

**Waitaki District Council
Contract No. 442
Report on Engineering Issues
Of a Coastal Roads Strategy**

Oamaru to Waianakarua



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Report on Engineering Issues

of a Coastal Roads Strategy

Oamaru to Waianakarua

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Executive Summary

This report examines engineering strategies for the Coastal Road Sites 1 to 7 located between Oamaru and the Waianakarua River.

- Site 7; the coastal section of Waianakarua Rd located between Bowally Rd and the inland portion of Waianakarua Rd. It is recommended that the coastal road be abandoned and that other local roads be utilised. A 3.5km section of Bowally Rd will require sealing.
- Site 6; the section of Waianakarua Rd located between Maclean Rd and Bowally Rd. It is recommended that other roads in the vicinity are utilised and the existing road is abandoned. That the feasibility of modest rock protection at the worst places along the toe of the cliff north of Bridge Point be investigated. That Maclean Rd is sealed as a lower priority project as funding permits.
- Site 5; the section of Waianakarua Rd located between the mouth of Orore Creek and Maclean Rd. The natural road causeway at the mouth of Orore Creek is recognised as being more prone to erosion than the coast and should be monitored for erosion on a regular basis. Improvements to the sand dunes on the causeway will aid erosion protection.
- Site 4; the section of Beach Road between Thousand Acre Road and Kakanui. It is recommended that no immediate action is taken at this Site but that ongoing monitoring of the coastline is carried out to establish long term erosion trends.
- Site 3; the section of Beach Road between Gardiners Road and Thousand Acre Road. This section of road has been closed due to erosion damage and the alternative route of Thousand Acre Road and Gardiners Road is recommended to be adopted permanently.
- Site 2; the section of Beach Road between Awamo Central Road and Gardiners Road. It is recommended that the coastal road is abandoned and that Thousand Acre Road be utilised as the alternative route to Oamaru.
- Site 1; the section of Beach Road from Oamaru to Awamo Central Road. It is recommended that the coastal road is abandoned and that Awamo Rd and the inland section of Beach Rd be the alternative routes.

Introduction

The Waitaki District Council Contract 442 “Professional Services for the Preparation of a Coastal Roads Strategy for Waitaki District” was awarded to Opus International Consultants Ltd (Opus) in October 2008.

The Contract Objectives are for Opus to:

1. Review Waitaki District Council’s current documents, interview appropriate staff and determine the options available for Waitaki District Council’s Coastal Roading Network.
2. Review specialist advice prepared by Council’s Coastal Erosion Advisor – Gary Tear, OCEL Consultants NZ Ltd.
3. Undertake analysis of the options in terms of Waitaki District Council objectives and New Zealand Transport Agency Economic Evaluation Manual. The analysis shall provide options for the Council to consider for the short term and the long term. The analysis shall also include the appropriateness of the approach including but not limited to:

Historic Places Act 1993
Land Transport Management Act 2003 (and Amendments)
Local Government Act 2002
Resource Management Act 1991
New Zealand Coastal Policy Statement
Regional Plan: Coast of Otago
Kai Tahu ki Otago

4. Facilitate a workshop discussion with Councillors
5. Prepare a Draft Coastal Roads Strategy for discussion with Council Officers
6. Prepare a Final Coastal Roads Strategy

Subsequent instructions from the Council reduced the scope of the objectives to only the Engineering issues of the Coastal Roads Strategy, with the immediate emphasis being on Sites 6 and 7 due to the pending Bow Alley Creek bridge replacement. Following this initial report the remaining sites were to be addressed with all sites being combined into one final report.

Overview

Land erosion caused by the sea is occurring along the coastline of the Waitaki District.

Information from old maps indicates that the coastline has been migrating landward continuously during the period of European settlement¹

The Intergovernmental Panel on Climate Change (IPCC)⁵ estimates that the sea level will continue to rise and therefore erosion of the Waitaki coastline can be expected to continue for the foreseeable future.

Over the last ten years various studies have been carried out on coastal erosion in the Waitaki District (see References). The purpose of this report, in accordance with the Professional Service Contract, is to:

- Bring together and summarise this information
- Develop coastal road network options for a 25 year time frame
- Undertake an economic analysis of various options
- Discuss and recommend strategies for the future

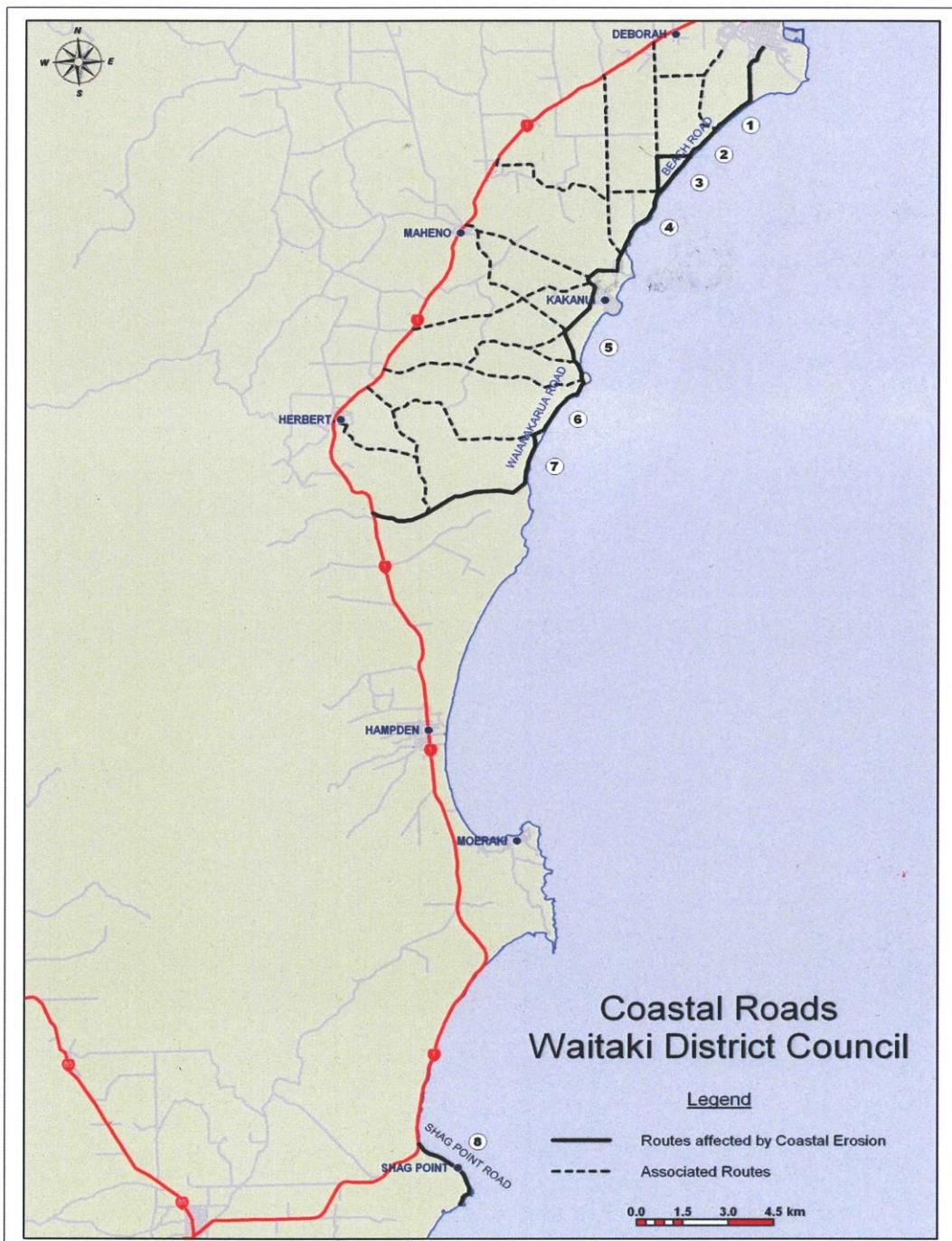
The average long-term rate of erosion on the Waitaki District coastline has been determined at between 0.25m and 0.6m per year depending on location¹. However, coastal erosion is typified by rapid erosion during storm events from the South-Easterly quarter, followed by periods of stability. During a single storm event erosion of up to 12m - 15m¹ can occur at localised sites.

For the purposes of detailed investigation the coastline south of Oamaru has been divided by the Waitaki District Council into eight sections, as follows:

Site 1	Beach Road	Oamaru to Awamoia Central Road
Site 2	Beach Road	Awamoia Central Road to Gardiners Road
Site 3	Beach Road	Gardiners Rd to Thousand Acre Road
Site 4	Beach Road	Thousand Acre Road to Kakanui
Site 5	Waianakarua Road	Kakanui to Maclean Road
Site 6	Waianakarua Road	Maclean Road to Bowalley Road
Site 7	Waianakarua Road	Bowalley Road to State Highway 1
Site 8	Shag Point Road	not considered in this report

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch

⁵ Climate Change Leadership Forum, report No.7 June 2008, www.climatechange.govt.nz

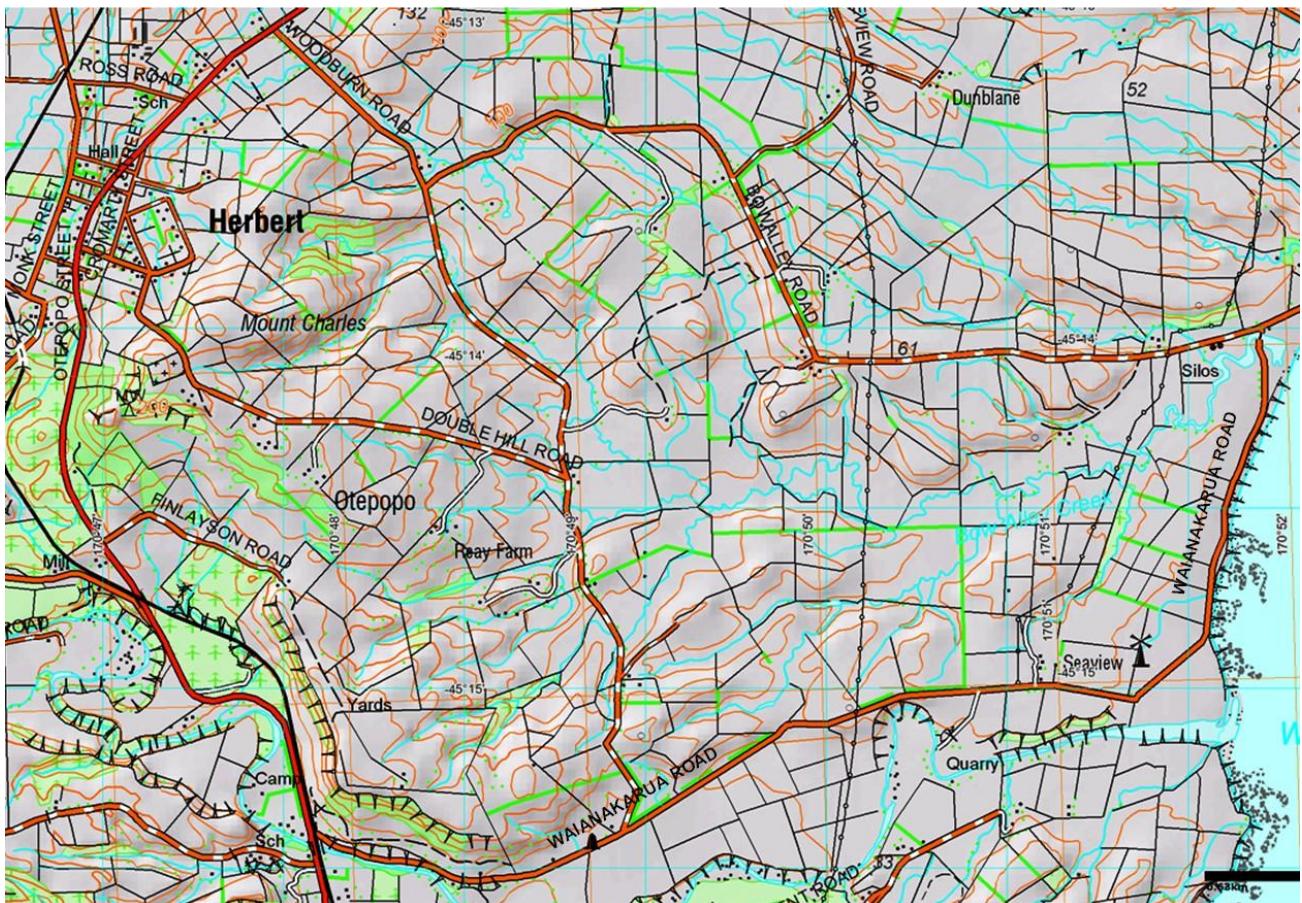


Map Showing the Eight Coastal Road Investigation Sites

This report considers the coastal erosion issues at Sites 1 to 7 between Oamaru and the Waianakarua River. Examination of Site 7 has been given urgency because it contains a weight restricted bridge that is due for replacement this financial year. In addition, urgent protection works have already been carried out at one location at Site 7 and other locations are under immediate threat. This report then examines the remaining Sites as a natural progression northwards along the full lengths of Waianakarua Rd and Beach Rd to Oamaru. As a consequence, the examination of Sites in this report is in the reverse order (i.e. in a northerly direction) compared to the list of Sites on Page 3.

Site 7 – Bowalley Rd to State Highway 1

Description of Site 7



[Site Map – Site 7](#)

Waianakarua Rd leaves State Highway 1 about 4km south of Herbert and heads east to the coast. It intersects the coast on the northern flank of a promontory partially protected from erosion by an offshore reef. The road then turns northward and continues immediately adjacent to the coastal bank.

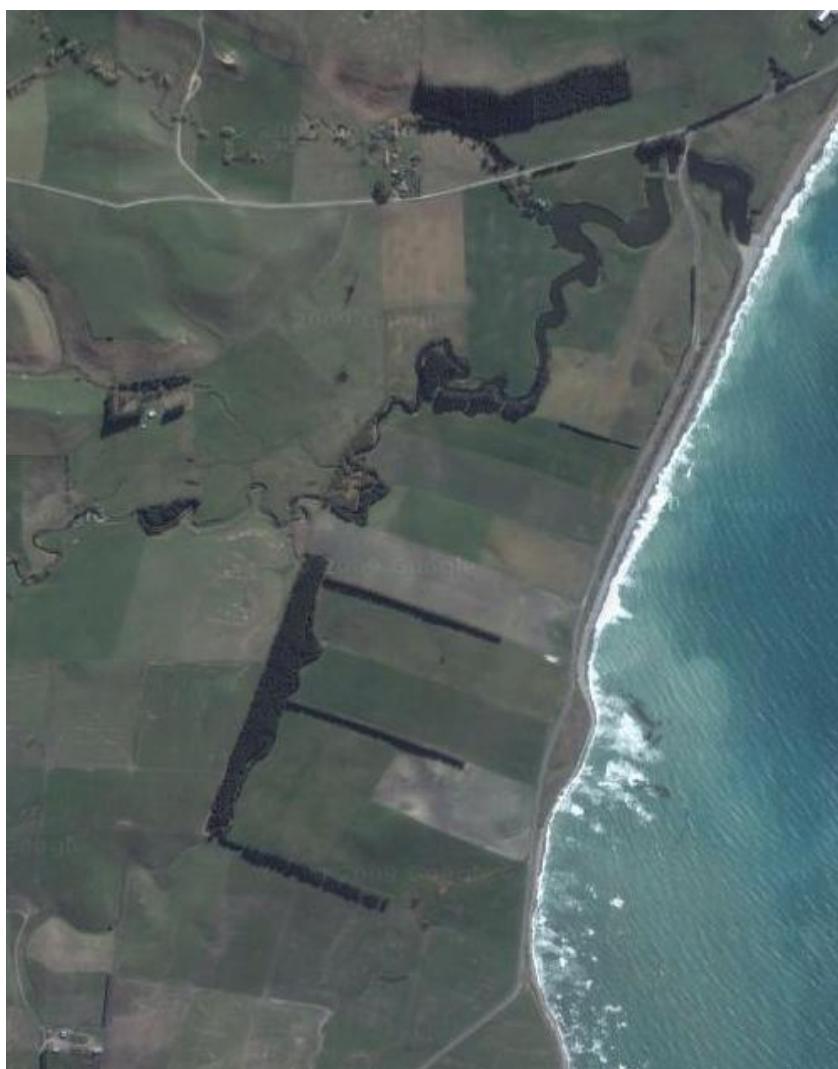
Note: The 'coastal bank' is defined as the sandstone, clay or gravel cliff or embankment at the landward edge of the beach and which defines the boundary between terrestrial and marine erosion processes.

After 350m the coastline deviates seaward at another minor promontory, again protected by an offshore reef. The distance from the road to the coastal bank at this location increases to about 100m. Immediately north of this promontory the road is again located immediately adjacent to the coastal bank. At this site a 100m long seawall was urgently constructed in 2007 following a storm event.



Site 7, The Section of Seawall built in 2007

The road continues northward for another 600m then veers inland as it approaches Bow Alley Creek. The road crosses the creek via a single lane timber bridge which is weight restricted. One hundred metres further north Waianakarua Rd intersects with Bowalley Rd at a distance of 360m inland from the coastline, and at the northern limit of Site 7.



Aerial Photograph – Site 7

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹.

The seaward shoulder of the road is currently within 8m of the adjacent coastal bank along two sections totalling 400m in length. This length of road is under immediate threat of damage from storm events.

A further 600m of road shoulder is currently in the 8m to 16m distance range from the adjacent coastal bank, this length of road will probably come under threat within the next decade.

Roading Network Protection Options

There are three options to safeguard the integrity of the roading network in the vicinity of Site 7:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch

Option 1 - Coastal Erosion Protection of the Existing Road

As stated earlier, the shoulder of the road is currently within 8m of the adjacent coastal bank along two sections totalling about 400m in length. Should it be decided to retain the existing road alignment, it is recommended that seawall protection structures be constructed immediately at these two locations.

A 100m section of seawall was constructed at this site in 2007 and cost about \$3,000 per lineal metre. This structure consists of an armour rock apron, extending down the beach, upon which a three tier gabion wall was constructed.

The cliff face at this location is higher than normal along this section of coastline due to its proximity to the promontory where the ground levels are somewhat higher. For future seawall construction a seawall of a lesser height may be able to be used which would reduce the cost of construction. In addition, the urgency of the work done in 2007 and lack of experience of the contractor may have also added to the cost of this project.



A David Hamilton & Assoc, report dated 2000³ suggests a seawall construction rate of \$520/lm
A GHD report dated 2007² suggests a seawall construction rate of \$2,300/lm
An OCEL Consultants report dated 2009¹ suggests a seawall construction rate of \$3,000/lm

The size and type of construction for each section of future seawall needs to be decided to suit the local circumstances, for the purpose of this report a seawall construction rate of \$3,000/lm has been adopted.

Random-rock protection structures function by absorbing wave energy as the waves swirl around and between the rocks. When these structures are first constructed this wave action flushes the sand and shingle out from under the rocks causing them to settle into the beach. These rocks may be thought of as 'lost' but are, in fact, forming a solid foundation for the structure. An alternative method of construction is to dig a trench along the alignment of the seawall and fill this with rock to form a foundation from the outset. In addition, the force of water moving between the rocks can be sufficiently forceful to pluck rocks out of the structure, causing them to be dragged back down the beach as the wave retreats.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch

² Preliminary Report on Coastal Erosion Waianakarua Rd and Beach Rd, November 2007. GHD

³ Beach Road Coastal Protection, October 2002, David Hamilton & Associates Ltd. Dunedin

When constructing random-rock protection structures sufficient rock must placed to:

- Allow for a rock foundation under the beach level
- Allow for the loss of rocks lost down the beach
- Be sufficiently substantial to absorb the wave energy within the structure

In addition, the sea water swirling around and between the rocks will contain beach sand and stones in suspension; this has a sand blasting effect on the rocks, and will slowly erode them away. Occasional top-ups of new rock will be required to replace this loss.

Random-rock structures must be substantial and occasional replacement of rock must be expected.

Both the OCEL Consultants report and David Hamilton & Assoc reports recommend that 5% of the construction cost of seawalls should be budgeted annually for ongoing maintenance and repairs, this has been allowed for in our economic calculations shown later in this report

After the initial 400m of seawall has been constructed it is recommended that a further 600m of coastline be protected at a construction rate of 100m of seawall every two years. This will protect the sections of road where the road shoulder is currently in the 8m to 16m distance range from the coastal bank. The total construction period is therefore thirteen years and the total construction cost is \$3,000,000.

If this current route is to be retained then the bridge over Bow Alley Creek needs to be replaced. The bridge is weight restricted due to the poor condition of the existing piles and abutments. The Waitaki District Council has estimated the cost to replace the bridge at \$450,000. This sum has been allowed for in our economic calculations of this option.

Option 2 - Create a new road further inland and abandon the existing road

An alternative to protecting the existing road from coastal erosion is to construct a new road further inland. A possible route has been found located about 600m inland and running parallel to the current shoreline. The new road would require the purchase of an area of land 20m wide by about 1900m long – approximately 3.8ha. The route would deviate from the existing Waianakarua Rd at the Site's southern end and intersect with Bowalley Rd at its northern end.

The proposed route is situated on parcels of land all within a single ownership. Along 1300m of its length the route is located along the boundary of adjoining land parcels that have another single but different owner. This route has the advantage that the road would provide frontages to the various parcels of land on each side of the road.

At the southern end there is a 600m section where the route runs along a land parcel boundary line where the same owner owns the land on both sides. At this location the paddock fencing does not coincide with the land parcel boundaries and therefore rearrangement of fences would be required.

Land Valuations for properties in the immediate vicinity have been ascertained using Quickmap software. For lots of similar size and land use the Capital Valuation as at 1June 2006 was from

\$21,000 to \$24,000 per ha. For the purpose of this report and as the land required for roading is part of a large farm a land value of \$24,000 per ha has been used. A premium of \$24,000 per ha has been added to compensate for goodwill, farm operation disruption and future revenue loss, giving a total purchase cost of \$48,000 per ha. Advice from an internal Opus Property Consultant suggests that a negotiated purchase involving a premium price can be preferable to using compulsory purchase procedures.

The cost to construct the new road has been determined using costing information in a report prepared by Montgomery Watson in 2000⁴ for possible replacement of a section of Beach Road. The cost has been updated to current value using NZ Transport Agency cost adjustment indices. The resulting cost, including the above land purchase cost is approximately \$1,929,000. It also includes a \$250,000 allowance for the construction of one large culvert and two smaller culverts across the tributaries of the Bow Alley Creek.

As the two end sections of Waianakarua Rd will remain at this Site, they can continue to provide access to the coastline and it is suggested that they be retained as part of the road network. The existing bridge may be able to be retained in service for light vehicles or pedestrian use only.



Plan of Proposed New Inland Road

⁴ Beach Road Investigations and Options Report – Project Feasibility Report, November 2000. Montgomery Watson NZ Ltd. Dunedin

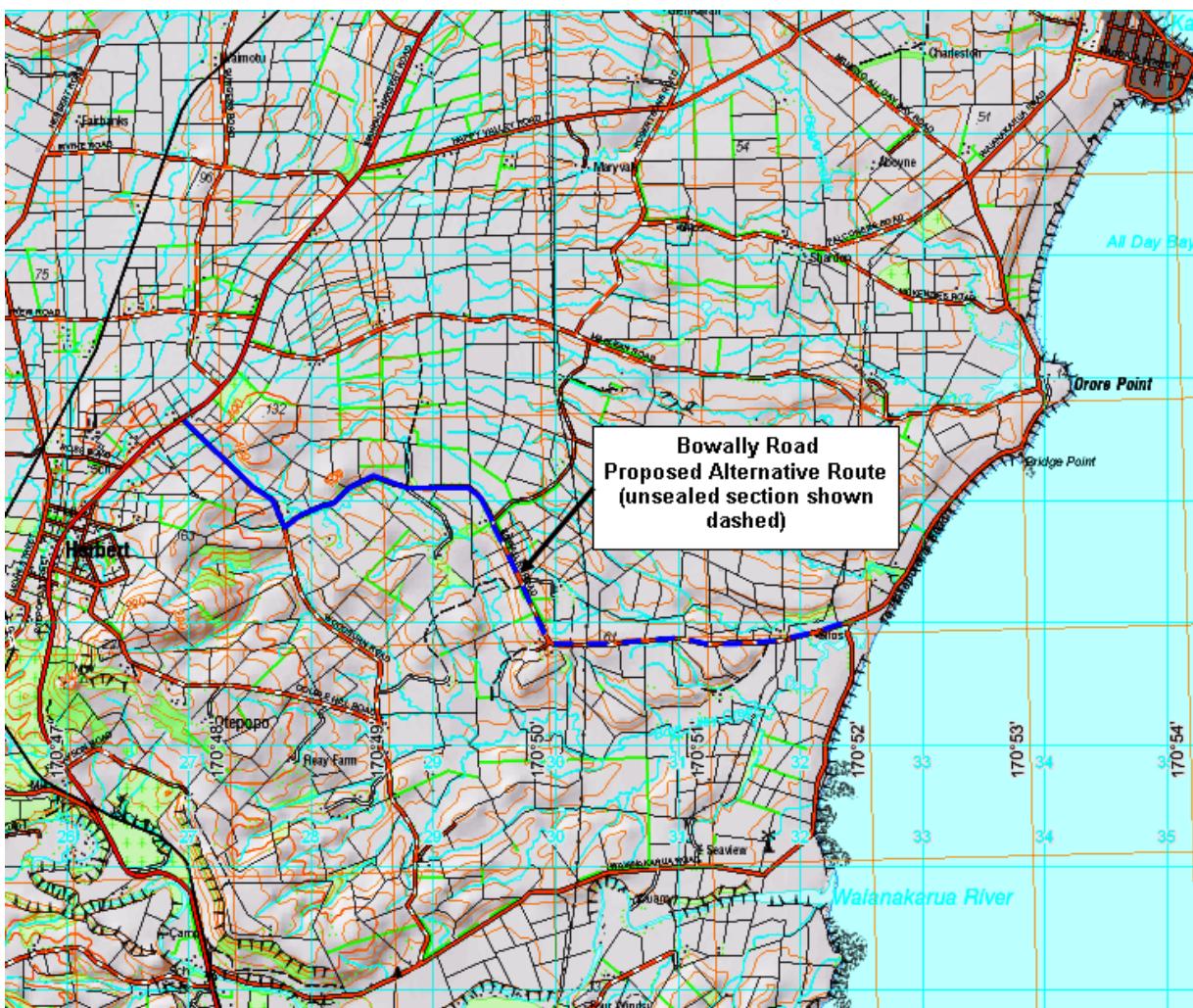
Option 3 - Utilise other roads in the vicinity and abandon the existing road

This Option involves the closure of the coastal section of Waianakarua Rd without the provision of an alternative through route in the immediate vicinity.

Waianakarua Rd forms the southern leg of the coastal scenic route starting at Oamaru. Woodburn Rd and Bowalley Road could be upgraded to cater for this regular through traffic. The section of Bowalley Rd between Clareview Rd and Waianakarua Rd, 3.5km long, is currently unsealed. To form a continuous sealed route from Herbert to Kakanui, along the coast, it would be necessary to seal this section of road. Discussion later in this report will indicate that the coastal scenic route cannot be sustained beyond the next decade. At that time the Woodburn Rd and Bowalley Road route to State Highway 1 will revert to being a high standard local access road.

Fonterra has advised that it has few dairy farm customers in this area and they can be serviced by milk tankers diverting from the State Highway. The closure of the section of Waianakarua Road would not adversely affect their operations.

The cost to upgrade and seal this section of road would be approximately \$525,000



Plan of Other Existing Roads

Conclusion

Since the three options involve costs over various time spans it is appropriate to use the NZ Transport Agency Discounted Present Value procedures to determine the equivalent current cost of expenditure over a 25 year period, these are shown in Appendix 1.

Current advice is that sea level rise will continue for the foreseeable future (next 100 years), only the rate of rise is still uncertain. Retaining the existing road alignment therefore involves a considerable level of physical and financial risk.

The cost of the new inland road option is significantly less than the coastal erosion protection option. Its construction involves standard road construction practice and is a low risk undertaking. Getting the approval of the landowner to release land for the new road is pivotal to this option.

Upgrading other roads is the least expensive option but does lower the level of service provided by the roading network in the vicinity of Site 7.

As the two end sections of Waianakarua Rd that will remain at this Site can continue to provide access to the coastline it is suggested that they be retained as part of the road network. The existing bridge should be retained in service for light vehicles or pedestrian use only.

Recommendation

That Option 3 – Utilise other roads in the vicinity and abandon the existing road be adopted.

That the unsealed section of Bowally Road be sealed

That Waianakarua Rd is closed at this Site when it becomes unsafe.

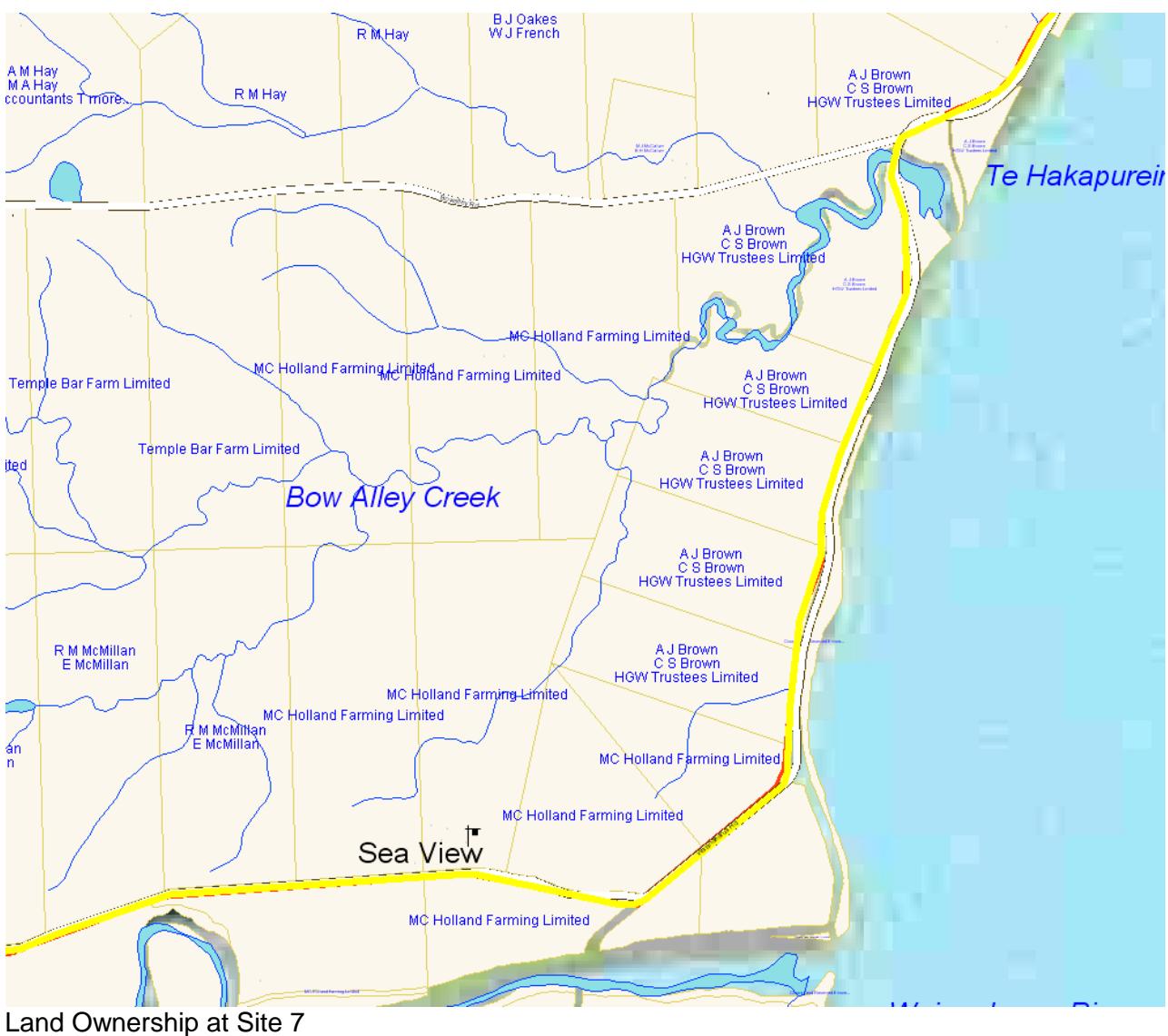
That the two sections of Waianakarua Rd, which will remain at this Site, be retained as part of the road network.

That the existing bridge be retained in service for light vehicles or pedestrian use only.

Current Land Ownership

If the Recommendation for Site 7 is adopted then consideration needs to be given to the affect on access to land adjacent to the section of Waianakarua Rd that is to be closed. At Site 7 it will be noted on the map on page 13 that all of the land adjacent to the threatened road is owned by two owners, with the 'Brown' properties having the bulk of the affected road frontage. These parcels of land, combined, have safe access, either directly off Bowally Road (although crossing Bowally Creek may be an issue) or from the short portion of Waianakarua Road that is to remain for public access to the beach, south of the Bow Alley Creek. Alternative access can therefore be provided at Site 7.

Note: General issues relating to land ownership are discussed on page 45



Site 6 – Maclean Rd to Bowalley Rd

Description of Site 6



Site Map – Site 6 and the southern part of Site 5

Three hundred and seventy metres north of its intersection with Bowally Rd, Waianakarua Rd returns to the coast and then runs parallel to the coastal bank for 1.6km. The road then travels over a headland called Bridge Point, which is protected by an offshore reef. North of the Point the road rejoins the coastline where there is another bay 400m long. At the north end of this bay is a large headland called Oroe Point. Here the road heads inland again and intersects with Maclean Rd at the northern limit of Site 6.

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹.

The long beach (Te Hakapurerei) that takes up most of Site 6 has a buffer of at least 10m between the road edge and coastal bank. There is vegetation growing down the bank which indicates that it is not being actively eroded. The photograph below shows a stratum of sandstone exposed at the base of the bank and this will be providing protection against wave action. Some rock protection work to check an isolated pocket of erosion is shown in the foreground.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch



Aerial Photograph of Site 6



Site 6 Southern Beach – Looking North, Sandstone strata present at base of the coastal bank.

Earlier coastal erosion reports do not mention issues at this beach so the overall impression is that it is relatively stable. There are four minor gullies in the coastal bank where natural land stormwater run-off discharges onto the beach. Protection works may be necessary at these gullies in the future, due to either run-off flood damage or storm sea surges being channelled up these gullies and putting the road at risk.

The 300m section of road adjacent to the beach at the north end of this Site, north of Bridge Point, is under immediate threat of erosion damage. The coastal cliff face is located directly adjacent to the road shoulder. The photograph below shows Bridge Point in the background, created by the sandstone reef extending out to sea (also visible on the aerial photograph of this Site). Recent slumping of the clay bank in the middle-ground of the photograph indicates active erosion in this area, contributed to by the absence of the sandstone strata at this location. Some minor protection works are shown in the foreground which does appear to be having some effect.



Site 6 Northern Beach – Looking South, Active bank erosion

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 6 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal Erosion Protection of the Existing Road

To construct a substantial seawall similar to that installed at Site 7 to protect the existing 300m section of road north of Bridge Point from coastal erosion would cost at least \$900,000. The cost of this type of protection works is not commensurate with the value of assets being protected and there is no justification for this level of expenditure to protect this section of road.

The existing rock placement work in this bay does appear to be providing some protection to the toe of the clay bank and could be an economic method to slow down erosion at this location.

Option 2 - Create a new road further inland and abandon the existing road

Option 2(a)

The area landward of the existing road is pastoral farmland with no dwellings or other buildings in the vicinity. It is possible to move the road a short distance inland, adjacent to its current position. The cost to relocate 300m of road is approximately \$250,000.

Option 2(b)

An alternative road alignment further from the coastline does exist. From the southern flank of Bridge Point a new road could be constructed in a north-westerly direction to meet Maclean Rd at the inland boundary of the Orote Creek lagoon. Traffic could then head east down Maclean Rd and rejoin Waianakarua Rd. This option has no merit in the 25 year timeframe of this report, however it could contribute to a longer term inland route, see the Site 5 section for further discussion.

Option 3 - Utilise other roads in the vicinity and abandon the existing road

The detour route, using other roads in the vicinity, to maintain a coastal route is so great as to not warrant serious consideration. The route would include Bowally Rd, Clareview Rd, and Maclean Rd and would exclude all of the coastal section of Site 6. The detour length is 9.7km and currently unsealed.

Another version of this Option is to use other roads for local access to State Highway 1 and to discontinue the coastal route at this Site in conjunction with also doing so at Site 7.

Conclusion

The coastal bank along the beach south of Bridge Point is stable and no action is required at this location.

Substantial coastal protection of the existing 300m section of road north of Bridge Point is not an economical option. Moving the road inland away from the threat of coastal erosion is the most economical solution. Whether the road is moved a short distance and kept parallel with the existing road or a completely new route is created would not greatly affect the cost. However the former option preserves the existing road linkages at each end and would cause lesser disturbance to any affected land owner. As with Site 7, getting the approval of the landowner to release land for the new road is pivotal to this option.

The option of upgrading other roads to maintain a sealed coastal route is a very expensive option due to the long detour distance required and the need to seal the full length.

The most practical long term solution for this Site is to close the coastal section of Waianakarua Rd north of Bridge Point once it becomes unsafe to use. The life of this section of road could be extended by placing rock along the toe of the coastal bank as is shown in the photograph above. To treat the full 300m length of the bay with this modest form of protection at say, \$500 / lineal metre would still be excessively expensive but treating say 150m of the worst affected sections could be worthwhile. The section of road south of Bridge Point is more stable and should be able to be kept open for a longer period of time.

Recommendation

That Option 3 - Utilise other roads in the vicinity and abandon the existing road be adopted.

That the feasibility of modest rock protection at the worst places along the toe of the cliff north of Bridge Point be investigated.

As funding permits sealing of Maclean Rd be considered as a lower priority project.

That Waianakarua Rd, from Bridge Point north, be closed when it becomes unsafe

That Waianakarua Rd, from Bridge Point south, be closed when it becomes unsafe

Current Land Ownership

If the Recommendation for Site 6 is adopted then consideration needs to be given to the affect on access to land adjacent to the section of Waianakarua Rd that is to be closed.



Land Ownership at Site 6

A very similar situation to Site 7 exists at Site 6, and coincidentally, it is the same land owner involved. The land adjacent to the threatened section of road is owned by one owner.

Safe access is available to the combined properties from both Bowalley Road and Maclean Road

Note: General issues relating to land ownership are discussed on page 45

Site 5 – Kakanui to Maclean Rd

Description of Site 5

Once past Maclean Rd, Waianakarua Rd travels across the northern flank of Oroe Point then descends onto a narrow strip of land between the coastline and the Oroe Creek lagoon. It then turns inland and stays inland from the coast until it reaches Kakanui.



Aerial photograph of the southern portion of Site 5

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹.

The causeway adjacent to the Oroe Creek lagoon will be partially protected from wave action by Oroe Point and its offshore reef. However, this causeway must still be considered vulnerable to erosion from both coastal erosion and by flood flows in the Oroe Creek. Loss of the causeway would cause significant problems as the only alternative route would be a new road around the inland side of the lagoon.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch



Site 5, Causeway at the mouth of Orote Creek - Looking South

The photograph above shows that seaweed and debris is washed up to underneath the trees during rough seas. The Waianakarua Rd is immediately behind the trees and at a lower level.

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 5 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal erosion protection of the existing road

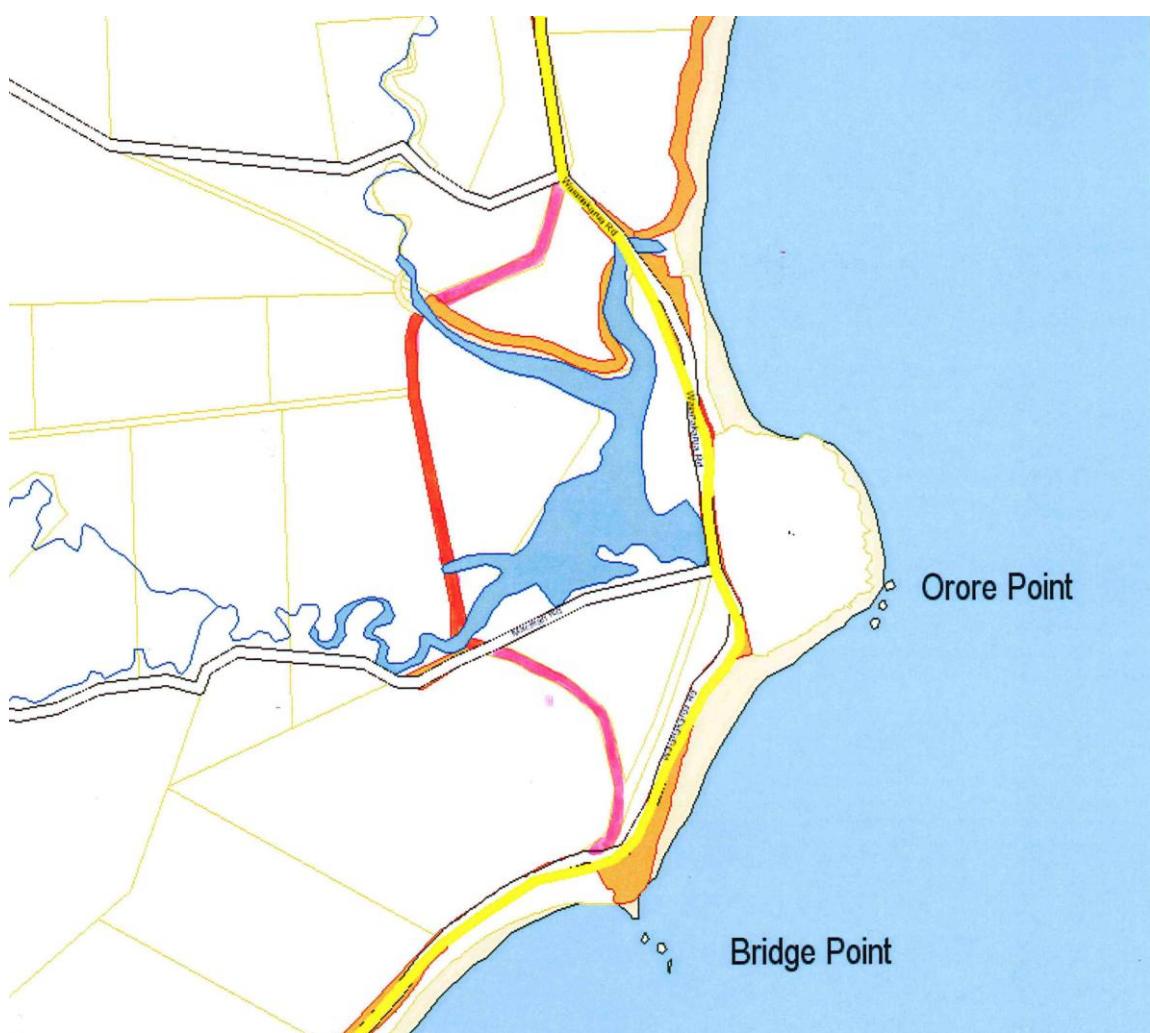
The length of beach fronting the causeway from the northern flank of the Orote Point to the Orote Creek mouth is 350m. Assuming some protection is also required on the north side of the creek mouth then the total length of protection works is say 400m. At the budgeted cost of \$3,000 / lineal metre, the cost of protection works would be \$1,200,000.

Option 2 - Create a new road further inland and abandon the existing road

Should the road causeway at the mouth of the Orote Creek lagoon be permanently breached then an inland route around the western side of the Orote Creek lagoon could be considered. Interestingly, this route appears to have been legal road at some time in the past and the land has subsequently been sold as the surveyed route now consists of several distinct land parcels. The route is shown on the following map. The length of the route is 1.6 kilometres. Since ground conditions in the vicinity of the lagoon are not known it is difficult to cost this new road. Using \$1,000/m as a rough order of cost the new road would cost \$1,600,000

Option 3 - Utilise other roads in the vicinity and abandon the existing road

The nearest alternative route is a circuitous one extending about 4km inland. It follows Maclean Rd, Falconers Rd and Mckenzies Rd, a total distance of 8km. The total length is currently unsealed and the cost to seal it would be \$1,200,000.



Future New Inland Route

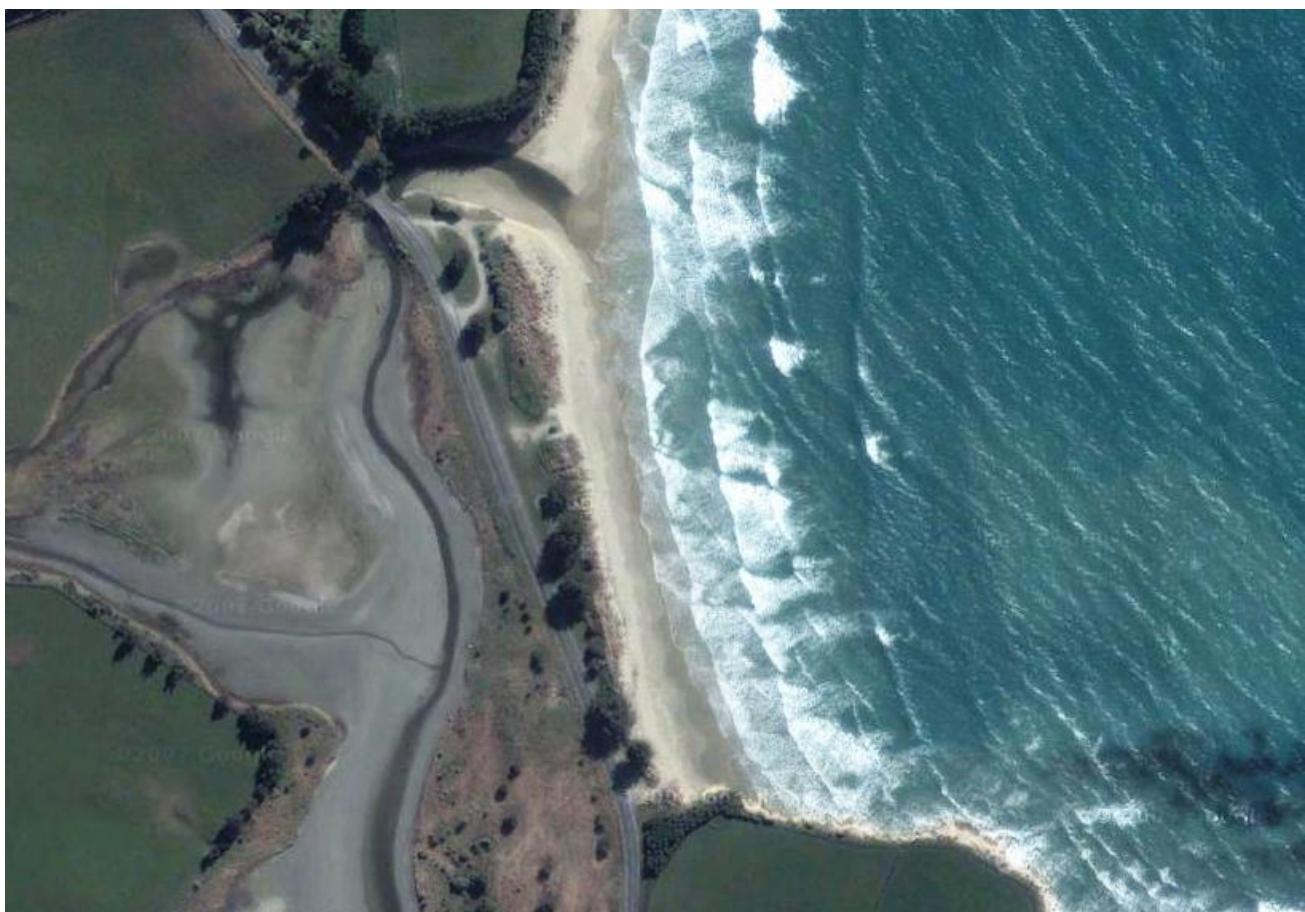
Existing Waianakarua Rd shown yellow. Possible inland route shown red

Conclusion

The causeway between the coast and the Orote Creek lagoon stands out as a potential problem area at Site 5. If it is breached then the low lying lagoon area behind will offer little resistance to further inundation and extensive erosion.

The resistance of the causeway depends significantly on its geological composition. Bars across river and creek mouths on the South Canterbury and North Otago coastlines are formed by the littoral drift of beach shingle. The mouth of the Kakanui River is a good example. These bars can be easily eroded and overtopped in storm events. Inspection of the causeway indicates that it consists only of loose sand and shingle rather than the much more resistant volcanic rock or sandstone that forms Orote Point nearby.

The southern end of the causeway appears to be particularly prone to breach due to the marram grass covered sand dunes, present at the northern end, being absent. The wave run-up height on the beach at the southern end is higher than the height of the adjacent road.



Aerial Photograph of Orote Creek Causeway

Recommendation

That no immediate action is taken at this Site but that the causeway at the Orote Creek lagoon is monitored and surveyed on a regular basis.

That, to maintain a protective bund along the causeway, the sand dunes on the causeway are preserved and that gaps in them are filled with beach sand and planted with marram grass, particularly at the southern end.

Current Land Ownership

The recommendation for Site 5 is that no immediate action is taken and that the causeway at the Orote Creek lagoon is monitored and surveyed on a regular basis. However, if the causeway is breached then consideration needs to be given to the affect on access to land adjacent to that section of Waianakarua Rd.



The land under the lagoon is owned by Central South Island Fish and Game. No other properties would have their access affected.

Note: General issues relating to land ownership are discussed on page 45

Site 4 – Kakanui to Thousand Acre Rd

Description of Site 4



Site Map – Site 4

Beach Road commences at the northern fringe of Kakanui and heads north along the coastline before heading inland just south of Oamaru.

Site 4 consists of the section of Beach Rd from the intersection of High and Tyson Sts, Kakanui, north to Thousand Acre Rd, a distance of 2.8km.

The road strikes the coastline 460m north of Tyson Rd and is situated atop a 20m high cliff with the sea beneath. The road follows the cliff edge for the remainder of Site 4



Aerial Photograph of Site 4

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹

This section of coast fortunately has a sandstone strata located at the correct elevation to resist wave attack of the shoreline. Minor variations in the hardness of the sandstone has caused differential erosion resulting in a series of miniature bays and headlands. In several locations the upper edge of the cliff is in close proximity to the edge of Beach Road. This is particularly evident on the section of coastline adjacent to Kakanui's oxidation ponds.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch



Site 4 - View looking South toward Kakanui



Site 4 - View along road looking south toward Kakanui

The lack of kelp beds on aerial photos suggests that the sandstone strata does not extend out to sea at this location.

Submerged reefs are able to ‘trip-up’ waves causing them to break and in so doing dissipate much of their energy. This section of coast is also orientated directly transverse to storm waves approaching from the South-East.

The existence of mature native vegetation over the upper cliff faces suggests that no subsidence of the cliff has occurred in the recent past. However there are several locations where past erosion of the sandstone strata or steep gully erosion of the clay face of the cliff has caused the cliff edge to approach near to the road verge.

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 4 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal Erosion Protection of the Existing Road

This section of Beach Road is relatively well protected from erosion by the sandstone strata and protection work required would consist of relatively small isolated works in individual bays. The construction of any coastal protection works at this location would be very difficult due to the inaccessibility of the cliff base. Work would need to be carried out from the cliff top. Tipping of rock down the gullies from the cliff top is undesirable due to the danger of having plant and personnel working close to the cliff edge and also to the haphazard placement and wastage of rock that would be achieved. The best practical solution would be to use a tracked or an all terrain crane positioned on top of the cliff but back from the cliff edge and fitted with a clam shell or rock grab to place rock under the guidance of a spotter person. This would be a slow and relatively expensive method but would achieve the desired results.

Option 2 - Create a new road further inland and abandon the existing road

If isolated erosion of the cliff face does threaten the road then the road can be ‘nudged’ inland at these locations. Only in the vicinity of the oxidation ponds are there physical restraints to this occurring.

Option 3 - Utilise other roads in the vicinity and abandon the existing road

Fortification Road and Seadown Road provide an alternative sealed road route to this section of Beach Road. Traffic heading to Oamaru can alternatively continue along Fortification Road to State Highway 1 and hence to Oamaru.

Conclusion

No active coastal erosion was observed at this Site and Beach Road is not under threat. Future coastal erosion is likely to take the form of erosion of the sandstone strata at the base of the cliff or slumping of the clay cliffs themselves. Long term monitoring of coastline should be carried out to identify the extent of these events and to give warning of any impending threat to Beach Road. The comparison of photographs taken from fixed positions and orientations at, say 6 monthly intervals, will after a few years, provide useful information on the long term stability of the coastal cliffs.

Recommendation

That no immediate action is taken at this Site but that ongoing monitoring of the coastline is carried out to establish long term erosion trends

Current Land Ownership



Land Ownership at Site 4

Site 4 is not anticipated to have any erosion issues during the time period under consideration. The aerial photograph of Site 4 shown in this report indicates the presence of two dwellings with accessways onto Beach Road; these are shown diagrammatically on the Land Ownership map for the Site. Access to the land containing the dwelling labelled 1 and access to the dwelling itself may become a problem if ever the adjacent Section of Beach Rd is closed.

Note: General issues relating to land ownership are discussed on page 45

Site 3 – Thousand Acre Rd to Gardiners Rd

Description of Site 3



Site Map – Site 3

Beach Road, at this Site, has been closed to traffic by the construction of earth bunds at each end. It was closed in February 2007 when rough seas caused significant damage to the road, with several sections being washed away. The southern boundary of this Site marks the end of the sandstone strata at beach level which is providing erosion protection to sites further to the south. The coastal bank consists of what appears to be bands of ancient beach gravels along with silts and clay. This material is unconsolidated and very easily erodible. There is one dwelling using this section of Beach Road for access, the owners drive around the earth bund at the northern end.



Aerial Photograph of Site 3

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 3 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal Erosion Protection of the Existing Road

The existing road has been damaged beyond repair by coastal erosion as demonstrated in the photograph below. Protection of the existing road is therefore not a practical option; however, for the purposes of comparison the cost to protect the full 1.7km length of coastal road at this site at \$3,000/lineal metre would be \$5,100,000.

Option 2 - Create a new road further inland and abandon the existing road

The topography at this site is flat and low lying compared to adjacent sites. The coastal bank is also low and consists of unconsolidated gravels, silts and clays. The composition of the coastal bank strongly suggests that the coastline has been further inland during past geological time. The current coastal area was built up as the old coastline retreated seaward. Because of geomorphologic features outlined above this site has the greatest potential for rapid erosion. The safe distance inland to position a new road is not determinable and the nearby availability of existing roads makes this option unattractive. However, again for the purposes of comparison the cost of a 1.7km new road further inland would be \$1,500,000.

Option 3 - Utilise other roads in the vicinity and abandon the existing road

The 'Utilise Other Existing Roads' option is currently being used at this site. Detour signs direct traffic heading north onto the sealed Thousand Acre Road and then onto the unsealed Gardiners Rd and back to the continuation of Beach Road. These roads currently provide a convenient alternative route. However, within the next decade this report recommends the eventual closure of Beach Road at Sites 1 and 2 further to the north. This will make Gardiners Road redundant as part of the coastal route and it will become a no-exit coastal access road. The cost to upgrade and seal Gardiners Rd is approximately \$150,000

Traffic heading to Oamaru can also continue along Thousand Acre Road to State Highway 1 and hence to Oamaru or opt to use Thousand Acre, Stonewall and Awamoa Roads, thus avoiding SH1, to enter Oamaru. Once Beach Road is closed further to the north these two routes will become the main routes for travel to Oamaru.

Conclusion

The erosion damage that occurred in February 2007 demonstrated the vulnerability of this site to rapid and extensive damage. There is no reason why these types of events will not reoccur in the future. A particularly cautious approach to future planning needs to be taken at this site.

Recommendation

That Option 3 - Utilise other roads in the vicinity and abandon the existing road - be adopted and that Thousand Acre Road and Gardiners Road be the immediately available alternative route and that the Thousand Acre Road to State Highway 1 and Thousand Acre, Stonewall and Awamoa Road routes be the eventual alternative routes.



Beach Road closure at the southern end of Site 3



Site 3 – Significant damage to Beach Road

Current Land Ownership



Land Ownership at Site 3

Note: General issues relating to land ownership are discussed on page 45

If the Recommendation for Site 3 is adopted then consideration needs to be given to the affect on access to land adjacent to the section of Beach Rd that is closed.

At Site 3 all land parcels that have frontages to Beach Rd also have alternative access onto either Thousand Acre Rd or Gardiners Rd. The dwelling shown diagrammatically on the land ownership map is currently using the closed section of Beach Rd for access.

Site 2 – Gardiners Rd to Awamoia Rd

Description of Site 2



Site Map – Site 2

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹

The lack of a coastal bank at Awamoia Creek makes the area vulnerable to coastal erosion, but more probably in the short term, to inundation during sea storm events. The elevation of the bridge across Awamoia Creek seems to be particularly low compared to the adjacent beach crest and the bridge could also be threatened.

The random-rock seawall near the northern Awamoia Creek bridge approach is quite substantially built compared to others. It appears to have been topped-up with additional rock recently shown by comparing recent photographs with older ones.

Erosion of the loess cliff north of the seawall is actively occurring.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch



Site 2 – Mouth of Awamoia Creek



Site 2 – Random-rock Seawall north of Awamoia Creek



Aerial Photograph of Site 2

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 2 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal erosion protection of the existing road

Active erosion of the coastal cliff is occurring along virtually the full 1.2km length of this site.

A cost of \$3,000/lineal metre has been adopted as the cost of seawall construction. The cost to protect this site is therefore \$3,600,000. Coastal erosion protection is accordingly not considered a financially viable option. The distance from the cliff face to the road verge is typically 15m, with a long term erosion rate of 0.5 m/yr the road will theoretically be threatened in 30 years; however lateral instability of the cliff face could reduce this timeframe considerably.



Site 2 – Active erosion of cliff face

Option 2 - Create a new road further inland and abandon the existing road

Moving the road inland is not a viable option at this site due to the hilly terrain adjacent to the existing road on the inland side. See the aerial photograph of the site

Option 3 - Utilise other roads in the vicinity and abandon the existing road

There is no convenient route to circumvent Site 2 on its own; however with the closure of Site 3 in February 2007 traffic already needs to detour onto Thousand Acre Rd. It can then progress directly to State Highway 1 and hence to Oamaru or avoid SH1 by travelling to Oamaru via Stonewall and Awamoia Roads.

Conclusion

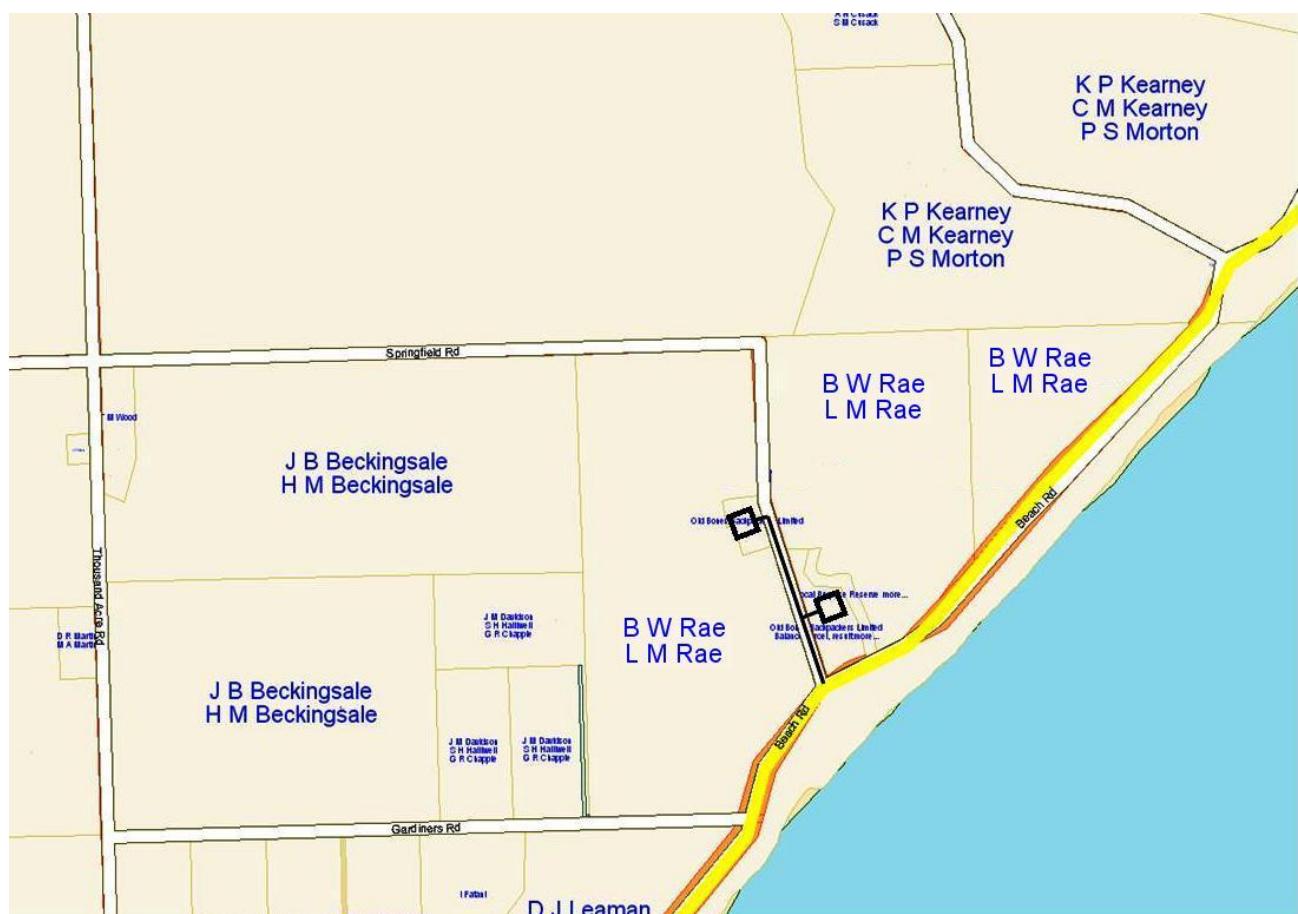
The high historical rate of erosion at this site and the highly erodible clay composition of the coast cliff make this a very vulnerable site. The relocation of the road inland is financially unachievable due to the topography. No practical local alternative route is available but Thousand Acre Road at the southern end of Site 3 and/or Stonewall and Awamoia Roads provide excellent alternative routes to Oamaru.

Recommendation

That Option 3 - Utilise other roads in the vicinity and abandon the existing road - be adopted and that Thousand Acre Road be the alternative route

Current Land Ownership

If the Recommendation for Site 2 is adopted then consideration needs to be given to the affect on access to land adjacent to the section of Beach Rd that is to be closed.



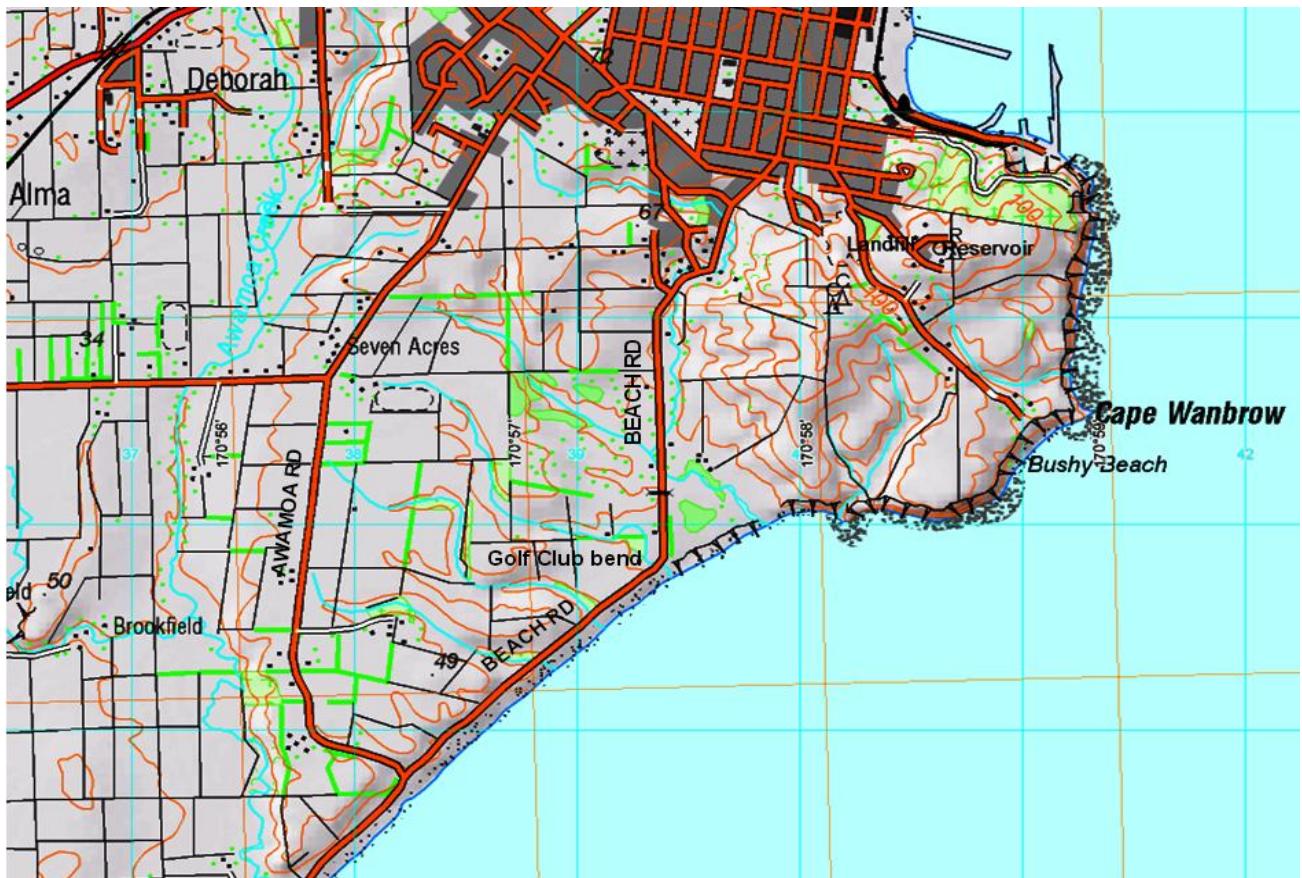
Land Ownership at Site 2

At Site 2 there are two dwellings associated with the Backpackers facility that have access off Beach Rd and are shown diagrammatically on the Land Ownership map. They appear to use a legal but unformed section of Springfield Rd. For future access to the backpacker's facilities, it may be necessary to form a trafficable access along the other unformed section of Springfield Rd, out to Thousand Acre Rd. The properties owned by BW Rae and LM Rae will, jointly, continue to have legal access onto the unformed section of Springfield Rd or alternatively onto Gardiners Rd.

Note: General issues relating to land ownership are discussed on page 45

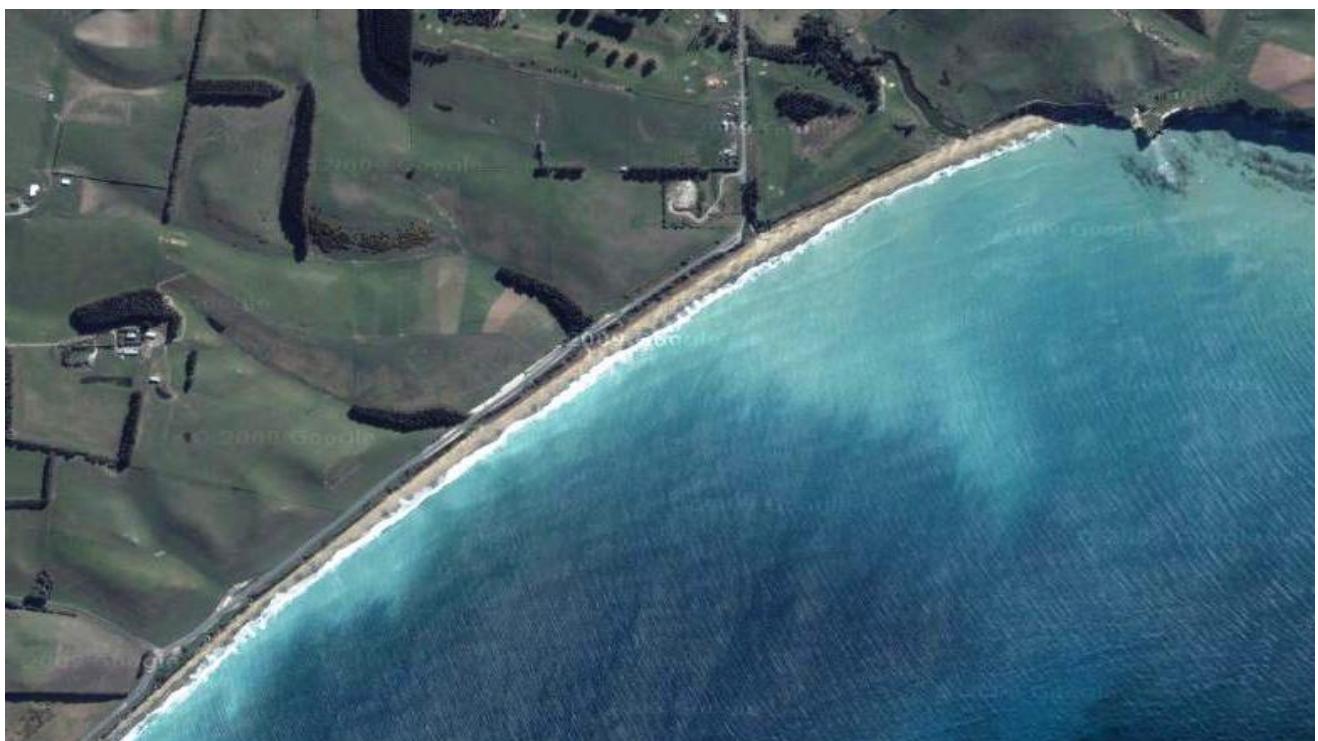
Site 1 – Awamoia Rd to Golf Club Bend

Description of Site 1



Site Map – Site 1

Site 1 commences at Awamoia Rd in the south and the northern boundary is located where Beach Rd turns inland to enter Oamaru. The higher coast cliff that commenced in Site 2 continues through this site, reaching 14m in height, to abut the Cape Wanbrow peninsula further north. Again, the coast road is located on top of the cliff. The line of the cliff its irregular and in several places the top edge is in close proximity to the road edge.



Aerial Photograph of Site 1

At the southern end of the site wave run-up reaches the base of the cliff. Progressing northwards the beach widens and marram grass has become established along the landward area.

There are no dwellings using this section of Beach Road for access.



Site 1 – Southern end, looking north



Site 1 – Northern end, looking north

Coastal Erosion Issues

The average long term rate of erosion on this section of coastline is estimated at 0.5m per year¹

Site 1 is directly south of Cape Wanbrow. Beach sand and shingle carried north by littoral drift will have its passage blocked by the Cape and will accumulate at this site. The gradual widening of the beach from south to north tends to confirm this. The establishment of marram grass along the rear of the beach at the northern half of this site indicates that it is not often inundated by wave run-up. However, no significant sand dune ridges have formed and the beach generally has a low profile.

The coastal cliff is about 50% covered by vegetation. Again the presence of the vegetation would appear to indicate that the cliff is stable.

However, this site has a long term rate of erosion of 0.5m per year and Beach Road has apparently been moved inland on two previous occasions, so from a historical perspective, there are erosion vulnerability concerns about this site. The existing road is again very close to the cliff edge.

This site gives the impression of having been subject to severe erosion in the past but is currently going through a period of calm. A severe sea storm could do considerable damage at this site.

¹ Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch



Site 1 – Irregular cliff face close to road edge.

Roading Network Protection Options

Three options to safeguard the integrity of the roading network in the vicinity of Site 1 are considered:

- Coastal erosion protection of the existing road
- Create a new road further inland and abandon the existing road
- Utilise other roads in the vicinity and abandon the existing road

Option 1 - Coastal erosion protection of the existing road

Wave run-up reaches the base of the coastal cliff along the southern portion of this site. It is certain that erosion is occurring to some degree. Further north the beach is wider and wave run-up does not reach the cliff base, however this section of cliff, as mentioned above, is still considered vulnerable to erosion. The length of coast requiring protection is 1.6km and a cost of \$3,000/lineal metre has been adopted as the cost of seawall construction. The cost to protect this site is

therefore \$4,800,000. Coastal erosion protection is therefore not considered a financially viable option.

Option 2 - Create a new road further inland and abandon the existing road

Hilly topography adjacent to existing road makes it difficult to relocate the road further inland.

Option 3 - Utilise other roads in the vicinity and abandon the existing road

Local residents can use Awamoia Rd and the inland section of Beach Rd for access to Oamaru.

Conclusion

The site continues the trend of the two previously discussed sites to the South. Protection of the coastal route is not financially viable and would be a very risky undertaking. Alternative access can be provided by the inland roads i.e. Awamoia Rd and the inland section of Beach Rd, both of which are sealed roads.

Recommendation

That Option 3 - Utilise other roads in the vicinity and abandon the existing road be adopted and that Awamoia Rd and the inland section of Beach Rd be the alternative routes.

Current Land Ownership

If the Recommendation for Site 1 is adopted then consideration needs to be given to the affect on access to land adjacent to the section of Beach Rd that is to be closed. Site 1 does not have any dwellings that use Beach Rd for access. The property owned by BW Rae and LM Rae, that currently accesses the middle portion of this section of Beach Road, will lose this access, however alternative access is available via another property with the same owners onto Awamoia Rd. See map on next page.

Note: General issues relating to land ownership are discussed on page 45



Strategic Considerations

The comments on the sites on Waianakarua Rd and Beach Rd in this report have treated each site in isolation. The recommendations for each site has been either ongoing monitoring or close the coastal section of road once it has become unsafe and use other existing roads to provide the required roading access and linkages. It is appropriate now to consider the implications of putting this strategy into effect.

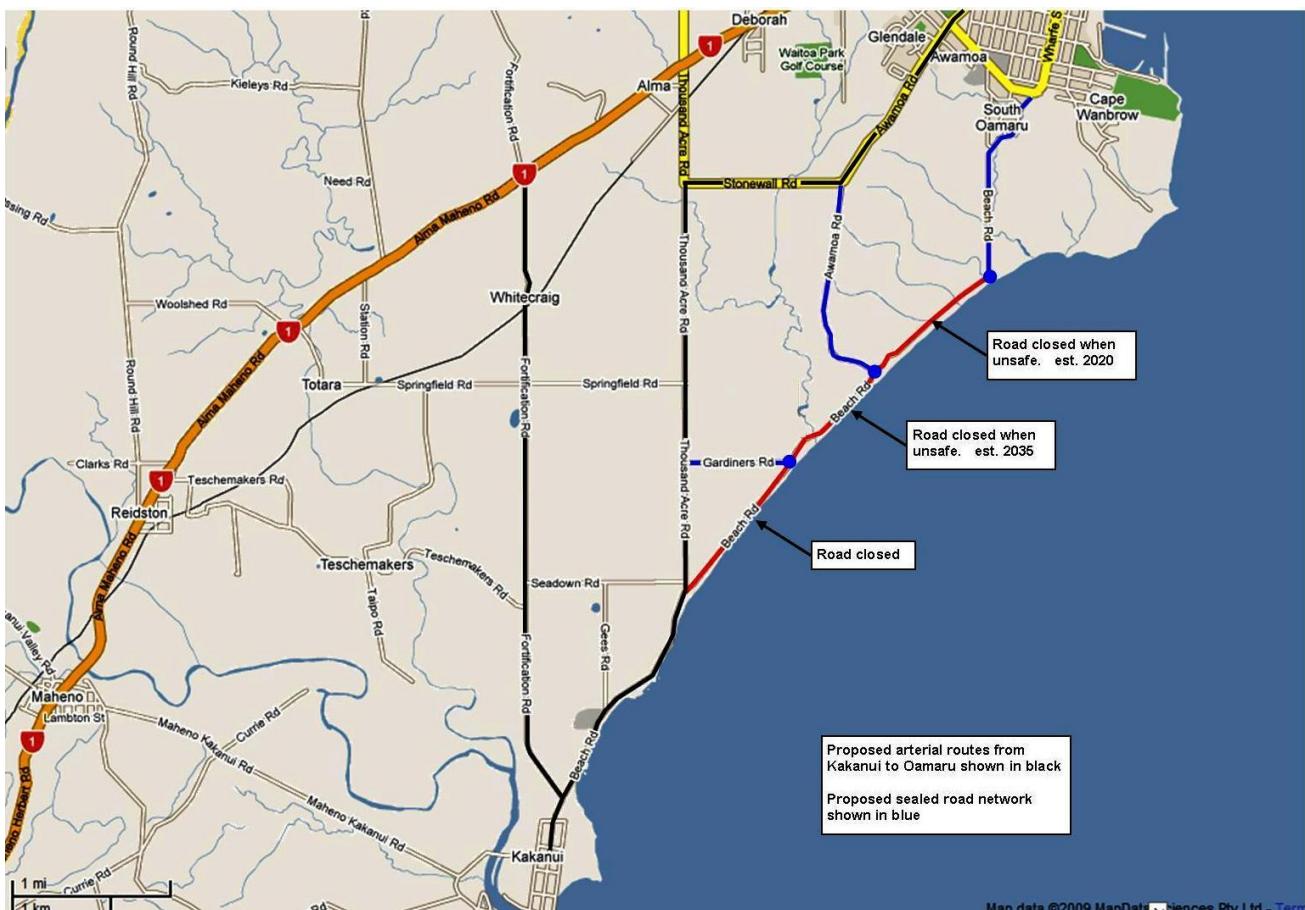
Sequence of Events

Consideration has been given to a likely sequence of events that could occur in the next 25 years. This can only be an approximation due to the uncertainties involved. The purpose is to not put definite dates on such events but rather estimate the likely order in which they could occur. When one event occurs it may well trigger immediate action, like closing a section of road that may also provide an alert for actions in preparation for the next likely event. This will allow a certain degree of forward financial planning to be established.

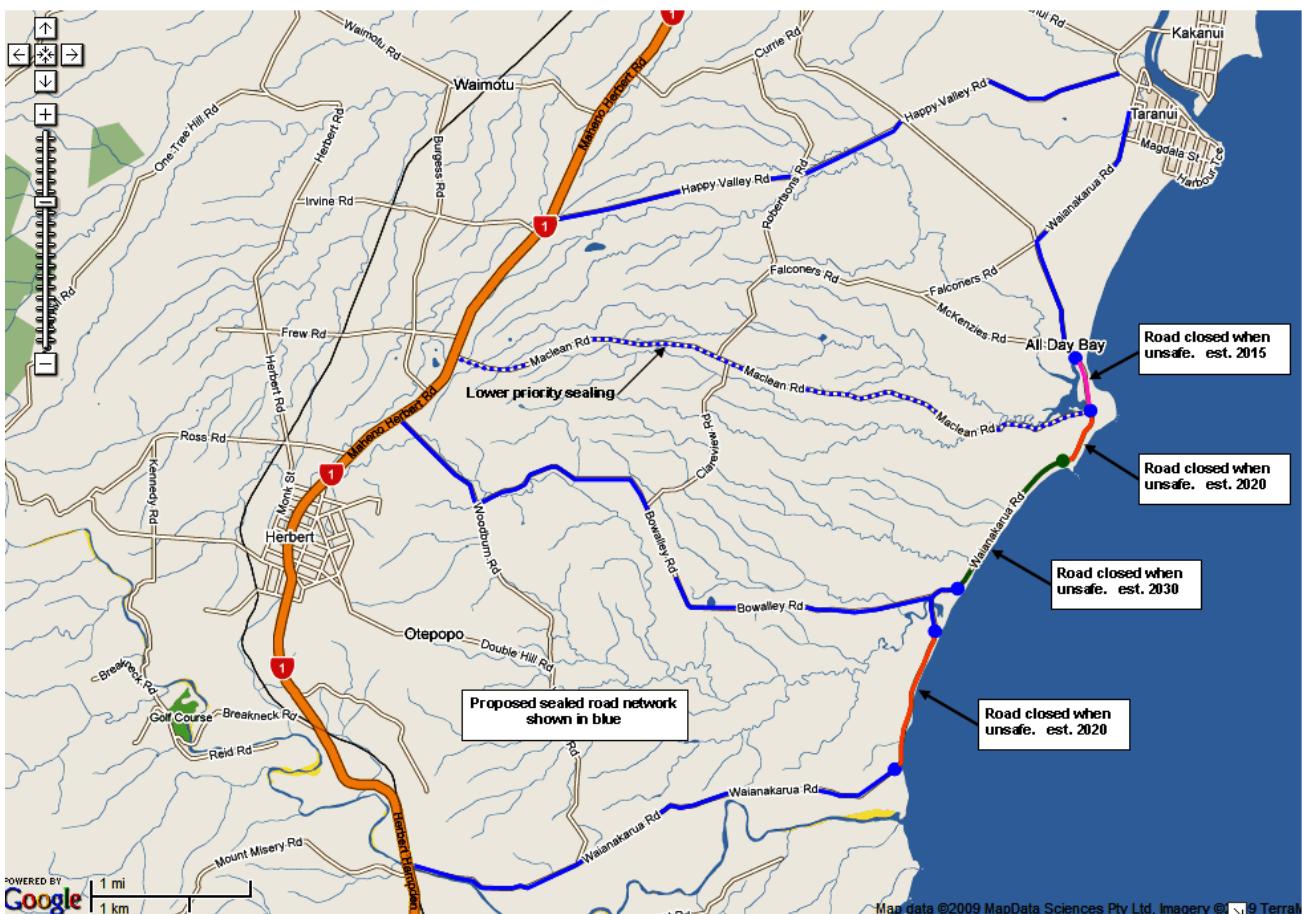
An estimated sequence of events is shown in Appendix 2

Final Roading Network

The plans below show the coastal roading networks for the areas Kakanui to Oamaru and Waianakarua to Kakanui once the threatened sections of the coastal road have been closed and the recommended road seal extensions have been completed. The road closure date estimates are those used in the Sequence of Events section.



Final Roading Network – Kakanui to Oamaru



Final Roading Network – Waianakarua to Kakanui

Legal Access

The plan of the proposed final roading network shows the sections of Waianakarua Rd that will be closed over the next two decades. There are no dwellings on these sections of road but there are many parcels of rural land with their own separate titles. The existing access to these parcels of land will be lost when the coastal sections of Waianakarua Rd are closed and legally stopped.

The following information is for informative purposes only and specific legal advice should be sought when appropriate.

Roads can be stopped under Section 116 of the Public Works Act or Section 342 of the Local Government Act 1974.

When closing a road under Section 116 2 (b) of the Public Works Act the Council has to either provide adequate alternative road access to adjoining land or get consent from the land owner to close the road without providing access. Where there are several parcels of land with separate titles but owned by one entity it is considered that access to one of the parcels is sufficient.

Under the Local Government Act road stopping requires public notification. The Act requires an explanation as to why the road needs to be stopped and coastal erosion that compromised the safety of road users should be more than adequate reason. There is no requirement to provide alternative access.

It is recommended that the provisions of the Local Government Act are used when erosion has progressed to the point where the safety of the road is compromised and road closures are required.

Should any land become landlocked then under section 129B of the Property Law Act 1952 there is power for the Court to grant reasonable access via an easement through or transfer of adjacent land.

The Council should ensure that the PIM / LIM file notes of properties neighbouring threatened roads include the existence of the erosion hazard to the roading land. The Council cannot put anything on the existing titles directly.

If there was a new subdivision of land adjacent to the threatened roading land the Council would be able to put hazard notices on the titles directly, should it (unwisely) allow subdivision.

Conclusion

The area of land East of State Highway 1, between Oamaru in the North and the Waianakarua River in the South, is predominantly pastoral farming land. The farming community is well served by a network of sealed and unsealed local roads and no farming property is more than 10km from the State Highway. Roading access for farmers and farm service providers to and from the nearby service town of Oamaru, via the State Highway, is very good. The coastal route is not essential to the farming community.

These Waitaki District coastal roads (Waianakarua and Beach) are quite unique in the South Island, being a road system deliberately constructed close to the coastline. The Kaikoura Coast road is another example, but there the Seaward Kaikoura Range prevented any other choice. The Kaikoura Coast Road has required extensive coastal erosion protection works to remain open.

The coastal route's primary function has evolved to service tourism. The extensive coastal protection works that would be required to keep it functional would downgrade the scenic value of this road.

There is an interrelationship between the high cost of maintaining the coastal route, versus the benefits that tourists using the route bring to the District and the methods used to protect the route versus the need to preserve the route's natural beauty.

It must again be emphasised that the average erosion rate of 0.5m per year quoted in this report can be misleading. This is a rate which is averaged over a very long time span and over a long length of coastline. In reality erosion will occur rapidly in localised areas, will occur at any time, could be severe enough to close sections of the coastal road and will cost significant sums to repair.

When dealing with coastal erosion the two and a half decade timeframe dealt with by this report is a short time. It is impossible to predict the actual extent of coastal erosion that will occur during that time. The Strategy for the Coastal Road must have overarching goals but must remain flexible on how and when these can be achieved.

References

1. Coastal Road Protection Options Report for Beach Road and Waianakarua Rd, May 2009, OCEL Consultants NZ Ltd., Christchurch
2. Preliminary Report on Coastal Erosion Waianakarua Rd and Beach Rd, November 2007. GHD
3. Beach Road Coastal Protection, October 2002, David Hamilton & Associates Ltd. Dunedin
4. Beach Road Investigations and Options Report – Project Feasibility Report, November 2000. Montgomery Watson NZ Ltd. Dunedin
5. Climate Change Leadership Forum, report No.7 June 2008, www.climatechange.govt.nz

Appendix

Appendix 1 - Cost Comparison of Options at Site 7

Appendix 2 – Sequence of Events

Site 7 - Comparison of Option Costs

NZ Transport Agency Discounted Present Value Procedures

Coastal Erosion Protection Option

Activity	Year	Rate	Quant	Unit	Cost	PV factor	PV Cost
Initial Protection Works	1	3000	400	m	1,200,000	0.91	1,092,000
Replacement of Bow Alley Cr Bridge	1				450,000	0.91	409,500
Maintenance Works (5%)	2				60,000	0.83	49,800
Protection Works	3	3000	100	m	300,000	0.75	225,000
Maintenance Works (5%)	3				75,000	0.75	56,250
Maintenance Works (5%)	4				75,000	0.68	51,000
Protection Works	5	3000	100	m	300,000	0.62	186,000
Maintenance Works (5%)	5				90,000	0.62	55,800
Maintenance Works (5%)	6				90,000	0.56	50,400
Protection Works	7	3000	100	m	300,000	0.51	153,000
Maintenance Works (5%)	7				105,000	0.51	53,550
Maintenance Works (5%)	8				105,000	0.47	49,350
Protection Works	9	3000	100	m	300,000	0.42	126,000
Maintenance Works (5%)	9				120,000	0.42	50,400
Maintenance Works (5%)	10				120,000	0.39	46,800
Protection Works	11	3000	100	m	300,000	0.35	105,000
Maintenance Works (5%)	11				135,000	0.35	47,250
Maintenance Works (5%)	12				135,000	0.32	43,200
Protection Works	13	3000	100	m	300,000	0.29	87,000
Maintenance Works (5%)	13				150,000	0.29	43,500
Maintenance Works (5%)	14				150,000	0.26	39,000
Maintenance Works (5%)	15				150,000	0.24	36,000
Maintenance Works (5%)	16				150,000	0.22	33,000
Maintenance Works (5%)	17				150,000	0.2	30,000
Maintenance Works (5%)	18				150,000	0.18	27,000
Maintenance Works (5%)	19				150,000	0.16	24,000
Maintenance Works (5%)	20				150,000	0.15	22,500
Maintenance Works (5%)	21				150,000	0.14	21,000
Maintenance Works (5%)	22				150,000	0.12	18,000
Maintenance Works (5%)	23				150,000	0.11	16,500
Maintenance Works (5%)	24				150,000	0.1	15,000
Maintenance Works (5%)	25				150,000	0.09	13,500
			1000		6,510,000		3,276,300

Replacement of Bow Alley Cr Bridge	450,000	409,500
Seawall Construction Cost	3,000,000	1,974,000
Seawall Maintenance Cost	3,060,000	892,800
	6,510,000	3,276,300

New Inland Road Option

Activity	Year	Rate	Quant	Unit	Cost	PV factor	PV Cost
Build New Road	1				1,929,000	0.91	1,755,390
	2				0.83	0	
	3				0.75	0	
	4				0.68	0	
	5				0.62	0	
	6				0.56	0	
	7				0.51	0	
	8				0.47	0	
	9				0.42	0	
	10				0.39	0	
	11				0.35	0	
	12				0.32	0	
	13				0.29	0	
	14				0.26	0	
	15				0.24	0	
	16				0.22	0	
	17				0.20	0	
	18				0.18	0	
	19				0.16	0	
	20				0.15	0	
	21				0.14	0	
	22				0.12	0	
	23				0.11	0	
	24				0.10	0	
	25				0.09	0	
					1,929,000		1,755,390

Utilise Other Existing Roads

Activity	Year	Rate	Quant	Unit	Cost	PV factor	PV Cost
Upgrade Bowally Rd	1				525,000	0.91	477,750
	2				0.83	0	
	3				0.75	0	
	4				0.68	0	
	5				0.62	0	
	6				0.56	0	
	7				0.51	0	
	8				0.47	0	
	9				0.42	0	
	10				0.39	0	
	11				0.35	0	
	12				0.32	0	
	13				0.29	0	
	14				0.26	0	
	15				0.24	0	
	16				0.22	0	
	17				0.20	0	
	18				0.18	0	
	19				0.16	0	
	20				0.15	0	
	21				0.14	0	
	22				0.12	0	
	23				0.11	0	
	24				0.10	0	
	25				0.09	0	
					525,000		477,750

Note: Bridge and road maintenance costs are not considered significant and have not been included.

APPENDIX 2

Sequence of Events

Year	Site 7	Site 7	Site 7	Site 6	Site 6	Site 6	Site 6	Site 5	Site 5	Site 4	Site 3	Site 3	Site 2	Site 1	
Event	Repair bridge	Waianakarua Rd closed	Seal Bowally Rd	Waianakarua Rd north of Bridge Point - place random rock	Close Waianakarua Rd north of Bridge Point	Seal Mcleans Rd to SH 1	Close Waianakarua Rd south of Bridge Point	Waianakarua Rd causeway - sand dune improvements	Waianakarua Rd at causeway lost in storm event.	Beach Rd - photographic monitoring of cliff erosion	Seal Gardiners Rd	Form Turn-around at seaward end of Gardeners Rd	Close Beach Rd	Close Beach Rd	
Timing	Year 1	5m to verge @ 0.5m/yr = 10yrs	To be completed prior to road closure	Year 1 & 2	say 5yrs of no erosion then 2.5m to verge @ 0.5m/yr = 5yrs total = 10 yrs	As funds permit. Years 11 to 20 assumed	10m verge @ 0.5m/yr = 20yrs	Year 1	Actual timing unknown	2 per year	Year 1	When Beach Rd at Site 2 is closed	15m verge @ 0.5m/yr = 30yrs, say 25yrs	say 5m verge @ 0.5m/yr = 10yrs	
Cost Calculation		Allow 240m ² of seal for each of two turning bays @ \$30/m ² . Road closed signage and barriers say \$10,000	3.5km @ \$150/km = \$525,000	Say 150m @ \$500/m = \$75,000	Allow 240m ² of seal for each of two turning bays @ \$30/m ² . Road closed signage and barriers say \$10,000	7.0km @ \$150/km	Allow 240m ² of seal for one turning bay @ \$30/m ² . Road closed signage and barriers say \$10,000	LS estimate	Allow 240m ² of seal for each of two turning bays @ \$30/m ² . Road closed signage and barriers say \$10,000	\$500 per occasion	1.0km @ \$150/km	Allow 240m ² of seal for one turning bay @ \$30/m ² . Road closed signage and barrier say \$5,000	Allow 240m ² of seal for one turning bay @ \$30/m ² . Road closed signage and barrier say \$5,000	Allow 240m ² of seal for one turning bay @ \$30/m ² . Road closed signage and barrier say \$5,000	Total costs per year
1	\$60,000			\$37,500	\$37,500				\$20,000		\$1,000	\$150,000			\$268,500
2										\$1,000					\$38,500
3										\$1,000					\$1,000
4										\$1,000					\$1,000
5										\$1,000					\$25,400
6										\$1,000					\$106,000
7										\$1,000					\$106,000
8										\$1,000					\$106,000
9										\$1,000					\$106,000
10										\$1,000					\$106,000
11										\$1,000					\$167,000
12										\$1,000					\$106,000
13										\$1,000					\$106,000
14										\$1,000					\$106,000
15										\$1,000					\$106,000
16										\$1,000					\$106,000
17										\$1,000					\$106,000
18										\$1,000					\$106,000
19										\$1,000					\$106,000
20										\$1,000					\$123,200
21										\$1,000					\$1,000
22										\$1,000					\$1,000
23										\$1,000					\$1,000
24										\$1,000					\$1,000
25										\$1,000					\$25,400
	\$60,000	\$24,400	\$525,000	\$75,000	\$24,400	\$1,050,000	\$17,200	\$20,000	\$24,400	\$25,000	\$150,000	\$12,200	\$12,200	\$12,200	\$2,032,000