

IN THE MATTER of the Resource Management
Act 1991

AND

IN THE MATTER of an application by Meridian
Energy Limited for resource
consents for the Mokihinui Hydro
Project

**STATEMENT OF EVIDENCE OF RICHARD REINEN-HAMILL ON BEHALF
OF MERIDIAN ENERGY LIMITED**

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1. **QUALIFICATIONS AND EXPERIENCE**

- 1.1 My full name is Richard Anthony Reinen-Hamill.
- 1.2 I hold the qualifications of Bachelor of Engineering (Honours) and Master of Civil Engineering specialising in fluid mechanics and sediment transport. I am a Chartered Professional Engineer and a member of the New Zealand Coastal Society. I have also completed the Making Good Decisions training assessment and certification programme for Resource Management Act Decision-Makers.
- 1.3 I am a Senior Coastal Engineer and Director of Tonkin & Taylor Ltd (“T&T”), Environmental and Engineering Consultants in Newmarket, Auckland. I have had 19 years of experience in hydraulic and coastal engineering, including 4 years at the Dutch Hydraulic and Coastal Research Institute, Delft Hydraulics where I undertook physical and numerical modelling studies of coastal processes for both applied research and commercial applications. I have specialist skills in coastal process and hazard assessments and the design of management options including seawall design and beach nourishment. I am also qualified to evaluate the effects of coastal structures on the physical coastal environment. I have carried out a large number of projects either as a coastal engineer or as a peer reviewer for regulatory authorities and decision makers and assisted in the first edition of a Ministry for the Environment guidance manual for local government in New Zealand for Coastal Hazards and Climate Change.
- 1.4 I have carried out seawall designs for major developments that have been constructed in the following areas;
- a. Ruby Bay, Nelson;
 - b. Harbour Driver, Tauranga;
 - c. New Plymouth;
 - d. Oriental Bay, Wellington.

- 1.5 I have also carried out numerous designs of seawalls that have gained consent, including most recently the Waihi Beach Seawall. On behalf of Western Bay of Plenty District Council, Tauranga City Council and Environment Bay of Plenty I prepared the standard designs of a range of seawall solutions for Tauranga Harbour. I have also carried out a peer review of a seawall along Bruce Bay, Westland for West Coast Regional Council.
- 1.6 I have read the Code of Conduct for Expert Witnesses (Rule 330A, High Court Rules and Environment Court Practice Note) and I agree to comply with it. I have complied with it in the preparation of this statement of evidence.
- 1.7 I have been involved in the following work in relation to Meridian Energy Limited's (Meridian's) Mokihinui Hydro Project (MHP):
- a. An evaluation of coastal management options to manage coastal erosion of the Mokihinui township based on NIWA's assessment of shoreline change around the Mokihinui River mouth;
 - b. Ongoing meetings with the community stakeholder group to develop and assess coastal management options. At this stage I have met with the community group four times to gain an appreciation of their concerns, canvas opportunities and ideas and develop outline solutions to manage the erosion issues;
- and I have prepared my statement of evidence in reliance on this work.
- 1.8 I have also reviewed:
- a. The reports and statements of evidence of other experts giving evidence on behalf of Meridian relevant to my area of expertise, including:
 - i. Mokihinui River Proposed Hydropower Scheme: Shoreline change around the Mokihinui River Mouth (NIWA, November 2007)
 - ii. The evidence of Dr Murray Hicks

- iii. Mokihinui River Proposed Hydropower Scheme: Sediment Report (NIWA, November 2007)
 - iv. Review of Studies for the Propose Hydropower Scheme: Shoreline Change Around the Mokihinui River Mouth (ASR, March 2008)
 - v. Review of Assessment of Effects at the Coast prepared by Dr. Martin Single as part of the Council's s42A report for the MHP
 - vi. Managing and adapting to coastal erosion on the West Coast: Ngakawau & Hector, D. Ramsay, NIWA January 2007
 - vii. Review of assessment of effects of sediment transport, J. Beck, June 2008 as part of the Council's s42A report for the MHP
- b. I have also read the latest edition of Coastal Hazards and Climate Change, a guidance manual for Local Government in NZ (July 2008) that updates the first edition of 2004. This provides an update of the consideration of climate change effects, taking into account the latest IPCC review of 2007;
- c. Relevant submissions of others, namely: A&M Hawes, B Morgan, L&D van Diepen, Mokihinui Ratepayers Association, Mokihinui River Community Society, P&E Atkins, B&J Climo, Green Party WC, M Turei, West Coast Greens, NZ Forest & Bird. All these submission raise issues on the impact of the dam on coastal erosion and the impact coastal erosion will have both on the river mouth and the community at Mokihinui.

2. SCOPE OF EVIDENCE

- 2.1 I have been asked by Meridian to prepare evidence in relation to coastal engineering issues and options to manage coastal erosion in the vicinity of the Mokihinui River mouth. This included:
- a. A brief review of the existing shoreline change issue and likely impact of the proposed dam

- b. Identification of areas susceptible to coastal erosion hazards
 - c. Identification and development of protection options to manage erosion
- 2.2 At this stage I am only looking at protection options and I am not commenting on the consentability of any options or detailed design.
- 2.3 In his evidence Chris Evans from Meridian discusses consultation with the community about the different options. I also understand that the Chairman of the Mokihinui Ratepayers Association intends to present in support of their submission.

3. **EXECUTIVE SUMMARY**

- 3.1 Based on the studies carried out by NIWA (M Hicks, 2007) and from the anecdotal evidence supplied to me by the local community, the existing community is significantly at risk from existing coastal erosion and inundation. Potential climate change effects will increase erosion and inundation pressure. These erosion and inundation risks will be further exacerbated by the construction of the dam due to the reduction of sediment supplied from the catchment to the coast.
- 3.2 The dam erosion effects will be finite, in that the shoreline will adjust to a new equilibrium position more landward than its present position. Superimposed on the existing situation, the dam will lead to more rapid erosion than currently experienced, with its effect reducing over time and with distance from the river mouth.
- 3.3 Engineering options to “hold the line” will involve significant cost and will, at best, provide a period of time during which the land erosion loss will be avoided. They will not provide a permanent solution to erosion without ongoing investment to maintain and enhance these structures.
- 3.4 I explored a number of options including managed retreat, beach nourishment, groynes, seawalls and combinations of these. The best

solution, in terms of best-practice coastal management is to relocate the community landward of the area susceptible to the coastal hazards of erosion and inundation. However, this approach was not the preferred option of the local community stakeholder group.

- 3.5 I have developed an engineering solution that combines a component of managed retreat and an armoured flood protection bund that addresses the quantified effects of the proposed Dam. This option will provide a period of protection of around 35 to 50 years that the stakeholder group considers reasonable. There will be increased maintenance requirements over that time period as a result of a retreating shoreline and increased wave energy attacking the face of the wall.

4. **THE PROPOSAL**

- 4.1 I confirm my evidence is based on the project proposal as described in the Assessment of Environmental Effects, brief details of which are described in Appendix 1.

5. **EXISTING ENVIRONMENT**

- 5.1 The existing coastal environment has been well characterised by NIWA in its 2007 reports and the evidence of Dr Hicks. Although I have not carried out a formal peer review of its reports, I have read both the NIWA reports and the reviews of ASR and Dr Single. In my opinion and experience having carried out similar studies for others, the work carried out by NIWA is sufficient to enable an appreciation of the existing situation and the likely effects of the proposed dam on shoreline change in the vicinity of the river mouth.
- 5.2 Key points concerning the coastal processes operating at this location that are salient for the development of erosion protection solutions are:
- a. There is an existing high rate of erosion in the vicinity of the river mouth that has been occurring for decades. South of the river the average erosion rate over the last century is in the order of 0.8 to

0.9 m/yr. The erosion rate is lower north of the river, at around 0.4 m/yr and reduces towards Gentle Annie, a rock bluff that acts as a headland control for part of the shoreline to the north of the river. From visual observation, erosion appears to be occurring along the entire shoreline from the airport at Westport to the Mokihinui River mouth.

- b. In simple terms, the main cause of erosion of this magnitude is an imbalance in sediment supply to wave energy. There is a strong and persistent westerly wave climate that results in a northerly sediment transport trend, with a theoretical transport capacity of 1 to 2 million cubic metres of sand per year (as calculated by NIWA) moving northwards.
- c. Erosion occurs if a similar volume of sediment is not supplied to the system, via the various rivers that discharge to the coast, or via longshore transport from further to the south, or if it is blocked by the construction of groynes, dams or some other structures that prevent that sediment from entering or passing through the system. Conversely, accretion will occur if sediment supply is greater than the longshore transport capacity.
- d. While the precise driver for reduction in sediment supply is not known, it is likely that large earthquake events, such as the 1929 Murchison earthquake, are likely to have supplied much larger quantities of sediment to the coast than would typically occur. The effects of this earthquake would have lasted many years due to the ongoing landslides and river clearances that occurred after this event. It is possible that this event resulted in a temporary accretion of the river delta and that the shoreline is re-establishing itself as a result of a lower sediment supply. Structures, such as the Buller River training groynes are also likely to have resulted in an interruption in sediment transport to the coast to the north of Westport.
- e. Predicted climate change effects as summarised in the recently released guidance manual for coastal hazards (July 2008) include increased sea level rise and increased persistency of westerly winds and extreme wind speeds. Both these factors have the potential to exacerbate existing erosion trends at Mokihinui. This implies the potential for higher rates of erosion in the future than has been experienced historically.

- f. NIWA assessed the potential effect of future sea level rise (SLR) using the Bruun Rule, a commonly used method to provide an indication of shoreline erosion as a result of an increase in sea level presented by the Ministry for the Environment (MfE, 2004) guidelines. Taking into account the relative effect, there may be an additional 0.5 m/year erosion rate along the entire shoreline due to sea level rise effects. I note the latest guideline takes 0.5 m to be a base value of sea level rise by 2100 and suggests considering the potential impact of an additional 0.3 m of sea level rise over and above the 0.5 m previously recommended. This will increase the potential climate change induced erosion.
- g. In addition to erosion, there is a risk of sea inundation to much of the Mokihinui settlement, due to the exposed location and the low-lying ground levels. Based on the LiDAR survey referred to in Dr Hicks' evidence, ground levels are in the order of 2 to 2.5 m, some 0.5 m to 1.0 m above the high tide level. Historically sea inundation has been significant, flooding much of the community. Potential climate change effects on top of "normal" storm-surge are likely to increase the frequency of inundation events.
- h. There is a community funded sea inundation bund structure currently in place in front of the settlement at Mokihinui. The main purpose of this structure is to prevent sea inundation from flooding the community. The structure comprises a double bund, with a drainage swale between them. A topographic plan of the settlement, showing the bund and swale is shown in Appendix 2. The bunds are formed from the excavation of beach and backshore deposits from the swale. The crest of the bund is around 5 m above Mean Sea Level, or around 3.5 m above the Mean High Water Spring tide level. The swale between the bunds is 2 m above Mean Sea Level or around 0.5 m above the Mean High Water Springs tide level.
- i. There is also a rock bund along the estuary providing protection from river flood effects. This rock bund has a crest elevation of around 4.0 m above Mean Sea Level (MSL) or 2.5 m above Mean High Water Springs tide level.
- j. The existing sea inundation bund suffers from erosion and requires periodic reforming after storm events at high tides. Repairs are currently carried out by members of the local

community carting and repositioning more rocks at relatively low cost. Appendix 3 shows a series of photographs of the bund, including a recent breach due to recent storm effects.

- k. While the bund structures have provided a reasonably low cost solution to historic inundation, as shoreline erosion continues in this area the existing bunds are being increasingly eroded by wave action. They are not armoured and are constructed in a steeper slope than the sediment naturally forms and are therefore sensitive to erosion.
- l. Notwithstanding the repairs undertaken by the community, due to ongoing natural erosion the bunds are becoming increasingly vulnerable to erosion with the risk of breaching becoming more and more likely unless the bunds are relocated landward. The risk of breaching and failure of the existing bunds is exacerbated by possible climate change effects and the influence of the proposed dam. Based on the current rate of erosion, the existing bund is unlikely to be effective for more than 5 to 10 years, unless it was relocated to a more landward position
- m. The consequence of bund failure will be extensive flooding of almost the township, most of which lies between 2.0 and 2.5 m above Mean Sea Level, or 0.5 m and 1.0 m above the Mean High Water Springs. Flooding of this area has occurred in the past, extending back to Burke Creek. This flooding initiated the construction of the existing flood protection bund. Therefore, the existing coastal hazards faced by the community at Mokihinui include erosion and inundation by the sea.

6. ACTUAL AND POTENTIAL EFFECTS

- 6.1 Based on NIWA's numerical model study (Hicks, 2007), the shoreline adjacent to the river could erode back some 45 to 75 m over a 100 to 200 year period as a result of the dam reducing the sediment supply to the coast, with the largest rates of change occurring over the first few decades. NIWA's assessment indicated that as much as 20 m shoreline erosion could occur within the first 10 years.

- 6.2 Putting this into context with the existing and possible future natural processes, I have identified the resulting area susceptible to coastal hazards over the next 100 years based on the following equations:

Without dams: $LT \times 100 + SLR \times 100 + 20 = 160$

With dams: $LT \times 100 + SLR \times 100 + DE + 20 = 205$

- 6.3 In these equations, LT is the long term trend based on historic observation (0.9 m/yr), SLR is the potential effects of climate change and increased sea level rise (0.5 m/yr), DE is the dam effect on erosion (45 to 75 m) and 20 m is a nominal buffer allowance.

- 6.4 This means that without dams, the shoreline in the vicinity of the river mouth may erode an additional 160 m from its present position, while with dams the erosion could affect up to 205 m over the next 100 years, increasing the landward extent by 45 m or 28%.

- 6.5 I note that the dam will not only have an effect on shoreline retreat, but that it will also cause a consequential reduction in beach level. This is based on the expectation that the entire beach profile, including the sub-tidal profile will retreat landward. For every 10 m landward retreat the beach will drop in the order of 0.1 m at a particular point on the beach. This drop in beach level will increase the amount of wave energy able to reach the shore and the beach levels may drop below this level during storm events. This reduction in beach level will occur even without the dam. However the accelerated erosion rate means that the beach level "with the dam" will be lower than the beach level "without the dam" at a particular point in time.

- 6.6 Even without the dam within the Mokihiui Township 26 out of the 70 lots are potentially affected assuming 100 years of erosion rates similar to that previously experienced. However, I note that these lots do not relate to individual properties, as there are fewer dwellings than lots. An additional 13 lots are affected should sea level rise effects occur. With dam effects there are a further 13 lots affected. The hazard line set backs as shown in Appendix 4 illustrate the potential effects of the

various future shoreline positions taking into account the ongoing erosion and the additional effects of possible climate change effects and the impact of the dams. To the north of the river erosion significantly affects one large property and the access road which is already situated on private land.

- 6.7 In terms of land area, 7.1 hectares will be affected within the township based on extrapolation of the existing trends, over the next 100 years an additional 2.9 hectares will potentially be affected by sea level rise and a further 3.2 hectares by the reduction in sediment supply from the proposed dam effect. After 100 years, the effect of the dam is likely to be significantly reduced. However, climate change processes and existing erosion trends may be ongoing. At this point in time there is little real benefit of extrapolating significantly beyond the 100 year time frame due to uncertainties associated with climate change and existing erosion trends.
- 6.8 North of the river much of the existing road reserve would be eroded and the access road will be under significant erosion threat. In addition to the road reserve 2 hectares of private property could be affected based on the extrapolation of existing erosion rates over the next 100 years. An additional 1.7 hectares will be affected by sea level rise effects and up to 2.4 hectares as a result of reduction in sediment supply from the dam.

7. OPTIONS FOR MITIGATION

- 7.1 Taking the possible shoreline change into account I considered a range of possible management and mitigation options to manage shoreline erosion while reducing risk to property and lives. These options included; managed retreat, cobble beach nourishment, a rock armour revetment, groynes and combinations of these options, such as groynes with nourishment. I also considered more unconventional systems such as offshore breakwaters, undercurrent stabilizers and beach face dewatering. These options, their pros and cons and indicative costs were discussed with representatives of the Mokihinui community. The soft engineering option of nourishment would require large quantities of imported cobbles and sand on a regular basis to replace the beach

sediments that would be eroded. This is unlikely to be feasible or cost effective. Similarly groynes were not considered an appropriate solution as they would require both the construction of the structures and nourishment to reduce end effects and increasing erosion risk elsewhere. Alternative systems are unproved and would be too high risk to consider for areas such as Mokihinui where chronic erosion currently exists. This resulted in the more detailed consideration of conventional rock revetments and set back solutions.

Rock Revetment

- 7.2 In considering the design of this rock revetment, I therefore had to take into account the likely shoreline change that would occur over that time period and the increase in wave height that would result from a lowering in the seabed adjacent to the revetment. This resulted in a large rock size of between 1.1 m and 1.9 m and some 30,000 m³ of rock. Based on discussion with local contractors I was aware that there was no consented local source of rock armour and therefore, a new quarry would be required, or rock would need to be transported from further afield. Based on the best available estimates of rock cost, the structure was cost prohibitive and a lower cost solution was required.
- 7.3 To reduce the volume and size of rock armour and therefore the cost, I relocated the seawall further landward and designed the revetment for a lower return period event. By doing this I was able to reduce the overall dimensions of the revetment to around 9,000 m³ of rock. However, even this volume is not currently available locally due to the lack of consented quarries along the West Coast and material may need to be brought in. I evaluated two options based on discussions with the local community group. The first option was to armour the seaward face of the existing inner berm. This provides an armoured structure 25 m landward of the existing high water line. The second option was to locate an armoured bund 45 m landward of the existing high water line. I have included sketches of these two options in Appendix 5 and 6 for the 25 m and 45 m landward revetment option, showing the plan view, a section and a more detailed sketch section of the typical rock armour profile.

25 m set-back revetment

- 7.4 The 25 m set back wall has the benefit of no significant impact on the community as it is effectively lining the seaward face of the existing rear bund (refer Appendix 5). I have included a return wall along the southern boundary of the township, extending landward. This is to prevent inundation and outflanking. I have also enhanced the existing rock revetment along the entrance to the river on the northern side of the township.
- 7.5 Taking into account the existing erosion trend and potential effects of the dam, the rear wall would be exposed to wave forces similar to the existing seaward bund in 12 to 20 years. The rock armour will provide an increased level of protection compared to the existing situation, but as erosion continues, the wall will begin to be undermined and experience localised damage after significant storm events. Ultimately the wall will require ongoing maintenance and repairs to maintain its integrity which will include increased toe construction and possibly crest raising to reduce overtopping. I consider the 25 m set-back design as providing security for some 20 to 30 years prior to requiring maintenance and then maintenance would be required after storm events with increasing frequency of maintenance over time as the shoreline continues to erode, or the wall would fail. However, with a commitment to ongoing maintenance this option would be able to mitigate the possible effects of the dam on coastal erosion for a period of between 50 and 80 years. Without maintenance it would still provide a significant enhancement to the existing bund, due to the presence of the rock armour and the geotextile filter layer reducing the erosion of fines from the bund.

45 m set-back option

- 7.6 The 45 m set back wall will require two dwellings to be relocated, but avoids the need to relocate the community hall (refer Appendix 6). The location of the wall has the benefit of a longer time period before wave action begins to impact on the wall And therefore will require lower maintenance costs compared to the 25 m set-back option. The 45 m set back represents the quantity of erosion likely to be experienced as a result of the dam and the wall therefore provides further protection to the community in terms of inundation protection. The 45 m set-back design

would be exposed to wave forces similar to that experienced at the existing bund location in 25 to 40 years and it would be in the order of 35 to 50 years before maintenance of the rock armour would be required. Maintenance, increasing over time could extend the life of this structure to between 50 and 80 years.

Managed retreat

- 7.7 Managed retreat involves developing a strategy to manage the coastal erosion hazard by relocating and removing existing assets from the hazard area. As erosion will occur progressively not all properties will be affected at the same time. Therefore, there is the opportunity to carry out managed retreat over a period of time. However, it is likely that six to eight properties will need to be moved as a direct result of accelerated erosion and the remainder over a longer time period as a combined result of dam induced erosion, long term trends and potential sea level rise effects.
- 7.8 There is no opportunity to relocate development landward of the existing hazard zone within the same property. Therefore, the options are:
- remove (demolish) and replace (i.e. new building on another site)
 - relocate existing dwelling to another site.
- 7.9 The key issue with this option is to have an area of land where the community could be re-established landward of the projected coastal hazard area and still within the locale so the amenity and lifestyle of the inhabitants of the township could be maintained. Sensibly this land should be located high enough to avoid the flood risk as well as the erosion risk. This option is likely to necessitate land purchase landward of the setback lines and changes of land area designation to accommodate the additional development and provide services to the lots (roads, power, phone, waste and water). Existing dwellings could then be relocated or demolished and new dwellings constructed.
- 7.10 All three options discussed above will mitigate the effect of the MHP and provide a greater “life” for the Mokihinui township than would occur even

without the MHP proceeding. I understand that Meridian are not recommending one option over another, but that Meridian believes this should be a decision which should be made in consultation with the Mokihinui Ratepayers Association (MRA). Chris Evans of Meridian will be providing additional information of discussions between Meridian and the MRA in his evidence. Regardless of the method chosen, you (the commissioners) can be certain that the effects of MHP on coastal erosion can be mitigated using either the 45 m setback revetment or the managed retreat option discussed above.

North side of river

- 7.11 On the north side of the river the recommended option is a combination of managed retreat and rock revetment. The key asset at risk is the formed road that runs along side the river which is already within private property. It is proposed to construct a short revetment, approximately 180 m long to protect the road and minimise additional erosion of private land. The remaining road will be relocated closer to the private property boundaries, as required following erosion events, and the shoreline allowed to adjust to a new equilibrium position. The plan showing the possible extents of the revetment and road relocation is shown in Appendix 6.
- 7.12 Monitoring will be carried out along both areas and mitigation for the north side is specified in the erosion management plan.

8. CONCLUSION

- 8.1 Based on the studies carried out by NIWA (M Hicks, 2007) and from the anecdotal evidence supplied to me by the local community, the existing community is presently significantly at risk from existing coastal erosion and inundation. It is my opinion that the existing bund has only 5 to 10 years of viable life remaining before consideration must be given to alternative methods to reduce erosion and inundation risk. Potential climate change effects will increase erosion and inundation pressure. These erosion and inundation risks will be further exacerbated by the construction of the dam due to the reduction of sediment supplied from the catchment to the coast.

- 8.2 The dam erosion effects will be finite, in that the shoreline will adjust to a new equilibrium position more landward than its present position. Superimposed on the existing situation, the dam will manifest itself in more rapid erosion than currently experienced, with its effect reducing over time and with distance from the river mouth.
- 8.3 Engineering options to “hold the line” will involve significant cost and will, at best, provide a period of time during which the land erosion loss will be avoided. They will not provide a permanent solution to erosion without ongoing investment to maintain and enhance these structures, however they will mitigate the effects of the MHP.
- 8.4 I explored a number of options including managed retreat, beach nourishment, groynes, seawalls and combinations of these. The best solution, in terms of best-practice coastal management is to relocate the community landward of the area susceptible to the coastal hazards of erosion and inundation. However, this approach was not the preferred option of the local community stakeholder group.
- 8.5 I have developed two engineering solution that combines a component of managed retreat, an armoured flood protection bund and a commitment to ongoing maintenance of that structure that addresses the quantified effects of the proposed Dam. These options will provide a period of protection of around 50 to 80 years that the stakeholder group considers reasonable with increasing maintenance requirements over that time period as a result of a retreating shoreline and increased wave energy attacking the face of the wall. Managed retreat, moving the community to adjacent higher ground would provide a longer term solution and have a reduced risk of damage. At this stage of discussions between Meridian and the community, all three options (25m wall, 45m wall and managed retreat) *are potential options to manage coastal erosion and inundation effects.*
- 8.6 My recommended option for the north of the river is to initially protect the existing road access at one location with a rock armour revetment.

Subsequently erosion effects along the open coast will be mitigated by relocating the existing road and allow the shoreline to adjust to a new equilibrium. The timing for this relocation will be determined by ongoing monitoring, with relocation considered when the beach crest reaches within 15 m of the formed road. This combined approach provides the most low key but effective erosion management approach to expected erosion effects north of the river.