
**Mokihinui Hydro Proposal Consent
Applications**

**Review of Assessment of Effects at the
Coast**

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1. Introduction

1.1 Background

This report provides a review of the assessment of effects on shoreline change and tidal hydraulics components of the assessment of environmental effects (AEE) documentation provided by Meridian Energy Ltd (Meridian) in support of resource consent applications RC07150 (01-26) for West Coast Regional Council, and resource consent applications RC07/180 (A-G) for Buller District Council relating to the Mokihinui Hydro Proposal (MHP).

The Mokihinui Hydro Proposal includes a dam located on the Mokihinui River approximately 3 km upstream from the township of Seddonville and 11 km upstream from the river mouth, a new lake upstream of the dam extending to just below the Mokihinui Forks Ecological Area, a new transmission line to carry electricity from the power station to the existing Inangahua-Waimangaroa transmission line at Cedar Creek, and a new substation at Cedar Creek.

This report will provide the decision-maker with information and advice related to the effects of the proposed activities on coastal processes and shoreline change in the vicinity of the Mokihinui River mouth and the wider coastal context.

1.2 Qualifications and Experience

My name is Martin Bernard Single. I hold a Ph.D. in Geography, which investigates coastal processes and geomorphological change. I am an environmental consultant with 20 years of experience. I am an associate member of the Institute of Professional Engineers of New Zealand, a member of the International Coastal Navigation Association PIANC and a member of the New Zealand Coastal Society. My areas of specialisation are coastal processes and coastal management of New Zealand ocean beaches, lakeshores and harbours.

I am a director and principal consultant for Shore Processes and Management Limited, specialising in the science, management and planning of coastal lands and waters. I have authored or co-authored over eighty reports dealing with coastal geomorphology and management in New Zealand, Scotland and Fiji.

My work has included:

- Hazard assessment and development of mitigation measures for private developers, large corporations, government departments and territorial authorities.
- Research into nearshore, beach and estuarine sediment transport.
- Investigations and audit control of consents for dredge spoil dispersal, beach nourishment, beach management prescriptions, coastal protection structures and planning.
- Assessing the physical environmental effects of hydropower operations on lakeshore morphology and processes.

1.3 Scope of Report

This report is prepared under the provisions of Section 42A of the Resource Management Act 1991 (RMA).

To carry out the review of the consent application I have considered the relevant sections of the AEE submitted by the applicant, and the following technical appendices:

- Mokihinui River Proposed Hydropower Scheme: Sediment Report (Hicks, Rouse, Tunnicliffe and Walsh, 2007)
- Mokihinui River Proposed Hydropower Scheme: Shoreline Change around the Mokihinui River Mouth Report (Hicks, Dickson and Gorman, 2007)
- Mokihinui River Proposed Hydropower Scheme: Mokihinui Tidal Hydraulics: Implications of Mokihinui Hydro Project (Goring, 2007)

In addition to being familiar with the relevant literature cited in the above reports, I have also considered the following work in carrying out this review:

- Response to s. 92 request, prepared by Meridian with advice (June 2008)
- Managing and adapting to coastal erosion on the West Coast: Ngakawau & Hector (Ramsay, 2007)
- Review of studies for the proposed hydropower scheme: Shoreline change around the Mokihinui River mouth (Black 2008)
- Coastal stability database, West Coast region, South Island (Benn, 2006)

I have also taken into account issues raised by submitters in relation to the effects on shoreline change and the river mouth processes and morphology.

I carried out a site inspection on Thursday 5th June 2008, involving walking over the shoreline area immediately south of the Mokihinui River mouth, inspecting the true left bank of the river in the vicinity of the mouth and walking along the shore north of the river to Gentle Annie Point and the lookout at the point.

This technical review considers:

- The methods and techniques used in preparation of the technical reports,
- The analysis and conclusions regarding environmental effects drawn in the technical reports,
- Mitigation of any adverse effects proposed through the technical reports, and
- Issues relevant to coastal processes made by submitters.

1.4 Statuary Considerations

This review has been carried out with reference to the Resource Management Act 1991 (RMA) and the New Zealand Coastal Policy Statement (1994) in regard to coastal hazards.

1.5 Non Statuary Consideration

In carrying out this review, consideration has also been given to previous reports on coastal processes and hazards on beaches of a similar nature to that at Mokihinui and to international best practice coastal management.

2. Review

2.1 Sediments Report

The sediments report (Hicks *et al.* 2007a) addresses the existing environment and the potential effects of the MHP. Investigations of the geomorphic character and sediment-related processes of the existing river, river mouth, and coastal environment includes:

- An overview of the geomorphic setting;
- A description of the form, sediments, and geomorphic history of the river downstream of the dam site;
- An assessment of sediment storage in the Lake Perrine – Forks area;
- An assessment of the effects of headwater landslide dams on the lower river sediment supply;
- Estimating the budgets of river suspended load and bedload;
- A description of the river mouth form and behaviour; and
- A reconnaissance review of the sediment budget and coastal erosion history of the adjacent coast.

Investigations of the effects of the MHP included:

- A numerical model study predicting sedimentation in the reservoir;
- A numerical model study predicting the effects of the dam on bed levels and substrate size between the dam and the river mouth, and on bedload delivery to the coast;
- An assessment of the effects of any bed level changes on bank stability;
- An assessment of the effects of changes in the river flow and sediment regime on the river mouth form and behaviour; and
- An assessment of the effects on coastal erosion.

In addition, the sediment report includes:

- Recommendations of methods to avoid, remedy or mitigate any adverse effects;
- An evaluation of uncertainties in methods and findings; and
- Recommendations of monitoring programs to check assumptions and improve information bases.

The study involved field investigations and desktop work including modelling.

Some aspects of the broader sediment study are of particular interest for the assessment of the conclusions regarding coastal change. These include the descriptions of the sediment characteristics of the catchment and the riverbed, the erosion, transportation and storage of sediments in the river, and the estimates of historical and future sediment supply to the coast. A review of the sediment work can be found in Ms Beck's review report. For the basis of the review on the effects of the proposal on coastal processes, the findings of the sediment report are accepted.

Chapters 4 and 5 of the sediment report describe the coastal system (river mouth and shore) in detail. The form of the river mouth is described as variable with a short spit attached to the south bank deflecting the mouth to the north. There is an associated tendency for erosion along the northern bank of the river mouth area. The mouth contains a bar system associated with an ebb-tide delta. Ocean waves penetrate across the bar into the river mouth at high tide. The aerial photograph analysis presented shows little change to the form of the river mouth area since 1966. However anecdotal evidence suggests that prior to the 1929 Murchison earthquake, the river mouth was wider and deeper, allowing navigation.

The applicant's advisors take the view that further work in modelling the potential river mouth changes due to the proposal "would require large investment for doubtful return" (S92 response). This view is accepted. However, the suggested approach to monitor and mitigate effects as and when they develop may lead to significant effects occurring before mitigation action can be taken. It is recommended that research be carried out into the nature of the dynamic variability of the river mouth to determine a more precise relationship between sediment supply (along the coast and from the river), river flows and wave action. Monitoring would be part of such research, and would help to separate the natural dynamics of the river mouth system from any effects of the proposal, as a basis for identifying effective mitigation of any adverse effects.

The general form and character of the coast is given in chapter 5 of the sediment report. I disagree with some of the general statements about the coastal geomorphology. In particular, I do not agree that the river mouth area should be referred to as a river delta. I also do not agree that the dominant sediment along the shore is sand. There is a mixture of sand and gravel at the shore, and the presence of sediment sourced from alongshore (mainly sands and smaller gravel sizes), from the contemporary Mokihinui River (sands, gravels and cobbles) and from erosion of the coastal hinterland (a full mix of sediment sizes). The coastal hinterland includes older deposits from the Mokihinui River as well as landslip and stream deposits from the uplifted coastal terraces. The description of the coastal geomorphology derived from the field inspection (section 5.3) is more accurate.

Sections 5.5 and 5.6 present an overview of the wave climate and littoral processes from past studies, and refer to the work of Hicks *et al.* (2007b). Section 5.7 presents an analysis of coastal erosion in the area, and includes erosion rates as determined by a number of different authors. The conclusion is that the adjacent coast has been eroding historically at rates averaging about 0.4 m/yr. The sediment budget analysis given in section 5.8 is reasonable, given the complexity of the coastal system and the uncertainties about actual volumes of sediment moving along the coast. I accept the conclusions presented in these sections.

Section 6.5 presents the effects of the proposal on the river mouth and adjacent coast. The main effect will be acceleration of the existing coastal erosion due to a reduction in the sediment supply from the Mokihinui River reaching the coast. The reduction is predicted to be of the order of 158,000 t/yr, but will lag the building of the dam by about 20 years due to erosion of sediments from the riverbed and banks below the dam. The modelling presented by Hicks *et al.* (2007b) gives more detail as to the effect at the coast. It is also expected that the estuary would deepen, and the bar and flanking beaches would become more sandy and less stable. This may increase the potential for erosion and seawater flooding of the Mokihinui settlement. It is concluded that the effects at a distance (gentle Annie point to the North and Miko to the South) from the Mokihinui River mouth would be minor.

Chapter 7 of the sediment report presents options for mitigation of adverse effects. Suggested mitigation includes sediment bypassing, hard engineering by construction of coastal revetments or groynes (for example) at the coast and/or planning measures to relocate assets threatened by erosion. It is recommended that the shoreline position and beach profiles be monitored. I will comment on mitigation and monitoring further in section 4 of this report.

2.2 Tidal Hydraulics Study

Goring (2007) presents a description of the nature of the tidal hydraulics in the mouth region of the Mokihinui River, and assesses how they may be affected by variations in the flow regime of the river associated with power generation. The study comprises three parts:

- An analysis of the existing conditions in the tidal reach
- An assessment of how the tidal hydraulics will be affected by hydro generation
- An estimation of the implications of the changes on various aspects of the environment in the tidal reach

The report concludes that the river mouth is dominated by the tide, with a median tidal range of 2.38 m at the mouth. The tidal range reduces upstream, so that at 2 km from the mouth, the median range is 1.95 m. When river flood flows exceed 112 cumecs, all flood tides are washed out. The tidal lagoon extends from the mouth to between 1 km and 2 km upstream depending on the river flow and tidal range. Far infragravity waves accompanying swell waves result in a surge through the river mouth and into the lagoon. The surge elevation was measured at up to 0.43 m at the mouth.

An investigation of a hydro generation flow regime of 120 cumecs showed that the proportion of flood tides that would be washed out by river flow increased from 57.7% under natural conditions to 59.4%. This was considered to be a less than minor effect. There would also be an increase in saline penetration into the lagoon at night, during low flow conditions. It was concluded that overall the effects of the MHP on the water levels and tidal flows in the lagoon would be less than minor. Changes in the morphology at the river mouth as a result of reductions in sediment supply could result in more far infragravity and swell wave penetration into the lagoon, and could cause more erosion to the banks of the lagoon.

The methodology of the tidal hydraulics study is sound, and although the natural variability of flows in the lagoon complicates the assessment of effects of the MHP, the conclusions reflect the study findings. Some submissions have commented on the effect of wave penetration on bank stability in the lagoon and along the lower reach of the river. Mitigation of these effects is discussed in the shoreline change study, with the main method of mitigation being the placement of structures along the banks.

Overall, I agree with the findings of the tidal hydraulics report. However the effects of the MHP on the tidal hydraulics and river mouth system must be considered in conjunction with findings of the sediments report and the shoreline change study. The sediment report notes that the river mouth morphology would become less stable, leading to an increase in the potential for erosion and saltwater flooding of the Mokihinui settlement. The shoreline change study notes that the dynamics of the river mouth morphology have not been fully captured from the examination of historical aerial photographs. Further, there is anecdotal information that the river mouth was navigable in the past, but no details of when this was or whether it was a short-term effect of the Murchison earthquake, or whether changes in the sediment supply due to the earthquake caused a change to the character of the river mouth.

It is likely that if the changes in sediment supply due to the MHP result in a change in the way the river mouth system works with regard to the ebb tidal bar and spit formation, then the tidal hydraulics would be modified to a greater extent, and ocean wave penetration into the lagoon would have a significant effect on the banks of the lagoon and lower river reach. However it is uncertain whether such changes are within the natural variability of the Mokihinui River mouth area, and may occur through natural processes and as a result of the ongoing long-term erosion of the coast.

Further research is required to better understand the river mouth system, in order to mitigate adverse effects of changes to the morphology resulting from a reduction in sediment supply from the river.

2.3 Shoreline Change Study

Hicks *et al.* (2007b) note that the shoreline change study tasks included:

- Deriving a hindcast wave record and climate for the study coast
- Mapping historical shoreline positions and calculating erosion rates

- Constructing a numerical shoreline evolution model and using it to simulate future shoreline shifts due to the predicted reduction in the sediment load of the Mokihinui River

Two numerical wave hindcast records were analysed for the coastal area off Mokihinui. Both models contained directional uncertainty when compared to a Waverider record from offshore of Ngakawau (approximately 10 km south of Mokihinui). The mean significant wave height was in the range of 1.6 to 1.7 m. The dominant wave direction was from the west, with resultant net longshore transport to the north. The methodology used to determine the wave environment is appropriate given the paucity of measured wave data for the area.

Historical shoreline positions and consequent erosion rates were determined from photogrammetry and examination of cadastral surveys. The results show spatial and temporal variations in shoreline movement. Differences between the movement of the shoreline position to the north and south of the river are similar to differences noted by Benn (2006) for similar rivers on the West Coast. The temporal variation is well explained by Hicks *et al.* (2007b) with regard to the influence of the 1929 Murchison earthquake and subsequent landslips and the failure of the slip damming Lake Perrine. South of the river, an erosion trend is evident since about 1955. Progradation of the shoreline has occurred north of the river (to Gentle Annie Point) between 1906 until sometime before 1987. Since 1973, there has been retreat of the shoreline north of the river. The historical and contemporary rates of shoreline retreat decrease with distance away from the river. Since 1987, the average rate of retreat is approximately 1 m/yr in the vicinity of the river mouth, decreasing to about 0.4 m/yr to the north and south.

The shoreline change study presents a 1-line numerical model that attempts to reproduce the shoreline development for the coast between Miko (south of Mokihinui), north to Gentle Annie Point. It is recognised by Hicks *et al.* (2007b) that the model does not replicate the known shoreline changes and recommended that the model is not relied on to predict changes to the shore north of the river. In reviewing the shoreline change study, Black (2008) notes that the model is inappropriate due to the inability of the model to replicate the existing shoreline. Black concludes that the model is not sophisticated enough to allow predictions of coastal change as a result of changes to the sediment inputs from the river. I agree with that conclusion. However, the use of the model in the study provides “order of magnitude” predictions of shoreline change south of the river, and provides a sound basis for understanding the type of change to be expected as an effect of the MHP.

The development of a more sophisticated model that would more precisely replicate historical shoreline change would require input variables that adequately define changes to the wave environment and fluvial and littoral sediment supply over time, along with well defined relationships between changes in shoreline position with regard to the mixed character of the coastal sediments. This type of data does not exist for the historical time period. The variable nature of the littoral sediment inputs is unknown, and other changes in the future (such as may result from climate change) cannot be adequately predicted to provide certainty to the output of the model for the future. It is unlikely that the output of a sophisticated and more expensive model would provide greater certainty to predictions of future shoreline change than those provide by the relatively simple (although already quite complex) model presented by Hicks *et al.* (2007b).

Hicks *et al.* (2007b) recognise the limitations of the model by providing general conclusions about future coastal change rather than relying on the model output. Their conclusions are:

- The Mokihinui shore is subject to ongoing coastal erosion
- Erosion rates are likely to increase as a result of global-warming effects
- A hydro-dam on the river would further increase erosion rates at the river mouth and along the coastal plain to north and south
- The effect of the dam on coastal sediment delivery would be immediate for the suspended sand load, while there would be a lag (of approximately 20 years) before gravel supply to the coast ceased
- There would be little delay before the onset of dam-induced coastal erosion

Recommendations for mitigation and monitoring are presented in section 6 of the shoreline change study. The mitigation recognises the existing hazard, and the need to develop an integrated plan to mitigate ongoing and future coastal erosion, while also acknowledging that the MHP would contribute to but would not be the sole cause of future erosion. No details of mitigation are presented in this report, although it refers to possible options as presented by Hicks *et al.* (2007a).

The following coastal monitoring programme is recommended in the shoreline change study:

- Aerial photography along the Mokihinui coastal plain on a 5-yearly basis for the first several decades, then at decadal intervals.
- Annual surveys of shoreline position (e.g., vegetation edge) and of beach profiles along the coastal plain using RTK-GPS survey technology. The profiles should be more closely spaced nearer the river mouth.

It is suggested that this would aim to improve knowledge of coastal erosion along the Mokihinui coastal plain, particularly around the Mokihinui River mouth. I agree with the value of such a monitoring program but think that the shoreline position and beach profile surveys need to be carried out more often. In particular, surveys should be made after significant storm events, and at least every three months. This information should become part of a research program that aims to determine the processes controlling erosion of the Mokihinui shoreline, so that effective mitigation can be planned and implemented. Identification of the proportional role of the MHP in projected future erosion would enable appropriate apportionment of cost of implementation of mitigation.

2.4 Conclusions of Review of Technical Reports Relating to Coastal Effects of MHP

The technical reports identify the effects of the MHP that would result in potential effects at the coast. These are the reduction in sediment load of the river and the modification of the river flow regime. The reports conclude that these effects will result in accelerated erosion of the coast in the vicinity of the river mouth, and possible modifications of the river mouth system and stability of the banks of the lagoon area.

The technical reports describe the existing coastal environmental processes to the extent of information available from analysis of aerial photographs, cadastral maps, wave and fluvial flow measurements and modelling of the long-term wave environment and shoreline change. The description of an eroding coast and a dynamic river mouth morphology fit the data. Due to the dearth of historical measurements (or documented observations) there are uncertainties as to the causative relationships between erosion at Mokihinui and changes to the local river sediment loads, and to changes in the regional littoral sediment supply to the coast. Given these uncertainties, the conclusions reached in the technical reports are justified. However to ascertain the direct effects of the MHP on coastal change or the proportional effects of likely future erosion, further research on the coastal environmental processes is necessary.

The effects of the MHP at the coast (adjacent to the River Mouth) are likely to be significant and adverse. The applicant has proposed possible mitigation measures that rely on monitoring of coastal change and response to the effects determined from the monitoring. In my opinion, this reactive approach does not adequately address the effects. Research is required to provide better understanding of the coastal processes at the Mokihinui River mouth, and an operational plan for mitigation of the effects of accelerated coastal erosion and possible changes to the river mouth dynamics is necessary. It is understood that discussions between the applicant and the Mokihinui community regarding these matters are ongoing, but the results of those discussions are unknown.

3. Submissions

Approximately 90 submissions relating to coastal processes were made. The submissions do not all oppose the MHP, with approximately 36% in support of the proposal to some degree having made comments regarding coastal processes. Submissions supporting the MHP did so providing there was suitable protection against accelerated erosion at the coast. The main themes from the submissions are as follows:

1. Meridian should provide or coordinate protection against accelerated coastal erosion.
2. The MHP would result in a decrease in sediment supply to the coast.
3. The MHP would result in (accelerated) coastal erosion adjacent to the Mokihinui River mouth and north past Gentle Annie Point.
4. There would be adverse changes to the riverbed and to navigation on the river.

It is difficult to estimate the role of the MHP in future coastal erosion at Mokihinui. Hicks *et al.* (2007a and 2007b) suggest that the MHP will reduce the sediment supply to the coast by 94%, and that this would contribute to erosion immediately after the construction of the dam, and continue for between 100 and 200 years. They suggest that the retreat rate from the MHP would peak at 2 m/yr just south of the river mouth during the first decade and decrease exponentially thereafter. The MHP induced erosion would occur in addition to the background long-term erosion and any erosion that might result from climate change effects (for example a possible increase in erosion from 0.4 m/yr at present to 1.4-1.5 m/yr due to accelerated rates of sea level rise).

With regard to the first and second submission themes, the effects are noted in the technical reports and mitigation has been suggested. Discussions between the applicant and the Mokihinui community regarding mitigation of coastal erosion are ongoing, and a number of options including coastal structures and relocation of assets have been discussed.

Replacement below the dam of the sediment trapped upstream has been considered as unfeasible due to cost and/or location of a suitable source of sediment. Even if the placement of the estimated 158,000 t/yr of an appropriate mixture of sediment could be carried out, the existing natural erosion would continue.

It is recommended that if the MHP were to be approved, then a joint research program should be put in place, funded by Meridian and managed by West Coast Regional Council, to determine the causes of erosion at Mokihinui and the options for mitigating the erosion hazard. This research program should run in conjunction with research on the river mouth system, and determination of the effects of changes to the river flow regime and the river sediment supply on the spit and mouth stability. These research programs would address the concerns expressed in the submissions.

The research would also provide more certainty to the extent of the effect of the MHP along the coast, and in particular to the areas north and south of the Mokihinui River. The conclusion of Hicks *et al.* (2007a) is that the effect would not extend south of Miko and only to a minor extent to the north of Gentle Annie Point. From my assessment of the information provided in the technical reports and my site visit, I concur with that conclusion.

4. Other Shoreline Effects of the MHP

The MHP AEE and associated technical reports reviewed consider the ocean coastal environment. Other technical reports consider the effects of geotechnical hazards and other issues related to the lake that will be formed above the dam. There is very little discussion in the AEE regarding the formation of a shoreline associated with the lake, and the lakeshore processes that may result. Consideration is given to the removal of vegetation from between RL 92 m and RL 102 m (page 50 of the Consent Application and AEE). However there is no discussion of the potential shoreline formation and associated shore erosion, deposition, creation of beaches and littoral transport of sediment along the shore. There may be beneficial and adverse effects on the track access to the upper part of the valley.

It is recommended that a condition of consent is the development and carrying out of a lakeshore monitoring program consisting of at least an annual photographic inspection for the first five years of operation. The monitoring program should also describe the likely shore development, so as to identify areas along the shore that could be considered as having an adverse effect on the environment and/or uses of the shoreline. An expert in lakeshore processes should review the monitoring program.

5. Conclusions and Recommendations

Potential effects of the Mokihinui Hydro Project on the coastal environment include a reduction in sediment supply to the coast from the Mokihinui River and modification of the flow regime and the river mouth system. The result of the loss of sediment supply will be accelerated coastal erosion in the vicinity of the river mouth and the Mokihinui settlement, and a change in character of the spit and shores of the river mouth morphological system. Changes to the flow regime of the river may result in changes to the interaction between the river and barrier spit at the mouth, and the tidal flows and far infragravity waves penetrating into the lagoon at the river mouth. This may result in additional erosion of the shore in the immediate vicinity of the mouth and around the lagoon.

The effects would become evident shortly after the construction of the dam, and would continue for 100 to 200 years, essentially changing the character of the shore. These effects would be additional to existing coastal erosion that alone (left unmodified by human actions) will result in a change in the character of the coast and river mouth, and to potential erosion resulting from projected changes in global climate (such as accelerated rise in sea level or changes in coastal storm magnitude, incidence and direction of attack).

There is a lack in certainty of the effects of the MHP and the proportional role of the MHP in future erosion due to a lack of historical information and process data leading to uncertainties in understanding of the existing environmental processes. For these reasons, the applicant has not proposed detailed mitigation. I consider that engineering or planning approaches can mitigate the effects. However the preparation of detailed options for mitigation, acceptable to the community and to the consenting authorities, should be a condition of the proposal going ahead.

I consider that inclusion of monitoring and research as to the nature of the physical environmental processes is essential to developing effective mitigation options for the effects of the MHP and should be included in any conditions of consent.

In addition, I consider that monitoring and assessment of the lakeshore development should be addressed with appropriate conditions. The research proposed will enable an understanding of processes, and provide a basis for appropriate mitigation responses.

6. References

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