**BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY**
**AT WELLINGTON**

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| **IN THE MATTER** | of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 ("the Act") |
| **AND** | |
| **IN THE MATTER** | of the applications by Trans Tasman Resources Limited (TTR) for marine and discharge consents to recover iron sand under sections 20 and 87B of the Act and |
| **BETWEEN** | **Trans- Tasman Resources Limited**<br>Applicant |
| **AND** | **The Environmental Protection Authority**<br>EPA |
| **AND** | **Kiwis Against Seabed Mining Incorporated (KASM)**<br>Submitter |

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**EXPERT EVIDENCE OF DOUGAL GREER**
**ON BEHALF OF KIWIS AGAINST SEABED MINING INCORPORATED**

**Dated 24 January 2017**

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**STATEMENT OF EVIDENCE OF DOUGAL GREER**

**INTRODUCTION**

1. My name is Dougal Greer. I am a Oceanographer, working for marine consulting and research company eCoast.
2. I have the following qualifications and experience relevant to the evidence I have provided:
    a. I hold Bachelor of Science degree (Hons) in Physics with Computing from the University of Bath, a Masters degree (distinction) in Evolutionary and Adaptive Systems from Sussex University and a graduate diploma in Statistics from the University of Auckland.
    b. I have 9 years' experience in marine research and consulting, have co-authored 17 peer-reviewed scientific papers, and have solely or jointly produced many technical reports pertaining to physical oceanographic processes.
    c. Much of my time as a physical oceanographer has been spent developing many numerical models of waves, hydrodynamics and modelling sediment transport due to natural processes as well as from anthropogenic sources.
    d. As part of my work I have written a cohesive sediment transport model which has been used in a variety of cases including estuarine sedimentation due to road construction, sediment mobilisation due to mangrove removal and for water quality modelling as part of an investigation into seagrass health. I have also regularly been involved in plume modelling from various sources (e.g. dredging and outfalls).
3. I am currently an environmental scientist and director at eCoast, which is a marine consulting and research organisation based in New Zealand. I have worked at eCoast as an oceanographer for the past four years.

4. I have appeared as an expert witness in the EPA hearing for the first application for the Trans Tasman Resources seabed mining application and for the marine consent application by Chatham Rock Phosphate Ltd to undertake activities in the Chatham Rise.

**PURPOSE AND SCOPE OF EVIDENCE**

5. I have been asked by Kiwis Against Seabed Mining to prepare evidence for the 2016 Trans Tasman Resources Limited (**TTRL**) marine consent hearing. This evidence is directed specifically at the work undertaken to determine the characteristics of the sediment plume produced by the proposed mining operation.

6. In preparing this evidence, I have reviewed the application itself and the following peer reviewed reports:

   a. EEZ000011_055_s158_Report_3(a)_HRW_Lab_Testing_of_Sediments_October_2014.pdf - (Dearnaley 2014),

   b. EEZ000011_056_s158_Report_3(b)_HRW_Source_Terms_and_Sediment_Properties_Report_October_2015.pdf - (Dearnaley 2015),

   c. EEZ000011_057_s158_Report_3©_NIWA_Sediment_Plume_Modelling_Report_FINAL_October_2015.p–f -(Hadfield 2015), and

   d. S158 Memo on contribution of source terms for the hydrodynamic model, Pinkerton.pdf - (Pinkerton 2015 Memo).

7. I have also reviewed the following evidence:

   a. Expert evidence of Michael Dearnaley on behalf of Trans Tasman Resources Limited – 15 December 2016,

   b. The EPA key issues report -September 2016, and

   c. GHD – review of sedimentation mobilisation and transport - 06 September 2016.

8. I have read the Code of Conduct for Expert Witnesses Environment Court's Consolidated Practice Note (2014). In so far as I express expert opinions, I agree to comply with that Code. In particular, except where I state that I am relying upon the specified evidence of another person as the basis for any expert opinion I have formed, my evidence is within my sphere of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions which I express.

**EVIDENCE**

9. As part of TTRL's application to extract titanomagnetite sand (iron sand) from an area in the South Taranaki Bight, sediment plume modelling was undertaken to estimate the changes in Suspended Sediment Concentration (SSC) and sedimentation due to the proposed mining operations.

10. The modelling is an important piece of work used by experts to assess the environmental impacts of the mining operation.

11. The plume modelling has been carried out in two parts: the first stage, undertaken by HR Wallingford, was used to simulate and understand near field plume and settling characteristics. The second stage, undertaken by Dr Hadfield of NIWA, provides predictions of far field characteristics of the plume. It uses the results of the first stage of modelling to parameterise the far field model. Overall, the models use well established and appropriate modelling platforms. However, there are a number of concerns over the model parameterisation and presentation of results which are discussed below.

12. The results in the present application are quite different than those in the first application which demonstrates the effect that model parameterisation can have on model results.

13. The near field modelling study was undertaken by HR Wallingford and uses results from lab experiments which are based on three sediment samples. It is unclear from the HR Wallingford reports if these samples are representative of sediments that will be found in the area to be mined. The experiments were used to determine the fall velocities of different sized flocculates formed from small sediment fractions (< 38 µm).

14. The near field modelling explores different pit dimensions under a range of current speeds and wave heights to determine how much discharged sediment will settle in the mining pit and how much will leave the pit as a

passive plume. The quantity that escapes as a passive plume determines the mass of sediment released in the far field modelling.

15. The 3D near-field modelling used wave conditions with constant wave height and period. The wave height is an intuitive concept but the wave period is also important. Low period waves (7 to 10 seconds) do not have a large effect on the sea floor at depths such as those considered for the proposed mining operation. Higher period waves (>10 s) are much more efficient at re-suspending sediment at depth. The 3D near field wave modelling uses peak wave periods of 7 to 10 seconds. An important point here is that in 40 m of water a 1 m wave with a 12 s period will give rise to less settling of sediment in the pit than a 2 m wave with an 8 s period. High period waves are common along this stretch of coastline and they should be explored in the nearfield modelling. The 1DV near field modelling does not specify the wave period that is used although this is an important piece of information for reviewing the model suitability. The use of low period waves in this modelling may lead to an underprediction of the amount of sediment leaving the pit.

16. The near field modelling used by the far field boundary conditions assumes a constant wave height. The modelling also assumes that the current and wave directions are at right angles to each other, a condition which maximises the amount of material that remains in the pit. Additionally, the wave period used in the model is very low (see paragraph 15). In reality the quantity of sediment that leaves the pit in the form of a passive plume will vary over time leading to greater variability in the size of the plume than is represented in the subsequent far field modelling.

17. The modelling report by HR Wallingford presents the Overflow and Underflow source rates broken down by settling speed fraction i.e. proportion (%) by mass of released material with different settling velocities (10, 1, 0.1, 0.01 mm $s^{-1}$). Two break downs are presented: one from HR Wallingford and one from NIWA. The NIWA estimate show a

higher percentage of the slowest settling fraction. The report uses an average of the two to estimate the quantity of each fraction that leaves mining area in the form of a passive plume. Had the NIWA estimate been used, the 0.1 mm $s^{-1}$ source would have been decreased by 28% but the 0.01 mm $s^{-1}$ source would have been increased by 45%. This would have led to a considerably larger plume in the far field model. The model would need to be rerun to determine how much larger the plume would be.

18. Appropriate input data was used for the far-field hydrodynamic model boundary conditions. The model performs well and takes into account the major physical drivers that are likely to affect hydrodynamics.

19. The far field sediment transport modelling uses modelled hydrodynamics and waves to drive the advection, settling and resuspension of both background and mining derived sediments for a period of approximately 2 years. This is expected to be representative of likely conditions; however, additional interannual variability is expected over the course of the mining operation (for example El Nino versus La Nina years).

20. The far field modelled discharge includes contributions from the hydro-cyclone overflow discharge and the de-ored sand discharge. Other potential for sediment sources include the processes associated with the retrieval of sediment and grade control drilling, but these are unlikely to add a significant amount of sediment to the plume.

21. The far field sediment modelling considers seasonal variability in SSC and sedimentation.

22. In the HR Wallingford near field modelling, an erosion rate of 8E-4 kg $m^{-2}$ $s^{-1}$ is used. This is the rate at which sediment on the sea floor is released into the water column once the hydrodynamic forces exceed the threshold for resuspension. HR Wallingford chose this as a typical representative erosion rate. The report notes that this value is four times as high as that value used in the NIWA far-field modelling from the first application (2E-4 kg $m^{-2}$ $s^{-1}$) and described this as 'conservative'. In fact,

the value used in the far field modelling is a very low value (Whitehouse et *al.*, 2000) so the value used in the near field modelling is not 'conservative' but 'typical'. Furthermore, the erosion rate used in the far field modelling continues to be the low value of 2E-4 kg $m^{-2}$ $s^{-1}$ in the current application.

23. As Dr Hadfield acknowledges, there is a degree of error associated with modelling sediment transport. Comparison of modelled background surface SSC against measured levels indicates that background levels may be underestimated in the model by up to a factor of two. Nonetheless, Dr Hadfield points out, and I would agree with him on this point, that error of a factor of two is considered good for sediment transport modelling. Comparisons between modelled SSC near the seabed and measured values show much larger errors of a factor of perhaps 5 or 10 by examination of the time series plots. Similar errors might be expected in the uncalibrated modelling of the plume.

24. As with the modelling of the background sediment processes, there will be a degree of error surrounding the modelling of the plume, but this remains unquantified. While the model results are a best estimate, other experts interpreting the results should be aware of this. Quantification and discussion of error has only been carried out against background SSC where modelled SSC showed large deviations from measured values. Similar or more extreme errors may be associated with the plume modelling. In line with taking a precautionary approach, it is important that other experts consider this though this topic has not been discussed in the modelling reports.

25. Quantification of error in numerical models is difficult to achieve. A common way to address this is to use conservative values when parameterising the model to provide a result biased towards the worst-case scenario. Some attempt has been made to do this in the modelling and this is documented in the reports. For example, the resuspension of sediment has been chosen to be conservative. However, there are areas

where the modelling is not conservative for example the allocation of sediment mass by settling velocity (see paragraph 17), the choice of wave period (see paragraph 15) and the choice of the erosion rate in the far field modelling (see paragraph 22). In such an instance, when non-conservative values are used, it is common to carry out sensitivity analysis. This is achieved by rerunning the modelling with parameter values altered, within a realistic range, to determine their effect on the model results. This has not been carried out in this modelling. The extent of the role these parameter choices have played in reducing the size of the plume in the model results is uncertain.

26. In paragraph 79 of his evidence, Michael Dearnley points out that within approximately 3 km of the plume, bulk dry density maybe poorly represented by ROMS and consequentially the sedimentation rates should be increased by a factor of 5 in this region. This effect will not abruptly end at the 3 km boundary and it is unclear how much sedimentation rates should be increased beyond this point.

27. In his evidence of Michael Dearnaley frequently refers to background sediments as 'natural' (paragraphs 4, 19, 54, 68, 70, 75, 82, 102, 108, 110, 111 and 112). The background sediments in the model are largely derived from riverine inputs which are heavily impacted by land based industry on the Taranaki Peninsula. The word 'natural' here is a misnomer. This is an important point since the modelled SSC values are not being compared to natural SSC values, but rather to natural levels combined with additional suspended sediment due to anthropogenic activity. Use of the word natural in this context was determined to be inappropriate in expert panel sessions during the first application.

28. Describing the 'background' SSC as 'natural' is also repeated in the Impact Assessment (4.4.2.3 Findings on Sediment Plumes).

29. Results of the far field plume modelling are frequently compared with background SSC levels. Since these background levels are heavily impacted by human activity, they should not be used as a bench mark

with which to establish acceptable increases to SSC from the proposed mining operation.

**CONCLUSION**

30. The modelling presented by the HR Wallingford and NIWA reports uses appropriate tools for simulating the background sediment levels, sediment plume and associated settlement. However, there are some questions around the use of these tools. Some effort is made to quantify the error associated with background surface SSC which was found to be 2-fold or more, and greater for comparisons with SSC at the bottom of the water column. Similar error would be expected to be associated with modelling of the plume which is as yet uncalibrated. All model results have a degree of associated error, but this needs to be taken into account when the results are interpreted by other experts. This has not been discussed in any detail in the modelling reports.

31. Some effort has been made to use conservative choices for some, but by no means all, model parameters. In some cases, parameters have been chosen which will minimise the size of the plume. Where conservative values have not been used, sensitivity analysis should have been undertaken to determine the effect of model parametrisation choices on model error. The absence of this analysis adds considerable uncertainly to the model results.

32. Background SSC levels are referred to as 'natural' in expert evidence and in the main application. This is a misnomer as background suspended sediment levels are already highly elevated due to land based industrial activity. As the background levels are highly impacted by anthropogenic activities, it is inappropriate to use them for comparison with the predicted plume.

**REFERENCES**

Whitehouse, R., Soulsby, R., Roberts, W., & Mitchener, H. (2000). Dynamics of estuarine muds. HR Wallingford & Thomas Telford, London (UK)