

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

**FIRST STATEMENT OF EVIDENCE OF DEREK GARARD GORING ON
BEHALF OF MERIDIAN ENERGY LIMITED**

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1. **QUALIFICATIONS AND EXPERIENCE**

1.1 My full name is Derek Garard Goring.

1.2 I have the following qualifications: Bachelor of Engineering (Civil) with First Class Honours from the University of Canterbury; Master of Science in Environmental Engineering Science and Doctor of Philosophy in Civil Engineering from the California Institute of Technology (Caltech). My PhD thesis was on the propagation of tsunami waves from the deep ocean onto the continental shelf. I am a registered engineer. I am a member of the New Zealand Hydrological Society and the New Zealand Coastal Society.

1.3 I am a principal of Mulgor Consulting Ltd, a company my wife and I formed in 2003. Prior to that, I was employed as a research scientist for 25 years by NIWA and its predecessors. One of my specialities is tidal hydraulics and I have published numerous scientific papers on this subject over the last 30 years. Currently, I work mainly in the field of analysis of long waves in the ocean. Tides are one example of long waves. Others include tsunami, rissaga (also known as meteorological tsunami), and far infra gravity waves. My clients include port companies, local authorities, and private companies such as Meridian Energy Ltd (Meridian).

1.4 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.

1.5 I have been involved in the following work in relation to Meridian's Mokihinui Hydro Project (MHP):

- a. Determining the nature of the tidal hydraulics in the mouth region of the river and how that may be altered by a regime of flow

changes resulting from hour to hour variations in electricity production, and whether this would result in any adverse effects that need to be avoided, remedied or mitigated;

- b. My work, which involved both field work and computer modelling, resulted in the following reports:

Mokihinui Tidal Hydraulics, Mulgor Client Report 2007/2, May 2007;

Mokihinui Tidal Hydraulics: Preliminary Modelling, Mulgor Client Report 2007/4, July 2007.

Mokihinui Tidal Hydraulics: Implications of Mokihinui Hydro Project, Mulgor Client Report 2007/5, August 2007.

and I have prepared my statement of evidence in reliance on this work.

1.6 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. Mr Roddy Henderson
- ii. Mr Ian Jowett
- iii. Mr Marty Bonnett
- iv. Dr Murray Hicks

2. SCOPE OF EVIDENCE

2.1 I have been asked by Meridian to prepare evidence in relation to potential effects on the tidal hydraulics in the mouth region of the Mokihinui River. This includes:

- a. A description of the existing, natural conditions in the tidal reach of the river; and

- b. An assessment of how those conditions will change under the proposed hydro generation regime.

3. **EXECUTIVE SUMMARY**

3.1 The main points of my evidence are:

- a. Under natural conditions, the tidal reach is dominated by the oceanic forces of tide and waves. However, if the river flow is large enough, the flood tide is washed out, and in large floods (several hundred cumecs) the water levels in the lagoon are affected.
- b. Under the proposed hydro generation regime, the situation will change on a day to day basis, but the overall effect will be minor.

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 characteristics were determined by a measurement program (described in full in my reports) that included the following fieldwork:

- a. Establishment of two sea-level recorders: one at the throat of the river mouth and the other 1.8 km upstream.
- b. Three flood-tide gaugings in which the flow in the river was measured continuously over the flood tide on 23 April, 20 July and 3 August 2007. The measurements were made mainly at the mouth, but some measurements were also made at various locations upstream, as shown in Figure 1 attached to my evidence.

- 5.2 Additional data were obtained as follows:

- a. River flow from the Welcome Flat/Burkes Creek water level recorder using a rating derived by NIWA.
 - b. Tidal constituents from the NIWA Tide Model for a location just offshore from the Mokihinui mouth. Using these constituents, the tide can be forecast for anytime in the future or hindcast for anytime in the past using a standard tide forecasting model.
 - c. Ocean swell heights from hindcasts of the NOAA WaveWatch III (NWW3) model.
- 5.3 In a river mouth system the tidal reach from the mouth upstream to the point where the water surface slope starts to rise can be considered as a lake with inflow from the river and outflow to the ocean. The lake level is determined by the difference between inflow and outflow. The outflow is determined by the energy balance between the outlet and the ocean, taking into account friction and entrance and exit losses. This is called the Bruun Model which I describe in detail in Appendix IIIa of my 2007/5 report
- 5.4 To determine how river flow interacts with the tide for the Mokihinui River, I derived a flood-tide model based on the Bruun Model in which I matched the rate of change of storage at mid-flood tide to the difference between the inflow and the outflow in the tidal reach. I calibrated the model using the three flood-tide gaugings. Thus, using historical river flow from the Welcome Flat/Burkes Creek archive (scaled up by 7% to account for tributary inflow) as inflow to the lagoon and tide levels from the NIWA Tide Model to give the rate of change of storage, I was able to calculate the outflow from the tidal reach. I ran the model for 18.6 years (a tidal epoch) and assembled the statistics. Then I repeated the simulation using the same flow conditions, but with a different start time for the tide. I repeated this process 10,000 times to yield robust statistics on the interaction between river flow and the tide. This procedure is a standard technique used when a system involves complicated interaction between independent processes. It is known as "Monte Carlo Simulation". The details of the model are described in Appendix IIIb of my 2007/5 report.

- 5.5 From the measurements described in Sections 5.1 and 5.2 and the modelling described in Section 5.3, I determined that the region of the Mokihinui River from the mouth up to the point where the water surface slope starts to rise has the following characteristics:
- a. The river mouth and lagoon are dominated by the tide. There is significant inflow of seawater during the flood tide, except when river flows exceed the tidal inflow at mid-flood tide. For the median tidal range, this occurs when the river flow is above 69 cumecs and this occurs 35% of the time.
 - b. The tidal range (i.e., the difference between successive high and low tides) is large in the New Zealand context, varying from 1.15 to 3.86 m, with a median of 2.38 m at the mouth (typically, around New Zealand the median tidal range is less than 2 m, except in Nelson and the Firth of Thames). The tidal range reduces upstream and at 2 km from the mouth it varies between 1.06 and 2.64 m, with a median of 1.95 m.
 - c. The mid flood-tide flow (excluding river flow) varies between 33 and 112 cumecs depending upon the tidal range. When river flows exceed 112 cumecs, all flood tides are washed out, irrespective of tidal range (and this occurs for 21% of flood tides).
 - d. There is a tidal lagoon that extends from the mouth to between 1 and 2 km upstream (depending upon the tidal range).
 - e. Levels in the lagoon generally follow the tide levels at sea. Above the lagoon, there is a backwater that extends upstream. In low river flows, the backwater extends several hundred metres above the SH67 bridge. This reach is a transition from tide-dominated levels in the lagoon to river-flow dominated levels further upstream.
 - f. Saline water extends to the upstream limit of the lagoon, but does not extend into the backwater section. The upstream limit varies depending upon river flow and tidal range. When the flood tide is washed out, no saline water penetrates into the lagoon.
 - g. Surge occurs during flood tide. Its origin is FIG (far infra gravity) waves that accompany swell waves that have propagated over many thousands of kilometres of ocean and combined into groups. When the swell waves break, FIG waves are released and propagate as free waves. Surge flows of ± 100 cumecs were

measured during flood-tide gaugings and wave heights up to 0.43 m were measured at the river mouth. Flow could vary between plus or minus 100 cumecs in 5 minutes. This far exceeds any likely flow changes that result from hydro generation. The FIG waves also affect water levels in side creeks potentially used for spawning and they are changing continuously by tens of centimetres every few minutes. The surge has periods of a few minutes. It is continuous, but is strongly modulated with the tide, being larger at high tide.

- 5.6 In summary, under natural conditions, the tidal reach from the river mouth to about the SH67 Bridge is dominated by the oceanic forces of tide and waves. River flows are only important if they exceed certain thresholds that depend on the tidal range and the time in the tidal cycle.

6. **ACTUAL AND POTENTIAL EFFECTS**

- 6.1 To assess the effects of MHP, I repeated the simulations described in Section 5.3, supplementing them by also modelling the generation flow which was supplied to me by Mr Roddy Henderson of NIWA. This is explained in more detail in Mr Henderson's evidence. Briefly, it involves holding the river flow to 16 cumecs during the evening and, then ramping up to 120 cumecs in two peaks during the day. Using this principle and a market demand weekly profile for generation, the 22 years of natural flow record were routed through the proposed dam and a generation flow record was produced. A second generation flow record was produced that replaced generation flows with natural flows during the whitebait fishing season. By calculating the difference between the statistics from the simulation of natural flows and generation flows with and without a whitebait fishing strategy, I was able to identify how the project will affect the tidal hydraulics.
- 6.2 The results of the simulations were as follows:
- a. For natural conditions, the flood tide is washed out for 58% of tides. Under hydro generation this will increase to 59%, which is considered a negligible difference.

- b. As a result of hydro generation, there will be more seawater flowing into the lagoon, by 10 cumecs under most conditions, as shown in Figure 2 attached to my evidence. This will occur because for the 41% of flood tides that are not washed out, the mid flood tide flow will be larger than under natural conditions. These enhanced conditions will occur mainly at night when the river flow is normally held at lower flows.
- c. Hydro generation will have no discernible effect on the water levels in lagoon. The reason is that these levels are governed by the ocean tide. To produce an effect on the lagoon levels the flood flow needs to be many times larger than the flood-tide flow. Even then the increase in the lagoon level will only be minor.
- d. For the reach upstream of the lagoon, there will be fluctuations of up to 1 m in level when the river flow is increased for generation purposes. Under natural conditions, fluctuations of this magnitude are not unusual. Indeed they occur four times per day under natural conditions as the tide rises and falls.
- e. The results of the simulations with and without a whitebait fishing regime were indistinguishable.

6.3 The implications for the tidal reach of changes in the flow regime are:

- a. Levels in the lagoon will be unaffected because flows much larger than the maximum generation flow are required before they show any significant response.
- b. Levels upstream of the lagoon will respond to river flow increases for generation purposes, but the changes in level will be no more than are experienced under natural conditions. These are put into context in Table 1 which is attached to my evidence. In Part 2 of my evidence, I will describe in more detail the changes in level that occur between the dam and the tidal zone as a result of hydro generation.

Changes in Morphology

6.4 Dr Hicks in his evidence indicates that as a result of the dam cutting off the sediment supply, there will be a deepening of the lagoon and the

beach will become more sandy and therefore less resistant to flow and waves. The effects of these changes will be as follows:

- a. The hydraulics of the lagoon is mainly governed by the surface area, not the depth. Therefore, providing the lagoon area does not change significantly, the changes will be minor. The water levels are governed by the tides at sea and will not change.
- b. Deepening of the river channel upstream of the lagoon may cause the backwater effect from the tide to penetrate further upstream, but this would depend on the extent of the change that occurred to the channel.
- c. In terms of the surge caused by FIG waves, opening the lagoon more to the sea will allow greater penetration of these waves into the river system. It could also allow greater penetration of swell waves. Presently, swell waves break on a gravel bar and dissipate most of their energy in the process. With the reduction of this bar, or as a result of changes in the beach morphology, swell waves could penetrate further into the lagoon, especially at high tide. This could cause increased erosion of the banks of the lagoon. I concur with the monitoring and subsequent mitigation proposed by Dr Hicks to counter these effects if erosion occurs.

Inanga Whitebait Spawning

- 6.5 Mr Bonnett in his evidence identifies Brewery Stream as a potential site for inanga whitebait spawning, but no spawning has been recorded in this stream. Brewery Stream flows into the lagoon, so its levels will match those in the lagoon. Hence, since hydro generation will have no significant effect on lagoon levels, it will have no significant effect on whitebait spawning in this stream (if spawning actually occurs).
- 6.6 Mr Bonnett's hypothesis that frequent floods wash out the inanga whitebait eggs laid at spring high tides is consistent with my findings presented in Section 6.2, where I pointed out that under natural conditions, for 58% of tides the flood tide flow is washed out by river flow. When river flow is high enough to wash out the tide, the water level in its tributaries above the lagoon will exceed the expected high-tide level. Therefore there is more than an even chance that inanga whitebait

eggs (assuming spawning occurs) will be washed out by river flow. Under hydro generation, this situation will be exacerbated to a less than minor extent because the proportion of flood tides washed out will increase by 1%.

- 6.7 For the lagoon, where the levels are governed by the ocean tide (except during river floods of several hundred cumecs), the factor controlling whitebait spawning could be the surge that results from FIG waves propagating into the river system. They have been measured at 0.43 m in height in the lagoon and they could get much larger under heavy swell conditions. These waves have periods of approximately 5 minutes and occur continuously. They are especially profound over high tide. The effect in a spawning stream would be for water levels to be continually rising and falling, accompanied by significant flow velocities that could flush eggs that are lying in the vegetation back into the stream.
- 6.8 During the whitebait fishing season, the change in flows into the lagoon has the potential to adversely affect the fishing experience, with the possibility that if the mid-flood tide occurs during the times when generation is at a maximum, it could be washed out, thereby preventing whitebait from entering the river system for that tide. This problem will be eliminated completely if the scheme is operated as run-of-river during the whitebait season as Meridian proposes.
- 6.9 Mr Watts in his evidence points out that the implementation of the whitebait fishing flow regime may result in a flow surge of a few tens of cumecs propagating down the river. For the tidal reach, such surges are minor compared to the surges of ± 100 cumecs every few minutes that occur as a result of FIG waves propagating into the reach under natural conditions.

Conclusion on Effects

- 6.10 In my opinion, hydro generation will have no adverse effects on the tidal hydraulics under the present morphological regime. The astronomical forces involved in the tidal hydraulics are so huge and their effects are so pervasive, that it would take substantial changes in morphology of the

coastline and river mouth for there to be significant changes in the tidal hydraulics. Dr Hicks has proposed a monitoring program that is designed to detect changes in the morphology. I concur with this strategy.

- 6.11 In conclusion, the tidal reach of the Mokihinui River is so dominated by oceanic forces (tide and waves) that the proposed hydro scheme will have essentially no overall effect on it. For the levels in the lagoon to differ from the levels at sea, the flow in the river must exceed several hundred cumecs, but the maximum normal operating generation flow is only 120 cumecs. This flow is of the same order as flow fluctuations resulting from FIG waves entering the lagoon, with the difference that the generation flows change a few times a day, whereas the FIG waves result in fluctuations of ± 100 cumecs every few minutes over the flood tide.
- 6.12 The distribution of the flow into and out of the reach with time will change. For example, during the night time when the flow is proposed to be low, the flood tide will always penetrate the river system, whereas under natural conditions this occurs for only some tides. On the other hand, any flood tide that occurs during the twice daily peak generation flows will be washed out. Overall, the change in the distribution in river flow with time will result in more seawater entering the lagoon, which is expected to have effects which are minor or less than minor as discussed in the evidence of Mr Bonnett.

7. ISSUES RAISED BY SUBMISSIONS

- 7.1 There were no issues raised by submitters on the tidal hydraulics.

8. CONCLUSION

- 8.1 After a detailed analysis of the tidal hydraulics of the Mokihinui River, involving field measurements, data analysis, and mathematical modelling, I conclude that while there will be some changes in the day to day tidal hydraulics, the overall effect of hydro generation will be minor.



Figure 1. Map of the tidal reach of the Mokihinui River showing the location of gaugings (numbers) and sea-level recorders.

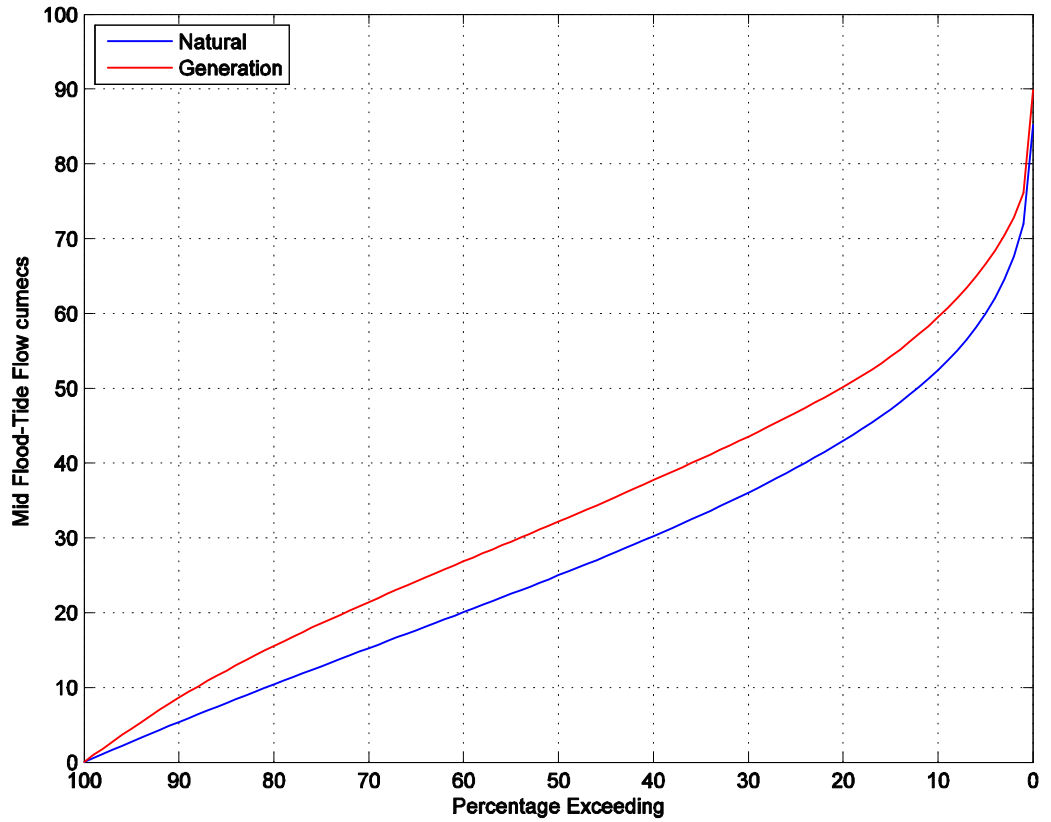


Figure 2. Comparison of CDFs for flow into the lagoon at mid flood-tide under natural conditions and with hydro generation.

Table 1. Water level fluctuations (m) in the tidal reach in response to various phenomena.

Phenomenon	Timescale	Throat	Gabion
Tide: Minimum	6 hours	1.15	1.06
Median	6 hours	2.38	1.95
Maximum	6 hours	3.86	2.64
FIG Waves	Few minutes	0.43*	0.16*
Hydro Generation	Several minutes	No effect	~ 1 †

* Average of the highest third of the waves.

† From an approximate rating.