without coming to grief. This includes adequate sight distance for awareness of approaching traffic, and an adequately low speed environment.

It is not common practice to roll in aggregate when applying it to an unsealed road, apart from the compaction provided by trucks and grader during this operation. It is common that a road, immediately after final shaping with a motor grader, will have some loose surface aggregate.

However, with the subsequent passage of traffic, and provided that an appropriate level of moisture is available (whether in the aggregate during placement or applied subsequently through rain), the road should "settle down."

Based on the photographs taken shortly after the time of the accident, the road surface was in a reasonably stable condition.

Therefore, although significant emphasis has been given in publicity following the September 2006 accident to the effect of the road metal on the road's safety, this is not a fundamental matter for consideration with regard to road improvement.

6 SUITABILITY FOR CURRENT AND EMERGING USE

Improvements perceived to be required for the road should focus on two main areas:

- ***geometrics*** (local increases in width and easing of both horizontal and vertical curves),
- ***provision of barrier sections*** on the lake side at locations which are relatively unsafe,

The road between the Dart River bridge and Greenstone requires does require attention to improve its suitability for current and emerging use.

The primary features which detract from a normal level of safety for an unsealed road, on this route are

- The lack of restraint offered to vehicles erring towards the lakeside and the illusion of protection offered by the scrub on the down-slope side
- Sudden variations in condition, notably
  - the scarp heading south near the jetty – an unexpected sudden descent and , for drivers heading north, a "blind summit," and
  - the sudden change of lighting for drivers entering the glade, and a potential "stroboscope" (flashing light) from the sun's rays dancing through the trunk plantation as they proceed
  - the sudden change in safe speed environment in the glades
- The lack of sight distance (blind corners, trees close to the vehicle path) upon entering each of the two bush glades.

Recognition must be given to the increasing numbers of non-locals as well as foreign tourists using the road, together with the advent of long wheelbase truck and trailer stock units, and even tourist busses. It is not necessary to provide a two lane road, but rather one with "passing opportunities" at regular intervals, located clearly enough so that approaching vehicles can decide which one is more able to give way to the other. Where the road reduces to a single lane, then width should be sufficient for the occasional over width vehicle needed to service the farm: specifically, its passage should not be impeded by guardrail or the like.

At the same time, the road should remain a low-speed road. This can be achieved by limiting the width increases as well as limiting the degree to which curves are eased.

7 RECOMMENDATIONS

7.1 General

The proposed recommendations should be considered with a view to making the road "safer" rather than "faster." A danger with all improvements is that the more "adventurous" drivers will continue to push the boundaries. Improvements should not be such that the safe speed varies significantly along the road, nor is significantly greater than at present (about 40 kph).

Consequently, around-table discussion of interested and qualified parties should be carried out to arrive at an appropriately tuned solution, in particular, one that does not offer the driver the opportunity to significantly increase speed at any point on the road

7.2 Minimum Width of Carriageway (Single Lane and Passing Bay) with and without Guardrails

It is proposed that the minimum width of maintained (graded) carriageway be

- 3.5 m, at single lane sections, and
- 5.5 metres at passing bays.

The result is less than the aims of the QLDC "*Guideline: Rural Roading Corridors*" (5.5m for less than 15 lots served) but equal to those for right of ways (3.5m). From the surveyed cross-sections shown for the south end of the road, it is apparent that sections of this road (where retained as "single lane" sections) will require minimal change.

Figure 17 suggests appropriate cross-sections for the four types of road sections. (The dotted line at left of the figure linking the cross-sections retains the top of lakeside embankment at a constant position on the cross-section and thus enables comparison of the landside embankment.)

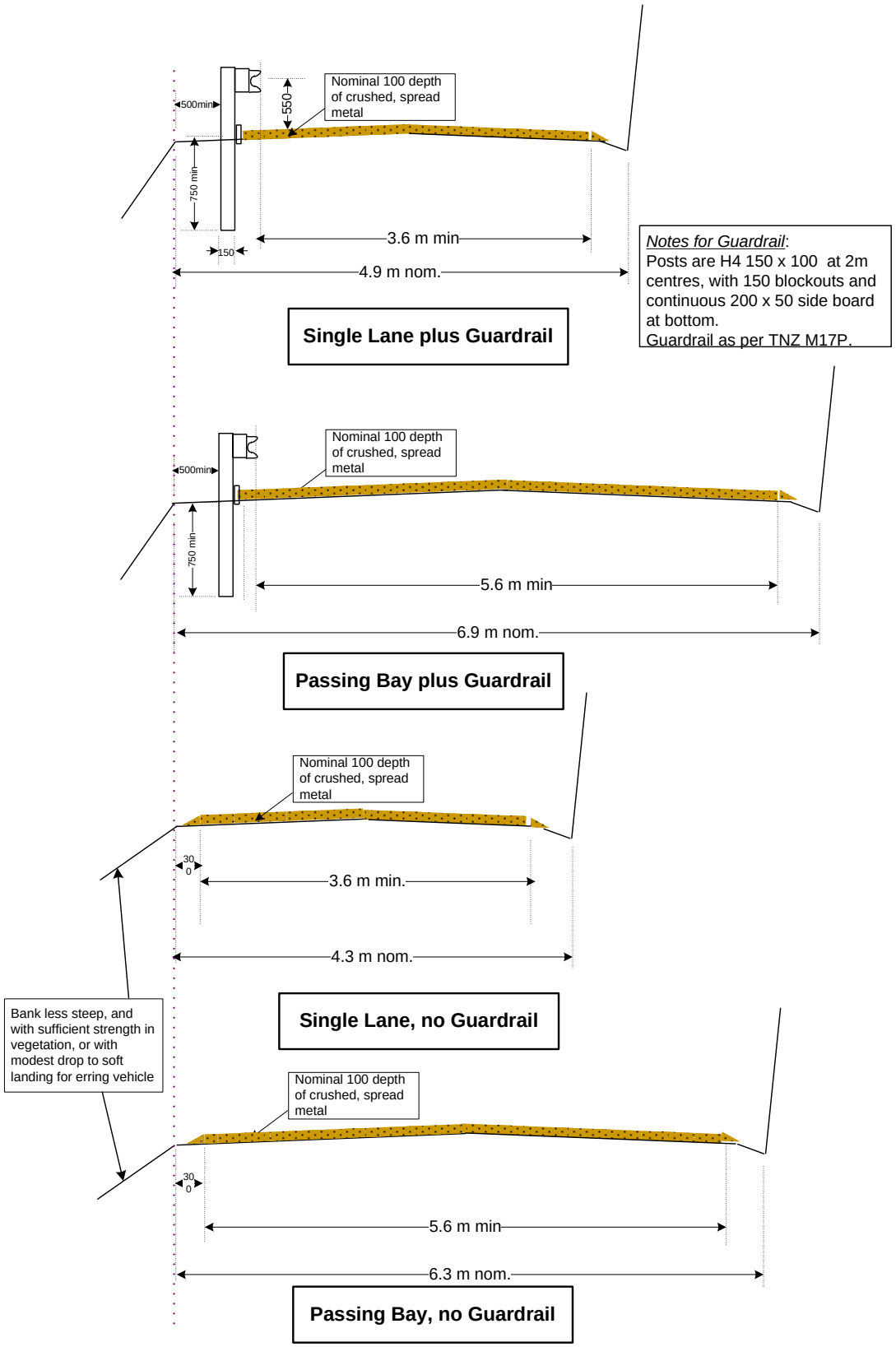

Figure 17: Proposed Minimum Cross-sections

At most, construction of a passing bay could require a cut into the uphill bank of about 3.5 metres. This may be avoidable by careful consideration of location of passing bays along the road.

The primary purpose of the proposed sideboards is to contain the road metal and avoid loss into the lakeside slope. These will also serve to resist impact-induced sideways movement of the post if they are coach-screwed into the posts, and are themselves in contact with the firm shoulder material.

The passing bays should be at least 10 metres long, plus entry and exit tapers. This will accommodate a van and trailer.

Guardrail details are based on those applying to State highways.

The difference in overall width between “one lane” and “one lane plus passing lane” locations is only about 2 metres, reflecting the minimal improvements being suggested.

Locations of passing bays will probably not be at ideal or regular intervals, but should ensure that approaching drivers are aware of the proximity of the next passing bay.

Passing bays should be constructed on the inland side of the road (not the lake side) in order to give consistency of definition of lakeside edge to the motorist.

In all cases, the north-bound driver should be required to give way to the south-bound driver, and this may need to be emphasised with signage at the north end of the route.

The above proposals should be refined through discussion.

7.3 Vertical Alignment

The alignment in the vicinity of the jetty at Greenstone should be improved. This is the only location where attention to vertical alignment is recommended.

Figure 18 develops Figure 2 to include the result of fitting a standard vertical curve to the existing alignment: a depth of cut generally varying between 1 and 2 metres is required.

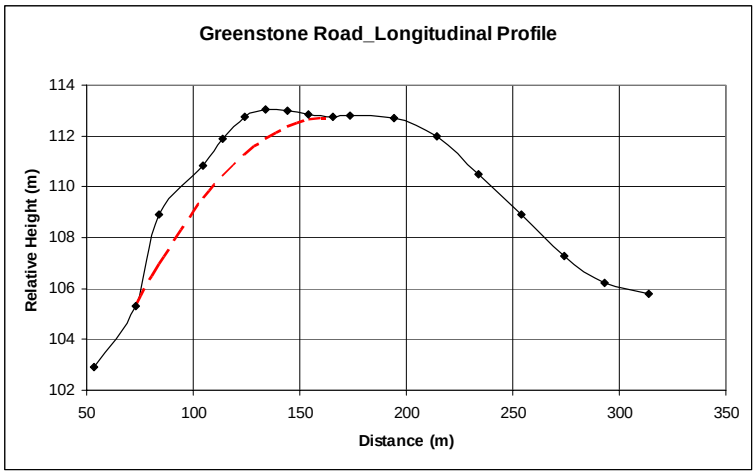

Figure 18: Proposed Easing of Crest at Greenstone

7.4 Horizontal Alignment

This is mainly a problem in the two glades. Easing (i.e. local increase in radius) of curves is required: these should improve sight distance as well as accommodate the swept path of a truck and trailer (stock unit). In some cases, visibility may be sufficiently improved by cutting back the uphill slope without substantially changing the hillside road edge and drainage, adjustment to tight curves by increasing radii to around 40 metres is likely to also be necessary.

Removal of a few beech trees will be necessary. Focus should be on minimising the number of trees removed, in order not to detract from the pleasant driving experience of the glades.

A survey of the glades has not been carried out within the scope of this report, but should be done as a basis for a design (including identifying trees needing to be removed) and subsequent discussion by affected parties.

7.5 Possibility of Restriction of Vehicle Type

The road, even with the improvement suggested, is going to remain a challenge to drivers of long vehicles. Accordingly, consideration should be given to restricting the length of vehicles to exclude B-trains and truck and trailer. There is no evidence that the effect of gross vehicle weight has been detrimental to the road, and hence it is not proposed that limitations on weight be applied (gross vehicle weight is likely to be less as a result of the limitation to a single prime mover component).

7.6 Ongoing Maintenance-

This primarily affects control of vegetation, motor grading, and maintenance of the fords.

The motor grading and metalling operation does not need change, except that signs warning of the presence of loose gravel should be put out at the north end and retained in place for about two week following grading. Grading and remetalling should be confined to periods when the road and available metal is damp.

It is acknowledged that the metal from the Dart River is not ideal, but a more cohesive product is not available in the area. Most unsealed roads lack a desirable level of skid resistance, and the focus on geometric (sight distance) and safety improvements (widening and guardrails) is a more effect way of decreasing risk.

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Reviewed by: Norman Major, FIPENZ

APPENDIX A
ROADS AND LOCATIONS DESCRIBED