BEFORE THE FAST TRACK PANEL
AT WELLINGTON

I MUA I TE KŌTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA ROHE

UNDER	the Fast Track Approvals Act 2024 (the "**Act**")
IN THE MATTER	of an application by Trans-Tasman Resources (TTR) for marine and discharge consents to undertake iron sand extraction in the South Taranaki Bight
BETWEEN	**TRANS-TASMAN RESOURCES LIMITED (TTRL)**
	Applicant
AND	**THE ENVIRONMENTAL PROTECTION AUTHORITY**
	The EPA

STATEMENT OF EVIDENCE OF DOUGLAS GREER
FILED ON BEHALF OF
KIWIS AGAINST SEABED MINING INCORPORATED AND GREENPEACE AOTEAROA INCORPORATED
Dated 6 October 2025

[redacted]
Barrister
Globelaw
[redacted]

[redacted]
Barrister
Magdalene Chambers
[redacted]

Introduction

1. My name is Dougal Greer. I am a director and oceanographer at marine consulting and research company ORCAS Consulting Limited.

2. ORCAS Consulting is a marine consulting and research organisation based in New Zealand. I have worked as an oceanographer for the past 19 years.

3. I have appeared as an expert witness in the EPA hearing for the first and second applications for the Trans-Tasman Resources' seabed mining application and the reconsideration hearing in 2023. I have also appeared as an expert for the marine consent application by Chatham Rock Phosphate Ltd to undertake activities in the Chatham Rise.

4. I have provided evidence as an expert witness in other marine modelling work, such as wastewater outfall and dredge plume studies.

5. My qualifications and experience relevant to the evidence I have provided are set out in paragraph 2 of my statement of evidence to the DMC, dated 6 October 2023 **APPENDIX A.** My Curriculum Vitae is attached to my statement of evidence from 2023.

6. I prepared the following statements of evidence as part of the original hearings and the reconsideration hearings in 2023:

    a. Greer, D., 2017a, Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 24 January 2017.
    b. Greer, D., 2017b, Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 27 March 2017.
    c. Greer, D., 2023 Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 06 October 2023.

7. I took part in expert conferencing on the plume model which produced the following joint expert witness statements:
    a. Joint Statement of Experts in the Field of Sediment Plume Modelling Dated Monday, 13th February 2017

b. Joint Statement of Experts in the Field of Sediment Plume Modelling – Setting Worst Case Parameters, Dated Thursday, 23rd February 2017
c. Joint Statement of Experts in the Field of Sediment Plume Modelling; and effects on benthic ecology dated 23 February 2024.

8. I attach to this statement of evidence:
   a. My statement of evidence from the reconsideration hearing: Greer, D., 2023 Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 06 October 2023: **APPENDIX A**
   b. Joint Statement of Experts in the Field of Sediment Plume Modelling; and effects on benthic ecology dated 23 February 2024 (reconsideration hearing) **APPENDIX B**
   c. My power point presentation to the DMC at the reconsideration hearing; **APPENDIX C**
   d. A copy of the relevant sections of the transcript for Day 3 of the reconsideration hearing which sets out my evidence: **APPENDIX D**

Code of Conduct

9. I confirm that I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note dated 1 January 2023. I agree to comply with this Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Purpose and Scope of Evidence

10. I have been asked by KASM and Greenpeace New Zealand to review and comment on the 2025 Fast Track application by Trans-Tasman Resources Limited, the Taranaki VTM project [FTAA-2504-1048].

11. In preparing this evidence, I have reviewed the application and statement of evidence from the previous associated hearing as well as the following statement of evidence:

a. Expert Evidence of Helen Skye Macdonald on Behalf of Trans-Tasman Resources Limited 19 May 2023.
b. Expert Rebuttal Evidence of Helen Skye Macdonald on Behalf of Trans-Tasman Resources Limited 23 January 2023.
c. EPA, Response to request for section 51 report for Taranaki VTM Project, 22 September 2025
d. TRC, Taranaki VTM Project Written Comment, 16 September 2025

12. I note that there is no difference between the plume modelling evidence provided as part of the reconsideration hearing in 2023 and the Fast Track Application 2025. The only difference is the years of operation which have changed from 35 years to 20 years. This does not impact the size of the plume only to the extent.

Summary of key effects in the TTRL Fast Track Application

13. In my evidence to the DMC in 2023 I gave written and oral evidence. I identified a number of key issues in the approach taken by TTR. These key issues remain the same and apply to the TTRL Taranaki VTM Project.

Suitability of modelling tools used

14. While the plume modelling tools used by TTR are broadly appropriate, I hold serious concerns about incorrect model parameterisation, calibration and interpretation of results.

15. In my opinion, these deficiencies mean the current modelling may significantly underestimate the spatial extent, magnitude, and variability of the sediment plume that would be generated by the proposed mining activities.

Model Parameterisation: Wave Period

16. A central issue is the incorrect wave period input used in the near-field modelling. The nearfield modelling determines how much sediment settles back into the mining pit and how much is released into the wider environment as a passive plume, which then feeds into the far-field model.

17. The model prepared by HR Wallingford[1] used a 7-second wave period, representing short crested, locally generated wind waves.

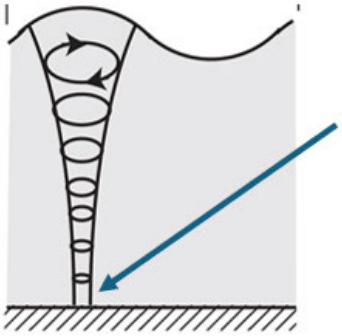
18. Based on my knowledge of this coastline and analysis of long term data at this site, a more appropriate typical peak wave period is approximately 13 seconds**,** reflecting long-period swells generated in the Southern Ocean. The regularity of these higher period swells are part of the reason why this coastline is internationally recognised as a surf destination. If the typical wave period were 7 seconds, the quality of the surf here would be very low.

19. A 13-second wave penetrates much deeper into the water column than a 7-second period wave. For typical wave heights, 13 s wave conditions would resuspend sediment on the seabed and stop suspended sediment from settling**,** whereas the effects of a 7-second wave are more confined to the surface layers and do not resuspend seabed sediment unless the waves were very large. This is illustrated in Figures 1 to 3.

20. This error is highly significant because using a 7-second wave period will grossly underestimate the amount of fine sediment leaving the mining pit, resulting in far-field modelling that fails to predict the true magnitude of the plume.

21. I have raised this concern since the 2017 proceedings, including during joint witness caucusing, yet the modelling has not been updated to account for this. In my view, the model should be rerun using a more appropriate wave period, and it should also incorporate a range of realistic wave heights and periods to reflect natural variability over time.

[1] EEZ000011_056_s158_Report_3(b)_HRW_Source_Terms_and_Sediment_Properties_Report_October_2015.pdf - (Dearnaley 2015) pages 11, 12,



Wave induced velocities penetrate through the water column and can suspend sediment on the sea floor.

Larger wave periods lead to larger velocities and more resuspension of sediment

Figure 1: Schematic showing how waves orbital velocities penetrate through the water column. Strong currents near the seabed lead to greater resuspension of sediment.

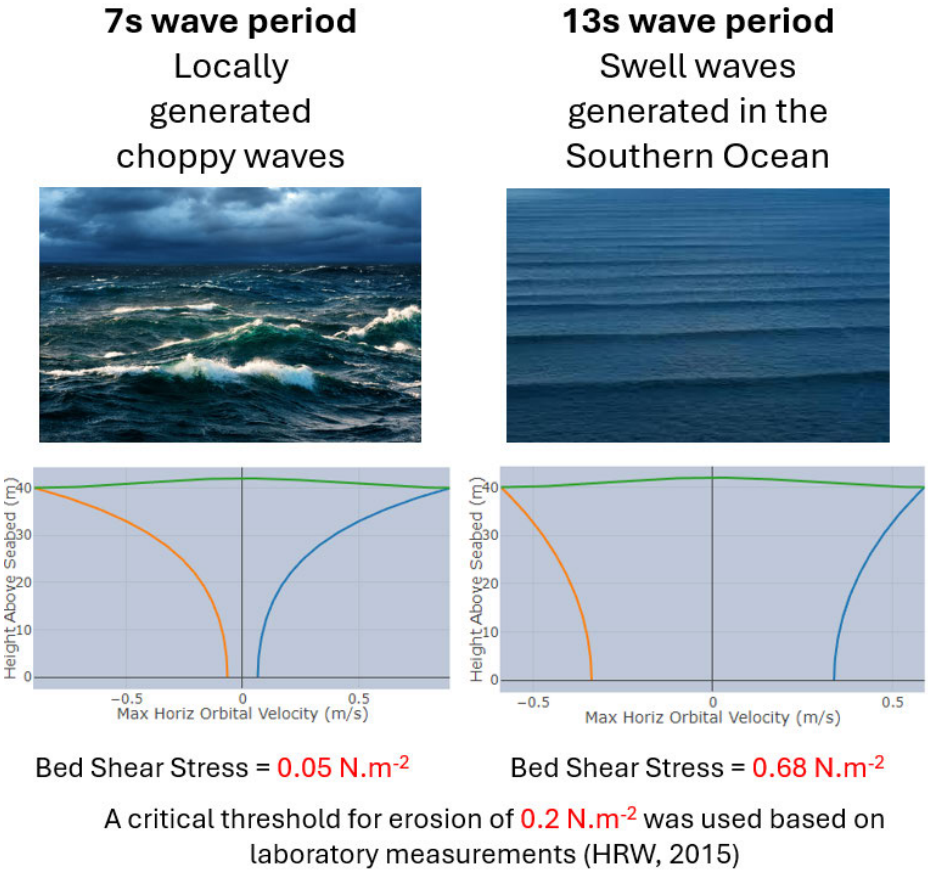


Figure 2: Comparison of effects of low (7s) versus high (13 s) wave periods on bed steer stress. High bed shear stress leads to increased sediment resuspension.

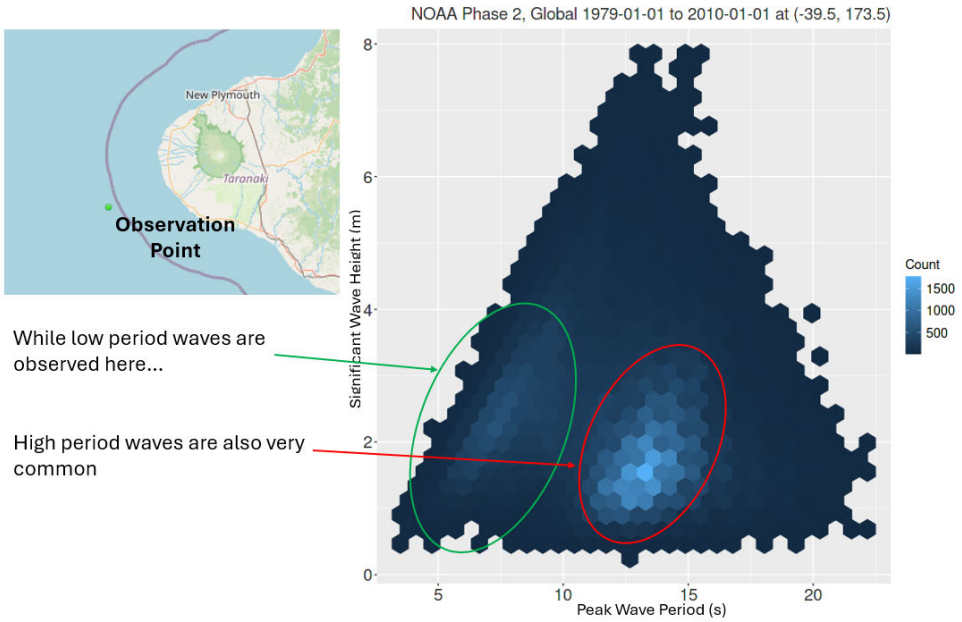


Figure 3: A 2D histogram of the wave climate near at the South Taranaki bight from a 30 year hindcast. This illustrates that 13 s waves with a height of approximately 2 m are common in this area.

Far Field Model Calibration

22. The far-field model calibration raises further concerns. The model was calibrated by comparing predicted suspended sediment concentrations (SSC) with observed data. At times, the observed SSC was five to ten times higher than the model predictions, particularly during storm-driven spikes (see Figure 4).

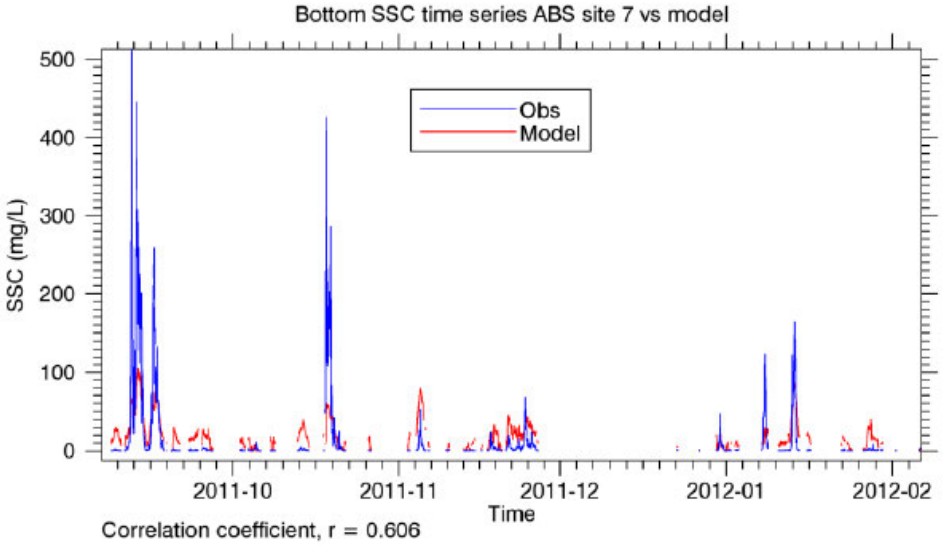


Figure 4: Comparison of modelled and measured data shows that the model underpredicts SSC by 5 – 10 fold in some cases. These 'spikes' define the high percentile model results.

23. These high ‘spikes’ or ‘peaks’ define the 99th percentile plots, which are used for understanding environmental impacts. If the model fails to capture these events, the 99th percentile outputs become unreliable.

Model Post-Processing

24. Model outputs were generated as 12-hour averages, which will have smoothed out peaks in SSC which arise due to tidal excursions over a 12-hour period. This will lead to further underestimation of SSC values, particularly for higher percentiles. Model output should be stored at least as hourly averages or hourly maxima to provide a reasonable estimation of higher percentile SSC values. Storage of model output at hourly intervals is standard practice for models of this type.

25. The smoothing of model output due to this oversight in post-processing will compound the errors due to the poor SSC calibration.

Fine Sediment Samples

26. The laboratory analysis of sediment characteristics was based on only three samples. These were used to calculate the erosion threshold and settling rates used in the near field and far field modelling. The 66 sq km mining area is very large (approximately half the size of Hamilton City) and it would be expected that sediment characteristics would vary considerably throughout the proposed mining region. In the absence of analysis of other samples, worst case values for the erosion threshold and fall velocities cannot be established.

27. An upper limit of 2.25% ultra-fines was imposed on material that would be mined. This was applied based on TTRL’s assertion that they would not consider mining material with a higher ultra-fines content than this for a “period of weeks to 1 month”. This infers that material with higher than 2.25% of ultra fine material would be mined for significant periods of time. Over shorter periods of time (< 1-month), it is not clear how long a higher level of ultra fines would be mined for. This has clear implications for the source term in the modelling

Effects on newly discovered and as yet undiscovered high value ecological habitats

28. Since the original modelling was undertaken, recent surveys have identified many new reef habitats (Morrison (2022)**.**

> *This report demonstrates that subtidal reefs are in fact common on Pātea Bank, with many more awaiting discovery by multibeam sonar mapping.*

The results of the plume modelling should be re-examined by ecologists and peer reviewed by independent ecologists. Note, however, that it will not be possible for the numerical modellers to provide information for all reefs in the area since many remain undiscovered.

29. The application states that "at this stage there is no indication that rocky reefs occur on the Pātea Shoals seaward of the Territorial Sea Boundary". An absence of evidence should not be taken to be evidence of absence and additional surveys would be required to confidently state that no such rocky reefs exist.

Background Sediment Levels

30. The model compares the mining plume only to existing "background" sediment levels. These background levels already include substantial anthropogenic inputs from river systems caused by land use practices in the catchment. Failing to separate natural and anthropogenic sources masks the true cumulative effects of the proposed activity. It effectively portrays the mining plume as relatively minor because the baseline is already heavily impacted. Best practice would be to explicitly identify and account for existing human inputs and consider how land use may change over time. This has not been done here.

Worst Case Plume Modelling

31. The second 2017 JWS included agreement from the experts that:

> *SSC contour plots and median and 99th percentile plots should be generated for shorter periods of time corresponding to the periods of highest release.*

However, this analysis was not included in the worst-case scenario reporting and consequently the model results do not show how the periods of higher release affect median and 99th percentile SSC during those periods.

32. I do not believe that the 'worst case' modelling represents a worst-case scenario. For reasons outlined above, there is considerable uncertainty in the model parameterisation, calibration and post-processing which give reason to believe that the model underestimates the size and extent of the sediment plume. I do not consider that the worst-case model favours caution and environmental protection.

Conditions

33. I have reviewed the conditions proposed to manage suspended sediment concentrations as part of the Fast Track application. Unlike similar large-scale dredging projects, there is no clear, standalone trigger value methodology report that explains how compliance thresholds were selected and justified. Instead, these matters are embedded in the conditions, such as Schedule 3, which I found ambiguous and unclear. In my view, this is a missing step in the application and undermines confidence in the effectiveness of the proposed monitoring and management regime.

Characterisation of Long-Term Oceanographic Variability

34. 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) and this is not accounted for in the modelling.

35. The modelling also fails to investigate the expected effects of climate change. Assessment of climate change impacts is now standard in large marine projects. Climate change could alter storm frequency, wave heights, and currents, potentially increasing sediment resuspension and transport altering dispersion patterns. Without considering these factors, the long-term predictions lack essential context.

Comments on New Review Material

36. I have reviewed the EPA report dated 22 September. I agree with this that further detail should be provided around the desalination process.

37. I have also reviewed the TRC position paper. I agree with this its conclusions that there the model has inherent uncertainty, although it appears that the reviewers may not have been aware of the additional uncertainty in the modelling introduced by incorrect parameterisation, poor calibration and incorrect post-processing of model results.

Salinity

38. The application states that "peak daily production of 30,000 m^3 of desalinated seawater will be required". This indicates that 30,000m^2 of freshwater will be produced but it isn't clear how much brine byproduct will also be created. Typical recovery rates from a desalination plant may be between 30% – 50%, leading to a discharge of 1 to 1.5 m^3 for every 1 m^3 of freshwater recovered. Brine salinity may be between 50 – 70 psu.

39. The application states that "The clean resalinated water from the filter system, will be discharged via an outfall pipe located 1m below the surface near the bow of the FSO vessel." It isn't clear what the 'resalinated water" is but it is presumably the freshwater part component. It is not clear if it is mixed with sea water before being released.

40. The application also states that "The discharged brine will be returned to the sea via the submerged tailings pipe." It is not clear what the volume of the water is, nor do we know the extent of its salinity. The above text insinuates that the discharged plume will be dense and will be released into the pit. If this is the case, this dense hypersaline plume will remain on the seabed and likely fill the pit with hypersaline water. It would likely ultimately overflow the pit and spread along the sea floor (depending on the volume/flux of release). Without detailed modelling, it is unclear how far this plume will spread nor what the ecological impacts of this plume will be.

41. The effects of this hypersaline plume could be widespread, but no detail or in-depth analysis is presented as to the expected effects of this plume.

Conclusions

42. My conclusions in the reconsideration hearing equally apply to the Taranaki VTM Project and are:

A. The modelling tools used in the modelling study are generally appropriate for use in a study of this kind.

B. However there are key and significant issues with the modelling:
    a) The use of a 7-second wave period in nearfield modelling will lead to a significant underestimation of the sediment plume leaving the pit. A larger wave period (around 13 s) would be more appropriate in this area. This was pointed out in 2017 but the modelling has not been updated.
    b) Modelled suspended sediment concentrations significantly underestimate peaks in observed data. This will lead to an underestimation in SSC values particularly for higher percentiles.
    c) Averaging outputs over 12 hours smooths out tidal peaks which will lead to further underestimation of suspended sediment concentrations particularly for higher percentiles
    d) Only three samples were used to infer erosion thresholds across the large mining area.
    e) There is considerable uncertainty around the variability in ultra-fines content across the area and it is unclear what level of ultra-fines would be mined for periods shorter than 1 month.
    f) Background sediment includes human inputs which makes the impact of the proposed mining activities appear smaller than they are.
    g) The model was run for 2 years and does not account for El Niño and La Niña cycles. It also does not incorporate expected climate change effects, which could significantly alter sediment transport and plume behaviour over time.
    h) Desalination brine discharge is not quantified or modelled. Dense hypersaline plumes may accumulate and spread along the seabed.
    i) The application has not been updated since the publication of a more recent study (Morrison, 2022) that shows previously undocumented reefs and predicts that many other reefs are likely as yet undiscovered.

j) The application does not include a standalone trigger value methodology report that explains and justifies compliance thresholds. Such a report is standard for an operation of this scale.

C. In summary, the current modelling falls well short of best practice for a project of this magnitude. Fundamental issues remain unresolved since 2017, including the incorrect wave inputs, limited calibration, inadequate sampling, and lack of consideration of cumulative effects and climate change. Without addressing these deficiencies, the predictions of environmental effects cannot be relied upon, and there is a high risk that the actual plume will be significantly more extensive and variable than currently projected.

References

Morrison et al. (2022). Offshore subtidal rocky reef habitats on Pātea Bank, South Taranaki. NIWA Client Report

Dated 6 October 2025

APPENDIX A: My SOE from 2023

BEFORE THE ENVIRONMENT PROTECTION AUTHORITY
AT WELLINGTON

I MUA I TE KŌTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA ROHE

UNDER	the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
IN THE MATTER	of a reconsideration of evidence by a decision-making committee appointed to consider a marine consent application by Trans Tasman Resources Limited to undertake iron ore extraction from the seabed in the South Taranaki Bight
BETWEEN	**TRANS-TASMAN RESOURCES LIMITED** Applicant
AND	**KIWIS AGAINST SEABED MINING INCORPORATED (KASM)** Submitter
AND	**GREENPEACE AOTEAROA LIMITED** Submitter

STATEMENT OF EVIDENCE OF DOUGAL GREER ON BEHALF OF KASM AND GREENPEACE

Dated 06 October 2023

Counsel Acting:

[redacted]
Barrister
Christchurch
[redacted]

[redacted]
Barrister
Magdalene Chambers
Whanganui
[redacted]

Introduction

1. My name is Dougal Greer. I am a director and oceanographer at 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 19 years' experience in marine research and consulting, have co-authored 23 peer-reviewed scientific papers, and have solely or jointly produced >100 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 as an oceanographer for the past 19 years.

4. I have appeared as an expert witness in the EPA hearing for the first and second applications 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.

5. My qualifications are set out in my statement of evidence dated 24 January 2017.

6. I prepared the following statements of evidence as part of the original hearings. The most recent of these include:

    a. Greer, D., 2017a, Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 24 January2017.
    b. Greer, D., 2017b, Expert Evidence of Dougal Greer on Behalf of Kiwis Against Seabed Mining Incorporated 27 March 2017.

7. I took part in expert conferencing on the plume model which produced the following joint expert witness statements:
    a. Joint Statement of Experts in the Field of Sediment Plume Modelling Dated Monday, 13th February 2017
    b. Joint Statement of Experts in the Field of Sediment Plume Modelling – Setting Worst Case Parameters, Dated Thursday, 23rd February 2017

Purpose and Scope of Evidence

8. I have been asked by KASM and Greenpeace New Zealand to review and comment on the updated evidence provided by Trans-Tasman Resources Limited, dated 19 May 2023 relating to plume modelling.

9. In preparing this evidence, I have reviewed the application and statement of evidence from the previous associated hearing as well as the following statement of evidence:

    a. Expert Evidence of Helen Skye Macdonald on Behalf of Trans-Tasman Resources Limited 19 May 2023.

10. I have reviewed the evidence of John Luick and refer to his evidence in regard to statements on flocculation.

Code of Conduct

11. I confirm that I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note dated 1 January 2023. I agree to comply with this Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

I make the following comments of the further evidence on the plume modelling provided by Trans-Tasman Resources

12. I stand by my original statements of evidence submitted as part of the original application. Some of the main points from those statements are reproduced here.

13. The latest submission relating to the modelling of the sediment plume is covered by the statement of evidence from Helen Macdonald. This statement does not provide new information but rather a summary of the application submitted in the previous hearing.

14. Ms Macdonald makes reference to the worst-case scenario that was modelled following conferencing of the experts. As stated in my previous evidence (Greer 2017b), agreement was not reached for important aspects of the worst-case scenario definition.

15. My view is that insufficient caution has been included in the 'worst-case scenario' for the following reasons:

    a. A worst-case scenario was only defined for the far field modelling and the near field modelling remained unchanged. The near field modelling

only considers wave periods between 7 and 11s with the 7s results being used to inform the far field plume source. Using an overly low wave period will significantly underestimate the amount of material leaving the mining area as a passive plume. This area often experiences waves with much higher periods that those used in the nearfield modelling. Therefore, even in the worst-case scenario, the modelling is likely to have underestimated the amount of material released in the passive plume.

b. An upper limit of 2.25% ultra-fines was imposed on material that would be mined. This was applied based on TTRL's assertion that they would not consider mining material with a higher ultra-fines content than this for a 'period of weeks to 1 month'. This infers that material with higher than 2.25% of ultra fine material would be mined for significant periods of time.

c. Consideration should have been given to the level of error associated with the far field modelling. The calibration in the near shore showed this to be approximately a factor of two at the surface and considerably greater (up to a factor of 5 or 10) at the seabed.

d. The laboratory analysis of sediment characteristics was based on only three samples. These were used to calculate the erosion threshold and settling rates used in the near field and far field modelling. The mining area is very large (approximately half the size of Hamilton City) and it would be expected that these values would vary throughout the mining region. In the absence of analysis of other samples, worst case values for the erosion threshold and fall velocities could not be established.

16. The second JWS included agreement from the experts that:

SSC contour plots and median and 99th percentile plots should be generated for shorter periods of time corresponding to the periods of highest release.

However, this analysis was not included in the worst-case scenario reporting and consequently the model results do not show how the periods of higher release affect median and 99th percentile SSC during those periods.

17. Much of Ms Macdonald's evidence refers to comparisons between modelling of the plume and 'background' SSC levels. 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 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. This approach fails to take into account cumulative effects of existing activities on the marine environment nor does it take into account the impact of the activity on long term resilience, maintenance or enhancement of the marine environment.

18. I have reviewed the evidence of John Luick which considers processes relating to flocculation. The issues that he identifies at [14] (a)-(e) highlight other parameters that should also be considered in the sediment transport modelling. The sediment transport model needs to include:

    a. A thorough examination of the models ability to represent vertical velocities in the study area as these will affect the settling rate of modelled sediment. To date this has not been undertaken as part of the study.
    b. Sediment characteristics from a larger sample of sediments in the proposed mining area.
    c. Consideration of the accumulation of suspended fine material in the far-field over long time periods.

19. At [29] of Helen MacDonalds evidence she states:

    The sediment plume modelling, like all models of this sort, has uncertainties and errors. Considerable work has been performed to understand the effect of model uncertainties on the results presented. This includes the worst case scenario modelling in 2017. I have

reviewed all of the plume modelling work in light of the Supreme Courts concerns regarding the effects of sediment, and in my view the sediment plume model used in the initial assessment is of good quality and fit for the purpose it was used for. I consider it provides a reliable basis for others to assess the effects of the sediment plume on the environment.

I disagree that the plume model or the worst case model is fit for purpose for the reasons I have described above. I do not consider that the worst case model favours caution and environmental protection.

20. A recent survey of the Pātea Bank has been undertaken to identify previously unknown reefs (Morrison, 2022). The report states that:

This report demonstrates that subtidal reefs are in fact common on Pātea Bank, with many more awaiting discovery by multibeam sonar mapping.

The results of the plume modelling will require re-examination by ecologists and peer review by independent ecologists. Note however, that it will not be possible for the numerical modellers to provide information for all reefs in the area since many remain undiscovered.

Dougal Greer
06 October 2023

APPENDIX B: Joint Witness Statement 2023 on plume modelling

BEFORE THE ENVIRONMENTAL PROTECTION AUTHORITY

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
AND	
IN THE MATTER	of a Reconsideration of Applications by Trans-Tasman Resources Limited (TTRL)

JOINT STATEMENT OF EXPERTS IN THE FIELDS OF:

SEDIMENT PLUME MODELLING; AND EFFECTS ON BENTHIC ECOLOGY

Dated 23 February 2024

INTRODUCTION

1. Expert caucusing on the topics of sediment plume modelling and effects on benthic ecology took place via videoconference on 23 February 2024.
2. The conference was attended by the following experts:
    a) Dr. Helen Macdonald (TTRL) (HM)
    b) Dr. Alison MacDiarmid (TTRL) (AM)
    c) Dr Michael Dearnaley (TTRL) (MD)
    d) Dr. Greg Barbara (Fishers) (GB)
    e) Mr Joris Jorissen (Fishers) (JJ)
    f) Mr Dougal Greer (KASM and Greenpeace) (DG)
    g) Dr John Luick (KASM and Greenpeace) (JL)
3. Steve Mutch (ChanceryGreen) acted as facilitator.
4. Jessie Richardson (EPA) acted as scribe.

CODE OF CONDUCT

5. The experts confirm that we have read the Environment Court Code of Conduct 2023 and agree to comply with it. We confirm that the issues addressed in this Joint Statement are within our area of expertise, unless stated otherwise.

SCOPE OF STATEMENT

6. In accordance with DMC Minute and Directions 10:
    a) The following Joint Statements have formed the starting point for the caucusing session:
        (i) Joint Statement of Experts in the Field of Sediment Plume Modelling, dated 13 February 2017 ("2017 Sediment Plume Modelling Joint Statement");
        (ii) Joint Statement of Experts in the Field of Sediment Plume Modelling – Setting Worst Case Parameters, dated 23 February 2017 ("2017 Worst Case Parameters Joint Statement");
        (iii) Joint Statement of Experts in the Field of Effects on Benthic Ecology, dated 20 February 2017 ("2017 Benthic Ecology Joint Statement").
    b) We have endeavored to:
        (i) comment on whether there is any new or updating evidence that changes the previous positions; and
        (ii) if so, identify what the evidence is and how it changes the positions.
7. A broad summary of the process adopted is set out in **Appendix A**.

8. In this Joint Statement we report the outcome of our discussions in relation to each issue (below) by reference to points of agreement and disagreement relating to facts, assumptions, uncertainties, and expert opinions. Where we are not agreed in relation to any issue, we have set out the nature and basis of that disagreement.
9. We record that:
    a) for the 2017 caucusing, different experts were involved in the sediment plume caucusing versus the benthic ecology caucusing; and
    b) different experts were involved in the 2017 caucusing and the current 2024 caucusing that is the subject of this Joint Statement;

    although there is some overlap in both cases.

ISSUES FROM 2017 JOINT STATEMENTS; AND CURRENT POSITIONS

A: 2017 SEDIMENT PLUME MODELLING JOINT STATEMENT

10. The following experts participated in caucusing on the 2017 Sediment Plume Modelling Joint Statement:
    a) MD
    b) GB
    c) JJ
    d) HM
    e) JL
    f) DG
11. AM did not participate as the topic is outside her area of expertise.
12. The below headings are reproduced from the 2017 Sediment Plume Modelling Joint Statement.

ISSUE 1: Basis for the Run of Mine (ROM) particle size distribution

13. All participants agree that all paragraphs under issue 1 of the "2017 Sediment Plume Modelling Joint Statement" still accurately record the areas of agreement and disagreement or uncertainty.

ISSUE 2: Source terms for the plume modelling

14. All participants agree with paragraph 21 under issue 2 of the "2017 Sediment Plume Modelling Joint Statement". To be clear, we mean the discharge of mining tailings from the IMV (integrated mining vessel) is the main source of fine sediment.
15. All participants agreed to discuss paragraph 22 under the "2017 Worst Case Parameters Joint Statement".

ISSUE 3: The representation of wave conditions in the near field modelling

16. All participants agree that all paragraphs under issue 3 of the "2017 Sediment Plume Modelling Joint Statement" still accurately record the areas of agreement and disagreement or uncertainty with respect to the 2015 model results.
17. All participants agreed to consider this further under the "2017 Worst Case Parameters Joint Statement".

ISSUE 4: Differences between the NIWA and HR Wallingford interpretation of the laboratory results for the settling velocity tests and implications for source terms used in the sediment plume modelling

18. All participants agree that all paragraphs under issue 4 of the "2017 Sediment Plume Modelling Joint Statement" still accurately record the areas of agreement and disagreement or uncertainty with respect to the 2015 model results.

ISSUE 5: Temporal variability of the sediment plume and its implications for effects

19. All participants agree with all paragraphs under issue 5 of the "2017 Sediment Plume Modelling Joint Statement".
20. All participants note that while the model simulates the key processes and is a useful tool, the discussion on whether the 2015 model results represent worst-case is to be further discussed below.

Attachment to the 2017 Sediment Plume Modelling Joint Statement

21. The participants did not further consider the questions and responses following the signatures of the "2017 Sediment Plume Modelling Joint Statement".

B: 2017 WORST CASE PARAMETERS JOINT STATEMENT

22. The following experts participated in caucusing on the 2017 Worst Case Parameters Joint Statement:
    a) MD
    b) GB
    c) JJ
    d) HM
    e) JL
    f) DG
23. AM did not participate as the topic is outside her area of expertise.
24. The participants confirm the scope of the 2017 Worst Case Parameters Joint Statement, as recorded in paragraphs 4, 5 and 6. Further caucusing on worst

case parameters was directed by the DMC in 2017.

25. The participants agree that that the definition and assessment of a worst case scenario is useful in evaluating potential impacts.
26. The below headings are reproduced from the 2017 Worst Case Parameters Joint Statement.

Run of mine (ROM)

27. The participants agreed:
    a. There will be variability in the ultra fines content in the ROM throughout the mining area.
    b. There are a number of factors influencing uncertainty regarding fines content, including the spacing of the boreholes and the variability of the benthic sediment.
    c. The variability in the benthic sediment may lead to spikes in the ultra fines content of the discharge.

28. DG, JJ, JL and GB agree with paragraphs 8 and 9 of the 2017 Worst Case Parameters Joint Statement.
29. DG, GB, JL and JJ agree there is uncertainty around how the plant will operate through areas of high percentage (greater than 1.8%) of ultra fines.
30. DG, JJ, JL and GB remain unaware of how long TTRL will mine different levels of high percentages of ultra fines (refer to paragraphs 11 and 12 of the 2017 Worst Case Parameters Joint Statement).
31. There is disagreement on the timescale used for the inclusion of temporal variability in the source term for the modelling. JJ, GB and DG are of the opinion that the shorter term variability in ultra fines content could materially affect the plume model results.

Discharge from the IMV / production rate

32. The participants agree on the methodology described in paragraph 15 of the 2017 Worst Case Parameters Joint Statement to determine the fine sediment release rate based on the ultra fines contents of the ROM.
33. Regarding the schematization (as defined in paragraphs 18 – 21 of the 2017 Worst Case Parameters Joint Statement) of the mining within the far field modelling. DG, JL, JJ and GB believe that time variability in the discharge rate of ultra fines content as well as time variability in waves and currents also may materially affect the model output, and therefore it should have been incorporated in the model.
34. DG, JL, JJ and GB do not agree with the adopted ultra fines content outlined in

paragraph 21 of the 2017 Worst Case Parameters Joint Statement as highlighted in the discussion around the **Run of mine (ROM).**

Retention of fines on the seabed

35. All participants agree that the retention of sediment in the pit is dependent on the wave period used in the modelling. Higher wave periods lead to greater resuspension and reduced settling of sediment.
36. DG, GB, JL and JJ understand that the near field modelling used to create the source term for the far field modelling used a wave period of 7 seconds to determine the retention rates in the pit and believe that a wave period of 12 seconds would be more appropriate based on the analysis of the available wave data for the area. This would lead to a considerably larger percentage of the 0.1 mm/s sediment fraction leaving the pit in the form of a plume.

Settling characteristics

37. The participants agree with paragraph 24 in the 2017 Worst Case Parameters Joint Statement.

Time varying source terms

38. Regarding the schematization (as defined in paragraph 25 of the 2017 Worst Case Parameters Joint Statement) of the source in the far field modelling, DG, JL, JJ and GB believe that time variability in the discharge rate of ultra fines content as well as time variability in waves and currents also may materially affect the model output, and therefore it should have been incorporated in the model. Additionally, a higher wave period should have been used as discussed above.

Comparison with the source terms used in the Impact Assessment

39. MD and HM confirm that the source terms described in paragraphs 26 - 28 were used in the 2017 worst case scenario modelling and all other model parameters remain unchanged.
40. DG, JJ, JL and GB disagree that the source terms used in the modelling represent the worst case scenario, as described above.

Other model parameters

41. DG, GB, and JJ maintain their positions in the 2017 Worst Case Parameters Joint Statement, regarding the thresholds for suspension. JL agrees with this also.

Communication of model results

42. MD and HM confirm that the output from the 2017 worst case scenario modelling was used to rerun the optical model.
43. MD and HM confirm that the model results were presented as agreed with the exception of the 99th percentile and median plots for shorter periods. Statistical analysis such as the 99th percentile could not be generated for short time periods as there were not enough data points. Time series at locations of interest which showed how short-term increases relate to the median and 99th percentile were produced.

C: 2017 BENTHIC ECOLOGY JOINT STATEMENT

44. The following experts participated in caucusing on the 2017 Benthic Ecology Joint Statement:
    a) AM
    b) GB
45. The other experts did not participate as the topic is outside their area of expertise.
46. The headings and question/issue references below (e.g. “MJ7”) are *as per* the 2017 Benthic Ecology Joint Statement. The bordered text is reproduced from the 2017 Benthic Ecology Joint Statement.

Recovery timeframes and influence of sedimentation (MJ7, MJ8, AM15, AM16, AM18)

Recovery timeframes and influence of sedimentation		
MJ7, MJ8, AM15, AM16, AM18	AGREED	DISAGREED
Facts	Recovery timeframes are predictions that, pre-development, are necessarily based upon assumptions derived from factual observations made elsewhere. Based upon experts' experience elsewhere, it was agreed that recolonisation of the seabed by biota will occur following iron extraction.	Nil
Assumptions	Based upon experts' experience elsewhere, it was agreed that it could be assumed that: • Regardless of whether full 'recovery' occurs, the suite of species that is established in the benthic community post-mining is likely to fulfil the same ecosystem function as that which is present pre-mining. • As 'larger biota', it could take several years for starfish and coral populations to attain their pre-mining characteristics (noting that it was unclear as to what was meant by 'coral' in the question – no hard or soft corals have been recorded [or are considered likely to occur] in the mining area, though some soft corals are present on nearshore reefs).	There was disagreement over whether or not it could be assumed that 'recovery' would occur within the mining area (i.e. whether benthic communities would become established that are the same as those present pre-disturbance), with the following points of view presented: • A different progression of species may become established due to changes in substrate, therefore there will be no 'recovery' (SM, GB). • Over time the benthic communities will 'recover' as the area will be recolonised from populations nearby and in the plankton and sand movement will progressively alter the surface features such that they will become indistinguishable to those present pre-disturbance (MJ, AM, IB).
	• The recovery of prey species of eagle rays may be affected over a limited area in the immediate vicinity of the mining. • Sediment plumes from mining in adjacent blocks may influence the successional development of the benthic communities in the mined blocks. However, the plumes will be dynamic and their influence will decrease with increasing distance from the site of the actual mining operation.	
Importance	Given the localised spatial area of impact of the mining operation, recovery timeframes are not considered by MJ, AM and IB to be of high importance in assessment of the acceptability of the proposed action from a benthic ecology perspective. SM holds a contrary view.	
Other comments on questions	It was agreed that MJ and AM were conveying the same message with respect to recovery timeframes, albeit using slightly different terminology. It was considered that the knowledge of the reproduction and early life histories of the types of biota that are likely to recolonise the mined area and surrounding impacted areas are sufficiently well known for the purposes of impact assessment.	

47. AM maintains her opinion with regard to the facts, assumptions, importance and other comments on questions.
48. GB maintains his disagreement that final species composition would be the same as pre mining or that the rate of recovery and functional ecosystems would take less than a few years.

Areal extent of effect of light attenuation on primary production (MJ9, AM10)

Effect of light attenuation on primary production		
MJ9, AM10	**AGREED**	**DISAGREED**
Facts	Effects of light attenuation on primary production are predictions that, pre-development, are necessarily based upon assumptions derived from factual observations made elsewhere. Noting that, in this session, benthic (not water column) primary production was being considered; based upon experts' experience elsewhere, it was agreed that:	Nil
	• Nearshore macroalgal communities are sufficiently distant from the mining operation that there is a negligible risk of light attenuation being sufficiently high for them to be affected. • If macroalgae are present on reefs closer than 5 km from the mining area, then primary production may be inhibited at times but there is negligible risk that they would be destroyed due to light attenuation as they have strategies (e.g. photoadaptation, carbon storage, switching to respiration) to cope with reduced light levels, which they would currently experience on a periodic basis due to natural and anthropogenic disturbances.	
Assumptions	It was agreed that, although predictions of impacts were based upon best available information and model outputs, which were in turn based upon various assumptions with respect to input parameters: • The impact assessment was made on the basis of the outputs from several models, of which the Wallingford model was only one. Hence changes in the Wallingford model would not directly translate into changes in predicted carbon flux. • All models have inherent inaccuracies, but the modelling undertaken for this Project took variability in many parameters into account and was done to the highest standard available. • Until monitoring was undertaken during mining operations, it would not be possible to determine the factors by which any of the models may be inaccurate. It is noted that, within the Environmental Monitoring and Management Plan (EMMP), compliance limits have been placed on SSC levels.	Nil
Importance	As effects of light attenuation on benthic primary production would be localised and temporary, it is not considered to be of high importance in assessment of the acceptability of the proposed action.	
Other comments on questions	The terminology 'minor' and 'moderate' is based upon accepted criteria described in reports submitted with TTRL's application.	

49. GB agrees in principle with the statements that the assessment was based on best available data at the time (including reliance on the sediment plume model) however the validity of the worst case sediment plume model is still uncertain and given the discovery of more macroalgal communities in the vicinity of the PPA there would be greater impacts than those predicted.
50. AM maintains her opinion.

Potential for food web effects (MJ10)

Potential for food web effects		
MJ10	**AGREED**	**DISAGREED**
Facts	Based upon experts' experience elsewhere, it was recognised that food webs are highly complex and that effects on benthic fauna would not necessarily translate into measurable food web effects. It was agreed that data collected for the Project demonstrated that benthic fauna within the mining area are also present outside of the zone of potential impact from the Project.	Nil
Assumptions	It was recognised that, with exceptions, higher trophic level species are typically motile and can range over broad areas, so if benthic fauna prey resources were depleted in the vicinity of the mining it could be assumed that they would forage elsewhere in the South Taranaki Bight (STB) or on other sources. It is noted above that the recovery of prey species of eagle rays may be affected over a limited area in the immediate vicinity of the mining.	Nil
Importance	The potential for food web effects is considered by MJ, AM and IB to be sufficiently low that it does not represent an important issue for assessment of the acceptability of the proposed action from a benthic ecology perspective. SM holds a contrary view based on the range of uncertainties and the large spatial scale of potential impact; GB has some uncertainty.	
Other comments on questions	The predictions of the likelihood of food web effects was partly informed by modelling, but more so by an understanding of trophic dynamics and food web interactions in similar environmental settings.	

51. AM and GB agree with the assumptions and facts. AM and GB agree that if there are large reefs close (within 1-2 km near field plume modelling area) to the proposed mining site, there is potential for significant ecological impact.

Subtidal reefs (MJ11, AM7, AM24, AM25, AM26)

Subtidal reefs		
MJ11, AM7, AM24, AM25, AM26	**AGREED**	**DISAGREED**
Facts	The following facts were presented and accepted as true: • The initial distribution of reefs available for use was based upon the DOC reef database which was suspected of including some sand waves. • TTRL surveys and analysis found that some of the areas shown as reefs on the charts were in fact sand waves. • A full multibeam swath mapping survey of the mining area indicated a complete lack of rocky reef inside the area. The multibeam survey data were used as inputs to the bathymetry maps shown in TTRL documents. • Video surveys further inshore located some rocky outcrops (the closest of which was about 5 km from the mining area) but the complete region between the mining area and the coast was not sampled or multibeam mapped. • Submitters have presented evidence that other subtidal reefs exist (inshore of the mining area) that have not been biologically surveyed. • Additional surveys by TTRL were focussed upon nearshore habitats, including reefs, as this is where concerns were raised with respect to sedimentation and light attenuation effects.	Nil
Assumptions	Based upon the following, it is assumed that there is minor risk of significant impact from sedimentation or elevated suspended sediment concentrations (SSC) from the Project to benthic communities on any un-surveyed subtidal reefs: • The locations of the un-surveyed reefs provided by the Submitters. • Time series data extracted from model outputs show that sedimentation rates beyond 2 km, and increases in SSC beyond 8 km, from the mining area are predicted to be low compared with assumed tolerances for benthic biota.	Nil
Importance	The risk of significant impact to benthic communities on any un-surveyed subtidal reefs beyond 8 km is considered by MJ, AM and IB to be sufficiently low (from elevated SSC or sedimentation) that it does not represent an important issue for assessment of the acceptability of the proposed action from a benthic ecology perspective. It is further considered that investigations of the subtidal reefs identified by the submitters is not warranted. SM's view is that the often large model under-estimations at the seabed and the unknowns with regard to un-surveyed reefs in close proximity to the operation means that it is difficult to have certainty about the importance of potential impacts to these benthic communities.	

52. AM and GB agree with the assumptions and facts. AM and GB agree that if there are large reefs close (within 1-2 km near field plume modelling area) to the proposed mining site, there is potential for significant ecological impact.

Basis of updated impact predictions (MJ12, MJ13)

Basis of updated impact predictions		
MJ12, MJ13	**AGREED**	**DISAGREED**
Facts	The following facts were presented and accepted as true: • The updated impact predictions were based upon revised models of sediment dispersion, optical effects and primary production, and upon more detailed analysis of some model outputs and thresholds for different biota from experience and reports on other systems. • No additional information on benthic communities and habitats from field surveys had been gathered in the time between the two TTRL applications. • It was agreed that the benthic surveys were not temporally optimal and were not intended or designed to document seasonal variability of communities. • No functional analysis was undertaken on the stability of habitats, but that the dominant functional groups within the STB are unlikely to change dramatically seasonally due to species such as the dog cockle that form beds that last for many years.	Nil
	• It was agreed the inclusion of additional monitoring sites within the mining area would provide a more robust BACI analysis for determining recovery/ re-colonisation rates within processed areas.	
Assumptions	It was assumed that the revised model outputs, and their more detailed analysis, provided sufficient increased understanding of carbon flow to the benthos, optical effects, etc., that further information on benthic communities would not materially alter the outcome of the impact assessment.	Nil
Importance	The updated impact predictions are considered sufficiently robust that this does not represent an important issue for the purpose of assessment of the acceptability of the proposed action from a benthic ecology perspective. It was considered by MJ, AM and IB that the collection of further information on the benthic communities in or around the mining area was not warranted; GB did not share this view. SM considers that increased understanding of the benthic communities in the mining area and in close proximity (i.e. within 5 km from the operation) would increase the confidence in the predicted impacts.	
Other comments on questions	It was confirmed that the evidence of Shaw Mead had been read.	

53. AM and GB agree that additional survey effort around PPA is necessary to identify sensitive benthic habitats within 2km of the mining area.

Best case or worse case assessed? (MJ14)

Best case or worse case assessed?		
MJ14	**AGREED**	**DISAGREED**
Facts	It was agreed that 'best case' and 'worse case' are subjective terms and no facts could be presented to assist with the resolution of this issue. It was, however, agreed that monitoring would be required to assess the veracity of the modelling outputs.	Nil
Assumptions	Similarly, there were no clear assumptions made with respect to this issue.	MJ and AM considered that the basis of assessment was a 'realistic case' and considered that the potential scenario presented by the submitter was unrealistic. MJ considered that the modelling undertaken was conservative and that impacts were likely to be less than those modelled. GB agreed, provided plume generation fell within the ranges predicted. SM maintained that there was insufficient information upon which to judge whether or not the impact assessment was based upon 'best', 'worse' or 'realistic case' conditions and considered that the impacts were under-predicted (in part due to large under-predictions in the model outputs versus the measured data at the seabed) and there would be the potential for permanent changes in benthos to occur.
Importance	The key issue of importance in assessing the acceptability of the proposed action is whether potential impacts have been adequately assessed for a 'realistic case', rather than whether a 'best case' or 'worse case' has been presented. In the event that the project is approved, it will be highly important that a robust environmental monitoring and management programme be implemented to confirm predictions and mitigate the risk of significant impacts upon benthic communities.	

54. GB clarified his point from 2017, the impact of the plume on the then known extents of sensitive benthic habitats would be minimal provided plume generation fell within the ranges predicted. Given the uncertainties remains around the worst case scenario of the sediment plume model and new information regarding additional sensitive benthic communities (including fish nursery areas). GB disagrees that the modelling is based on best available information.
55. AM maintains her opinion provided the plume generation fell within the ranges predicted.

Location of plume generation (MJ15, AM20)

Location of plume generation		
MJ15, AM20	**AGREED**	**DISAGREED**
Facts	It was agreed that the absence of a mining plan from the latest TTRL document could limit the understanding of potential impacts by some readers.	Nil
	MJ confirmed that a mining plan had been developed and was flexible; it would be progressively refined on the basis of drilling results and was based on single pass mining. This would dictate where within the mining area the activity would be undertaken at any given time. MJ and AM confirmed that different locations and volumes of sediment loading had been taken into account during the assessment. The two locations at which plume generation was assessed represent the physical 'extremes' of the mining operation (i.e. one closest inshore, the other furthest offshore).	
Assumptions	Nil	Nil
Importance	This issue is not of high importance for the assessment of the acceptability of the proposed action as it relates to the planning of mining operations, rather than to the potential impacts arising therefrom. SM noted that the location/planning of the mining operation is important with respect to the impacts on the recolonisation of already worked areas due to the proximity of the continuing operation.	

56. AM and GB agree the facts and assumptions and points raised by SM on the importance of the mining operation in the 2017 Benthic Ecology Joint Statement due to the uncertainty around TTRL planned mining process, timing and schedule across the PPA.

Seasonality and natural disturbance (MJ17, AM17)

Seasonality and natural disturbance		
MJ17, AM17	**AGREED**	**DISAGREED**
Facts	AM presented the following facts with respect to this issue: • The NIWA study was initially intended to provide a snapshot of benthic communities within a single short period of time. • Sampling was spread over a longer timeframe due to weather conditions.	Nil
	• The area over which sampling was undertaken was extended to cover potential disposal sites identified by TTRL.	
Assumptions	Nil	There was disagreement with respect to the following assumption: • MJ, AM and GB are of the view that, given the natural disturbance regime in the STB, the biota present would be adapted to periodic perturbation, which provides insight into their resistance to impact and their capacity to recover from impacts. • SM does not share this view, since the background levels at the proposed mining site have never previously been anywhere near as high as will occur if mining was taking place; the offshore waters will be subject to annual discharge rates that are higher than many of the rivers at the coast.
Importance	This importance of this issue for assessing the acceptability of the proposed action is whether the existing data provide adequate confidence that either the existing communities will recover over time, or that communities of equivalent ecosystem functionality will become established. The general consensus was that information on seasonality would be of interest, but that it is not critical information for assessment purposes.	

57. AM and GB agree with their previous statement on facts, assumptions and importance, but both emphasize the importance of a time series across seasons to determine the rates of species successions and population dynamics of benthic communities before mining takes place.

New species (AM1)

New species		
AM1	**AGREED**	**DISAGREED**
Facts	AM presented the following facts with respect to this issue: • New species were found during the NIWA survey. This was to be expected as the biota of the west coast shelf area of NZ are poorly described due to a paucity of sampling. This also applies broadly to offshore areas around all of NZ. • Most new species were found in the bryozoan beds at the foot of slope, offshore from the mining area. • Those new species that were found within the mining area were also found outside of the mining area; no new species were found exclusively within the mining area.	Nil
Assumptions	From the experts' knowledge of the life histories of similar species, it is assumed that the same species would be found in similar habitats elsewhere in the STB, and more broadly offshore NZ. Hence it is considered there would be negligible risk of the Project leading to extinction of the new species. From an ecotoxicity perspective, it is assumed that the new species would be no more susceptible to toxic effects than similar known species.	Nil
Importance	Expert knowledge indicates that this issue is not of high importance for assessing the acceptability of the proposed action as no species were found exclusively within the mining area or within the area of potential impact.	

58. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Clams (AM2, AM3, AM4, AM5)

Clams		
AM2, AM3, AM4, AM5	**AGREED**	**DISAGREED**
Facts	The key fact with respect to this issue is that surf clams presently exist in waters that are (at least periodically) highly turbid.	Nil
Assumptions	From model outputs, it is assumed that SSC and sedimentation rates would be insufficiently high to pose a risk of significant impact upon the clams or their food sources. From a consideration of the low levels of heavy metals concentrations in the sediments to be mined, and the dilution that would occur between the mining area and the surf clam habitat, it is assumed that there is negligible risk of significant impacts on clams from any heavy metals that may be released into the water column from the mining activity. It is presumed that the reference to the sensitivity of clams to algal blooms refers to toxic algal blooms being generated as a result of the release of nutrients from the mined sediments. Considering the distance between the mining area and the surf clam beaches (e.g. Foxton), and the assumed low levels of nutrients in the sediments to be mined, it is assumed that the operation poses a low risk of triggering algal blooms that could affect the surf clam beaches.	Nil
Importance	The key importance associated with this issue is that monitoring of the mining operation would need to be sufficiently robust to affirm the low levels of SSC and sedimentation in the coastal zone that is shown in the modelling results. Monitoring of heavy metals in solution and particulate form within and beyond the sediment plume will address concerns regarding potential exposure of clams to heavy metals.	
Other comments on questions	Knowledge of the distribution and biology of the surf clams was considered to be sufficient for the purposes of risk assessment. Detailed knowledge of the sensitivity of surf clams to fine sediment, algal blooms and heavy metal concentrations was considered by AM and MJ to be of low importance, given the predicted very low likelihood of the clams being exposed to these stressors as a result of Project operations.	

59. AM and GB maintain agreement with the 2017 facts, assumptions, importance statement and other comments on questions.

Bivalve rubble (AM6)

Bivalve rubble		
AM6	**AGREED**	**DISAGREED**
Facts	The dredge efficiency was maintained by modifying the deployment practice to prevent clogging of the equipment. The species make-up of the bivalve rubble habitats is described in Beaumont et al (2015). The dominant species was the dog cockle.	Nil
Assumptions	Nil	Nil
Importance	Nil	

60. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Cawthron report (AM8)

Cawthron report		
AM8	**AGREED**	**DISAGREED**
Facts	The Cawthron report draws heavily on the NIWA survey reports; the original NIWA data were used for the assessment as the Cawthron report didn't contain data to a sufficient level of detail. Any rare and vulnerable ecosystems and habitats of threatened species identified in the Cawthron report were distant from the mining area.	Nil
Assumptions	Nil	Nil
Importance	Nil	

61. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Applicability of Wellington Harbour experimental outcomes to STB (AM12, AM13)

Applicability of Wellington Harbour experimental outcomes to STB		
AM12, AM13	**AGREED**	**DISAGREED**
Facts	The following facts were presented: • Initial experimental work in the STB found that physical oceanographic disturbance was too great for successful execution of the experiments. • The experimental results were not critical to the assessment of potential impacts from the Project; the risk assessment would be unchanged if the results were not considered.	Nil
Assumptions	Nil	Nil
Importance	The experimental outcomes are of no importance for the assessment of the acceptability of the proposed action.	

62. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Role of iron in re-colonisation (AM12)

Role of iron in re-colonisation		
AM12	**AGREED**	**DISAGREED**
Facts	The following facts were presented: • The Wellington Harbour experiment was not designed to predict re-colonisation; only to look at responses of benthic communities to the reduced iron concentrations in sediments. • Studies conducted elsewhere (e.g. the Pilbara region of Western Australia) have shown that benthic fauna abundance varies more greatly with particle size distribution (PSD) than with iron content. • Within the STB, there was no correlation between fauna abundance and iron content; it was more closely correlated with PSD.	Nil
Assumptions	On the basis of the above facts, it is assumed that re-colonisation rates following mining will be more closely linked to sediment PSD than to sediment iron concentrations.	Nil
Importance	This issue is not of direct importance for the assessment of the acceptability of the proposed action. However, it signifies the need to: • Include iron in the suite of metals to be analysed in sediments and water during the mining operation, though the potentially confounding effect of changes in PSD will also need to be considered during data interpretation. • Increase the number of monitoring locations within the mining area.	

63. AM and GB maintain their previous agreement and note that along with PSD, porosity, and aerobic conditions of the redeposited sediments are likely to be more important than iron concentration in determining the benthic community recolonization.

Effects on species not found (AM14)

Effects on species not found		
AM14	**AGREED**	**DISAGREED**
Facts	The following facts were presented and agreed as true: • It is not possible to census the entire suite of species present in any marine area; hence surveys comprise a sub-sampling of the species present within a study area and some uncommon species may not be collected.	Nil
Assumptions	It is assumed that the fauna sampled by NIWA are representative of the more common species present in the broader region and that effects upon any species not found would be similar to those on fauna that were sampled.	There is disagreement over the assumption that modelling was conservative: • MJ, AM and GB consider that the models upon which the impact assessment is based are conservative and actual impact zones are likely to be no larger than those predicted by the models. • SM disagrees that the modelling is conservative as the model underestimates surface SSC by a factor to 2 (Hadfield) to 5 (as shown in plots), and underestimates SSC at the seabed by often over 10 times.
Importance	This issue is not of direct importance for the assessment of the acceptability of the proposed action. However, it signifies the need to ensure that monitoring of the mining operation is sufficiently robust to affirm the model predictions.	

64. AM retains her opinion in the 2017 statement.
65. GB now disagrees with the 2017 statement because as the predictions rely on the suitability of the worst case parameters used in the SSC model as discussed above in the sediment plume modelling discussion.

Terminology – 'background' vs 'natural' (AM19)

Terminology – 'background' vs 'natural'		
AM19	**AGREED**	**DISAGREED**
Facts	It was agreed that existing SSC and sedimentation in the STB region are affected by anthropogenic inputs to rivers; hence these are considered to be 'background' rather than 'natural' levels.	Nil
Assumptions	Nil	Nil
Importance	The fact that incorrect terminology was used to describe background SSC and sedimentation rates is not of importance for the assessment of the acceptability of the proposed action from a benthic ecology perspective. It has been acknowledged that the use of the term 'natural' was incorrect.	

66. AM and GB do not agree that the use of incorrect terms are of no consequence. As the benthic communities are already experiencing elevated SSC from other impacts above natural conditions it cannot be said with certainty that additional increases in SSC over a sustained (>30 years) would not cause harm to benthic communities. Refer to expert agreement to Tolerance limits from 2017.

Mining area relative biodiversity (AM21)

Mining area relative biodiversity		
AM21	**AGREED**	**DISAGREED**
Facts	A comparison between the biodiversity within the mining area and within similar systems in NZ and elsewhere is presented in MacDiarmid et al (2015).	Nil
Assumptions	Nil	Nil
Importance	As the submitter was not aware of this comparison, this issue is not of importance for the assessment of the acceptability of the proposed action.	

67. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Tolerance limits and sensitivities to suspended sediments (AM22)

Tolerance limits and sensitivities to suspended sediments		
AM22	**AGREED**	**DISAGREED**
Facts	It is not known whether the benthic communities in the STB are at their 'natural stress loads'.	Nil
Assumptions	It is assumed that experimentally derived tolerance limits and sensitivities of similar species to those in the vicinity of the mining operation are appropriate to apply in the risk assessment of the Project.	Nil
Importance	The key importance associated with this issue is that monitoring of the mining operation would need to include monitoring of benthic communities, regardless of whether or not measured SSC levels exceed criteria levels. This will mitigate the risk that criteria levels, set relative to background concentrations, are too high to prevent impacts upon benthic communities (e.g. if they are already at their 'natural stress loads').	

68. AM and GB maintain agreement with the 2017 facts and assumptions.
69. AM and GB now disagree with the 2017 importance statement "This will mitigate the risk that criteria levels, set relative to background concentrations, are too high to prevent impacts upon benthic communities (e.g. if they are already at their 'natural stress loads')". Monitoring is not a mitigation measure unless it is linked to a management plan for remediation and feedback to modify mining practices to include (but not limited to) either stop works, avoid areas where plumes would enter areas of sensitivity or alter mine processes, habitat remediation where practicable.

Long-term effects of elevated nickel and copper on larvae (AM23)

Long-term effects of elevated nickel and copper on larvae		
AM23	**AGREED**	**DISAGREED**
Facts	The tolerance of larval stages of benthic species in the Project area to long-term exposure to elevated nickel and copper concentrations is unknown.	Nil
Assumptions	On the basis of measured nickel and copper concentrations in the sediments to be mined, it is assumed that dilution within the water column will be sufficiently high to alleviate the risk of significant impacts upon larval stages.	Nil
Importance	The key importance associated with this issue is that the Project would benefit from:	

	• Ecotoxicity testing as part of the Baseline Environmental Monitoring Plan (BEMP) to establish tolerance levels (to nickel and copper) of larval stages of benthic species that are similar to species occurring in the vicinity of the Project. • Water and sediment quality monitoring as part of the BEMP and the EEMP, undertaken to determine whether metal concentrations are below the 95% protection level in the ANZECC & ARMCANZ (2000) water quality guidelines at sites further than 1 km from the mining site (to take into account dilution and mixing) and are above background levels. Toxicity monitoring using relevant biota would be undertaken if levels exceed the ANZECC & ARMCANZ guidelines.

70. AM and GB maintain agreement with the 2017 facts, assumptions and importance statement.

Uncertainties

71. AM and GB maintain their agreement with paragraphs 17 -19 of the 2017 Benthic Ecology Joint Statement.

SIGNATURES OF EXPERTS

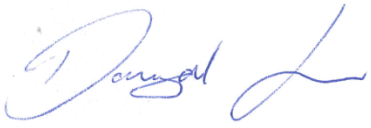
Helen Macdonald (TTRL)

Alison MacDiarmid (TTRL)

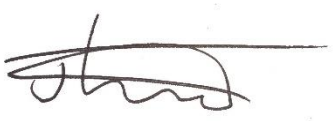
Michael Dearnaley (TTRL)

Greg Barbara (Fishers)

Joris Jorissen (Fishers)



Dougal Greer (KASM and Greenpeace)



John Luick (KASM and Greenpeace)

Appendix A: Overview of process adopted in caucusing

1. Review of previously agreed statements in 2017 Joint Statements:
   (a) Review statement – review experts' reconsideration of 2017 Joint Statement agreements.
   (b) Review any new data relevant to specific statement.
   (c) Confirm agreement with previous statement. If no longer agreement, then add to list of items to consider as unagreed statements.

2. Review of previously unagreed statements in 2017 Joint Statements:
   (a) Review statement.
   (b) Review any new data relevant to specific statement.
   (c) Develop agreement where possible. Note areas of disagreement.

3. Discussion of "other issues".

APPENDIX C: Power point presentation to the DMC 2023

Dougal Greer

Presenting on sediment plume modelling

Sediment Plume Modelling Summary

- The tools presented in the application are broadly appropriate for use in an investigation of this kind.

- I am concerned about the parameterisation of the models and the interpretation of model results.

- I believe that the model results likely underestimate the extent of the plume and plume variability generated by the proposed activities.

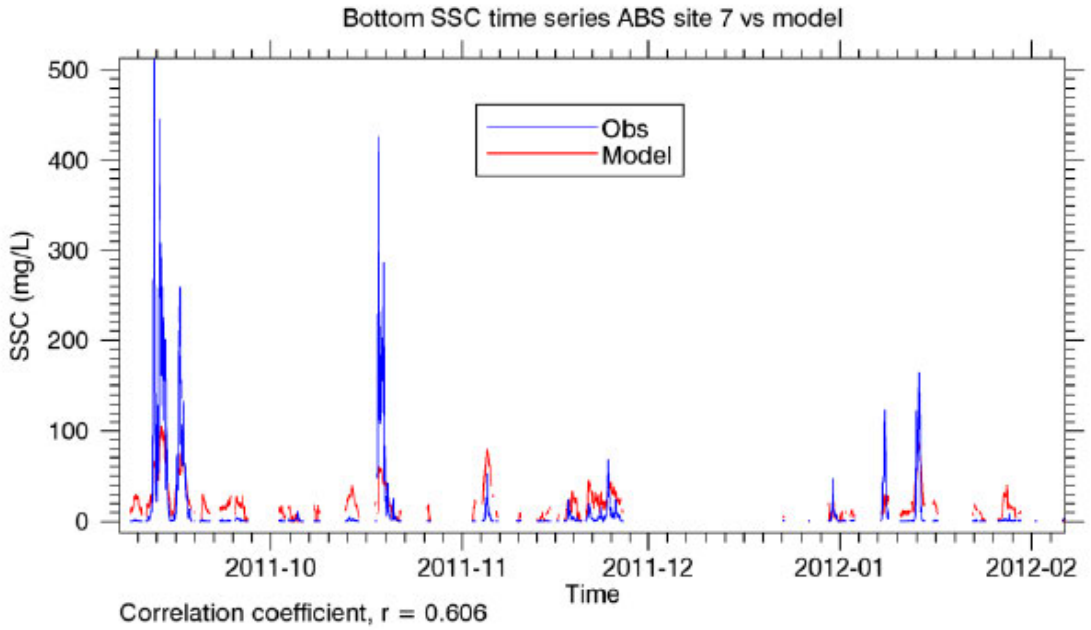
Sediment Plume Modelling: Nearfield Modelling

- Nearfield model: wave characteristics:
  - HRW (2015) used a 7s wave period (local wind chop).
  - A 13s wave period would have been realistic and **would result in a much larger proportion of fines escaping from the pit as a passive plume.**

Sediment Plume Modelling: Calibration

Comparison with measured data shows that the **model underpredicts SSC by 5 – 10 fold in some cases**.

These ‘spikes’ define the high percentile model results.



Sediment Plume Modelling: Fines

- Concentrations of ultra fines that may be mined on short time frames have not been defined. Mining high percentage ultra fines for short periods (one to several days) will lead to spikes in SSC.

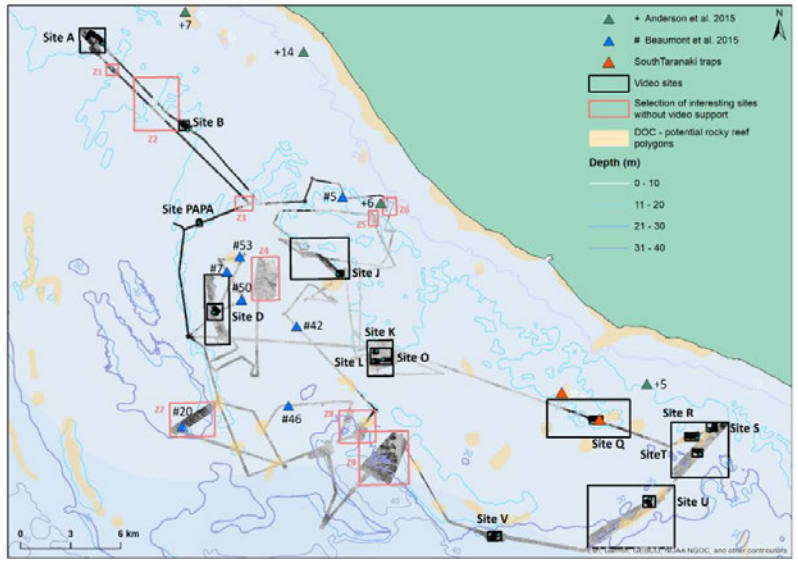
> d. Averaged over any one (1) week period, the extraction of seabed material having a size of <8µm, shall not exceed 1.8% of the total seabed material extracted.

- Experiments to determine the characteristics of fine material (erosion threshold, settling characteristics) were based on 3 samples taken from an area over half the size of Hamilton City.

Sediment Plume Modelling: Habitat

- It appears that new sites of interest have been discovered in the area since the previous application

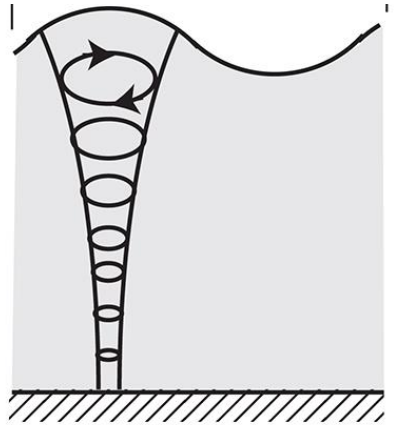
‘This report [Morrison, 2022] demonstrates that subtidal reefs are in fact common on Pātea Bank, with many more awaiting discovery by multibeam sonar mapping’

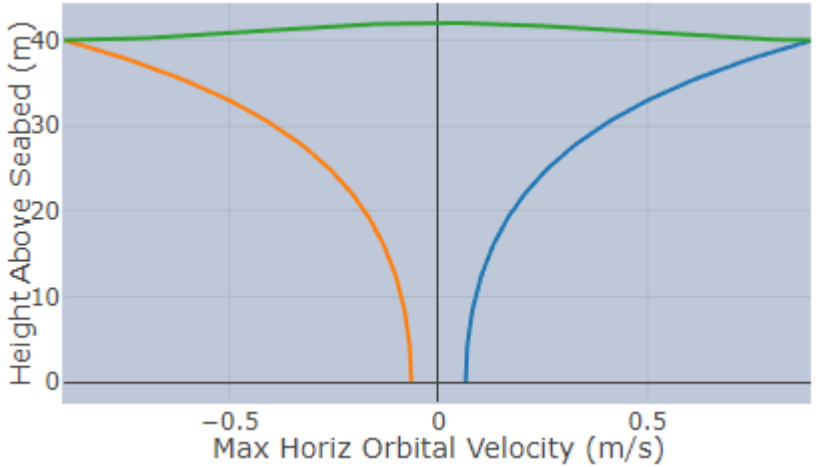


- Finally, many of these points were made clear in the JWS from the previous application and have not been addressed since then.

Nearfield modelling: Wave Characteristics

Wave induced velocities penetrate through the water column and can suspend sediment on the sea floor.

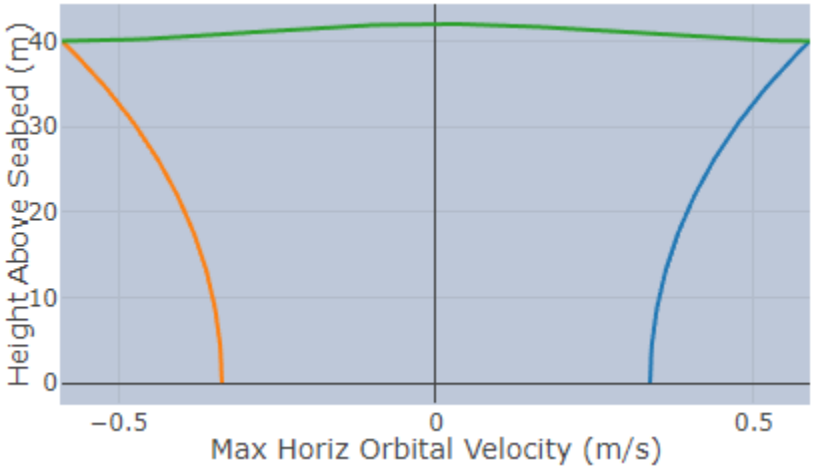




HRW (2015) used Period = 7 s

Choppy waves generated by local winds.

Bed Shear Stress = 0.05 $N.m^{-2}$



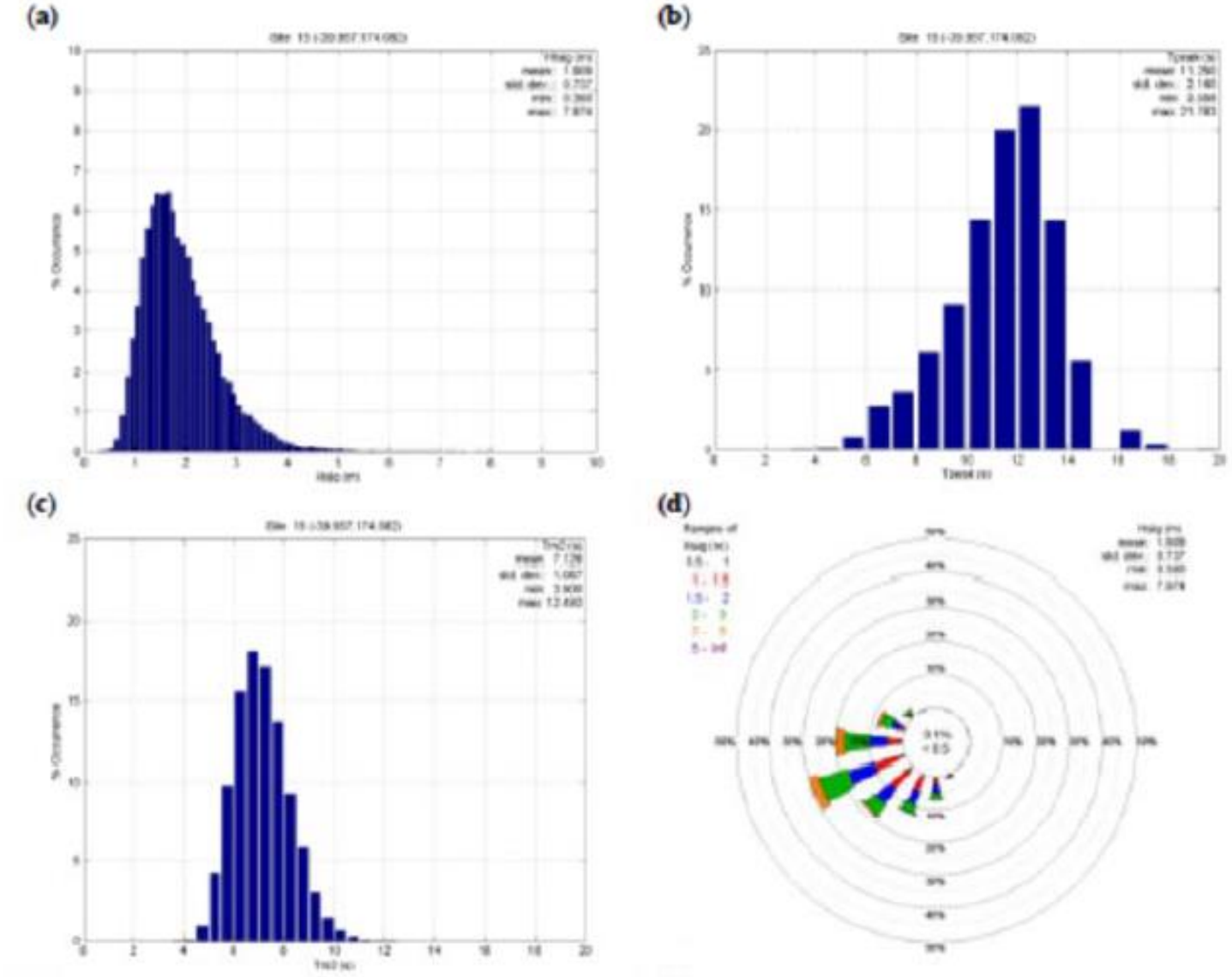
Should have used Period = 13 s

Swell waves generated in the Southern Ocean.

Bed Shear Stress = 0.68 $N.m^{-2}$

A critical threshold for erosion of 0.2 $N.m^{-2}$ was used based on laboratory measurements (HRW, 2015)

Wave Characteristics in South Taranaki



APPENDIX D: Transcript from my presentation to the DMC in 2023

MS POMARE: Kia ora.

CHAIR: Thank you very much, Dr Mitchell. That's been most helpful, and we'll look forward to hearing from you again later in the hearing.

DR MITCHELL: Thank you, sir.

(witness excused)

CHAIR: That brings us to the opening of the case for Greenpeace and KASM. Mr Currie and Ms Haazen, would you like to just explain how you would like to proceed given the limits and time, but bearing in mind that the staff have advised us that they are well on track to secure an extra day in the April tranche of the hearing.

MS HAAZEN: Thank you, sir, for that indication. I think what we'll do, as we indicated earlier, we will call Mr Greer, who's the first of the two sediment plume experts that Greenpeace and KASM will be calling, and then see how far we get and if we if we can get to Mr Cockren, we'll deal with him today as well, and then have our legal submissions and the rest of our experts in the next tranche.

CHAIR: First up.

MS HAAZEN: Yes, first up.

CHAIR: First up, best dressed next time. Yes.

MS HAAZEN: So, if Mr Greer could…

MR GREER: Thank you.

Mr Greer (affirmed)

CHAIR: Good afternoon. Sorry to have your appearance delayed, but it's good that you were able to stay and get underway now. Welcome.

MR GREER: Thanks very much. All right. So, I've got a few --

MS HAAZEN: Sorry, Mr Greer, if you could just-- I'll just take you through confirming your evidence before you start with your PowerPoint. Can you just confirm that your name is Dougal Greer and that you're an oceanographer, and have prepared a statement dated 6th October 2023?

MR GREER: Yes.

MS HAAZEN: And you've also taken part in the joint witness caucusing for the sediment plume modelling and the benthic ecology?

MR GREER: That's correct. Yes.

MS HAAZEN: Thank you. You can now start on your presentation for the DMC.

[2.15 pm]

DOUGAL GREER PRESENTING

MR GREER: Thanks very much. Would you like me to just go through some slides and provide some information? And I guess as before just feel free to stop me where appropriate.

So, in summary, in very broad terms, I think that the tools presented in the application are broadly appropriate for use in an investigation of this kind, but I am concerned about the parameterisation of the models and the interpretation of the model results. I believe that the model results are likely to underestimate the extent of the plume, and the plume variability generated by their proposed activities, so to speak to that, I'd like to go through some of the points of why I've reached those conclusions.

The first of these is probably the most technical, so bear with me, and I can go as deep or not deep as you'd like. Firstly, I'd like to talk about the near-field sediment plume modelling. And now the near-field modelling describes the source term in the far field modelling. I'm sure you're aware of that by now, and it defines how much sediment settles into the pit and how much is released out as a passive plume. So, it's quite important. Now within that, you have to specify as parameters for the modelling the wave height, period, and direction. And these are all important parameters in that modelling.

In the modelling presented by HRW, they used a wave with a period of seven seconds, so I've got a couple of pictures there, that is what a seven second wave period kind of looks like. It's a messed-up wind swell generated by local winds. And I think a much more appropriate wave period to use would have been about 13 seconds, which is what you commonly see on this coast. The reason this place is a surf mecca is because of all that high period swell and the frequency of its occurrence. If the common wave period here were seven seconds, people would not be surfing here. So, I think I can categorically say that the use of the seven second wave period was incorrect in the modelling.

So, why does that matter? Waves as they pass by, they oscillate the water column, and they do that at the surface, and that penetrates down through the water column. If you've ever swum on the beach and swum under the water when there's waves there, you'll have felt yourself

being swayed backwards and forwards. That is those wave orbital velocities penetrating through the water column. Now, a seven second period wave only oscillates the water near the surface, and in 40 metres of water you, don't feel it very much near the seabed. That is to say, it doesn't suspend sediment very much near the seabed, but a 13 second wave is a very different beast. It causes strong oscillations near the seabed and in this situation here, would cause resuspension of sediment. Furthermore, the near-field modelling does not take account of the variability in wave heights, wave periods, and wave directions that are observed through time. I have another slide which goes deeper into this if that's useful if you'd like me to go deeper into it.

So, I guess what I'm saying here is that the use of a more realistic 13 second wave would lead to considerably larger amounts of fine material leaving the pit and therefore more material being released in the far field modelling.

QUESTIONS

DR DE LUCA: Mr Greer, here you got data that shows how often there are 13 second waves compared to seven second waves?

MR GREER: I do. It's actually at the very end of this. I thought I'd put it there just in case it was useful, so I'll skip to the very end if that's useful.

DR DE LUCA: Okay, thank you.

MR GREER: It's actually it's taken from Dr Dearnaley's -- oh hold on. Oh no. I've messed it up.

DR DE LUCA: You're gone too far.

MR GREER: It's actually taken from something that Dr Dearnaley put in. There we go. I don't think you'll actually be able to see the writing very well. I understand where they got the seven second number from. Without wanting to go too deep into it, waves happen in a spectrum. You get lots of different frequencies happening at the same time and we have what we call summary statistics. So, you say that there is the mean wave period, but what we more commonly refer to is the peak wave period, and that's really what you measure the common wave period as. In the top right there -- I'm sorry you can't see the axes -- that shows the peak wave period, and the highest of those peaks happens around between 13 and 14 seconds. Now, what they did is they relied on the mean wave period and came up with -- which is the bottom left graph -- and the peak of that comes in at seven seconds. So, that was the error that was made in the modelling. So, yes, approximately the mean wave period that you would get is 13 seconds. You commonly get wave periods up to 18 seconds, you see sometimes lower wave periods as

well, but looking at the peak wave period, a seven second period will happen maybe sort of 10 per cent of the time. So, not very often.

[2.20 pm]

DR DE LUCA: So, Dr Dearnaley used the mean wave period in you've used the peak wave.

MR GREER: Used the peak. And when you look at the model, for example, they used the Telemac(?) wave model that takes as an input the peak wave period. It's generally appropriate to use the peak wave period. It's much more common to use that to define the waves that you observe. Yes, to look at a seven second period in this area, in this context, makes no sense.

DR DE LUCA: Thank you. Okay.

MR GREER: So, jump back.

DR DE LUCA: You can go back. Thanks very much.

CHAIR: How do you recommend we decide between the two options?

MR GREER: Which wave period that you'd use?

CHAIR: Yes.

MR GREER: Like how or why, do you mean?

CHAIR: Yes.

MR GREER: I think we can agree that 13-second wave energy is present in the area. We also agree that that's just what people commonly use. The seven-second wave energy is not relevant to this because it just oscillates near the surface. Now, if those graphs at least demonstrate one thing, it's that there is 7-second wave energy and 13-second wave energy, and everything in between, present at the same time.

I'll tell you the problem with using a mean. You can sometimes have two swells at the same time. I don't want to drag you too much into the weeds, but you can have a situation where you get a swell coming from the Southern Ocean. You get that all the time here. It comes from underneath Australia, so you get a peak of wave period at 13 seconds. Then locally there's some wind as well and that generates -- it's windy around here, right, so that generates wind swell that might be down at five seconds. So if you can imagine the kind of frequency or the period, wave period along this access and energy here. You've got two peaks, one of the local swell, one for the far-off swell. If you look at the mean

you get a number of seven seconds, which is between those two peaks. It's not particularly meaningful, it's neither of them. Whereas what we generally look at is which is the biggest peak. That's the main wave energy in the area. That's just standard practice. If you look at any kind of wave forecast, you would always see it referring to the peak wave period. If you look at any of the boating or the surfing forecasts, it's what you kind of observe when you're out there.

Similarly with wave height, we use significant wave height, and that is the limit above which there are -- it's like the 66th percentile of the waves, essentially. It relates to what you see when you look out at the ocean, and it's the same thing with the wave period. You might have a mean of seven seconds but -- does that clarify things at all?

CHAIR: It doesn't tell me what you think we should do and why. Change the input into the model?

MR GREER: Yes, absolutely. I think it used the wrong input. I pointed that tout in 2017 in my evidence and in the joint witness statement. As I say, I really think this is categorically a mistake and the modelling hasn't been updated since then.

DR BYROM: So do you think the model should be rerun with the 13 seconds?

MR GREER: Yes, it should be run with 13 seconds. I also think that, given that we're almost ten years past that point, I think that the model should be run with a selection of different wave heights and periods, reflective of the variability that we see. Part of the reason for that is that when you look at times when you have 16-second wave periods, for example, nearly all of the material will be lost from the pit, I imagine. That's also the same time when none of the material will be settling nearby, so it's important that those things happen coincidently.

There are other things in this modelling too where they've used just a couple of conditions to look at the near-field situation. Again not wating to drag you too much in the weeds, they looked at the current being at right angles to the waves. That minimises the shear stress that's there. That's what raises the sediment off the seafloor. When they're mot aligned, it raises the amount of sediment that's suspended, and that happens. All of those circumstances I think could have been explored more thoroughly and now, ten years later, with more computing power, it's easier to do that.

DR BYROM: Just in relation to that as well, one of the things that came up yesterday was the relative importance in the models of -- or rather the relative importance overall, I suppose, of waves versus underwater currents. I just wonder if you could comment on that, because I believe the answer yesterday was that the currents, the deep ocean -- not deep ocean, but

the underwater currents, are more important in terms of the predictions, the outputs from the model, than this wave fluctuation that you're talking about.

[2.25 pm]

MR GREER: Yes, I would disagree with that. As a broad statement without having to pull out a whole textbook - and this is a broad statement - you can kind of say that waves suspend sediment, currents move the sediment. Because the waves are just moving backwards and forwards over a short distance, they raise the sediment off the seabed, but -- they cause quite violent disturbances on the seabed which raises the sediment up. But they rely on more like tidal currents or oceanic currents to move them to another place. That's the movement that you see towards the shore. That's your D'Urville current.

Yes, the currents do have an effect on raising sediment off the seabed but not as much as the waves. If you had a 2-metre waves with 13 seconds -- do you mind if I just talk to this slide a little bit? This is similar stuff. You see in the very far left is an image showing the oscillation of the waves. The top picture there shows a seven-second wave, and you can see how the orbital velocities are attenuated towards the seafloor. So close to the seafloor they're quite small, whereas in the bottom picture, a 13-second wave, they're still very big at the seafloor.

Now, they came up with - you see the bottom line - a critical threshold for erosion of 0.2 newton metres squared. So the shear stress is the violence on the seafloor. When that number is above 0.2, then you're getting all that fine material eroded up. So for their 2-metre, 7-second wave, you get a bed shear stress of 0.05, which basically means that it's not being suspended. With the 13-second wave it's being completely suspended.

To bring that back to the currents, that means that, yes, they used a strongish current. But in reality, when you get tidal oscillations - so they go to that speed, then they come back and stop, then they go the opposite direction - during that process, when the currents get weaker, the sediment is still in suspension. So when the tidal current speeds back up again, it's going to take the sediment and move it on.

So I disagree with Dr Dearnaley about that. The waves are really important for keeping the sediment in suspension so that when the currents do increase in speed, they can carry the sediment away. Bear in mind an event with 2-metre wave with a 13-second period could go on for days, and they frequently do. They come and go over the space of sort of four days, five days.

CHAIR: When the sedimentary plume modelling experts were caucusing, did the concept of putting your 13-second parameter and running the model on that basis come up?

MR GREER: I don't know whether it was discussed to be redone, it was certainly my recommendation that that at least should be done.

CHAIR: No, no, but did you ask him to do that? And if not, why not?

MR GREER: So we're talking about the caucusing now or in 2017?

CHAIR: No, now.

(audio cuts out 2:28:25 - 2:28:50)

MR GREER: -- sort of weeks, months to get that done and processed, something like that. They're reasonably long projects, sometimes, these things. As you'll see as I go on, I think there's other things that need to be updated in the modelling, which would require a longer timeframe as well.

CHAIR: All right, so the best that you can do is speculate on what the effects of using a 13-second --

MR GREER: There's some speculation but I think I can say certain things with some certainty. Considerably more of the fines will leave the pit.

CHAIR: Thank you.

MR GREER: Now, I'll do a bit more jumping around here. Okay, so moving on to the model calibration, the far-field model was calibrated by comparing model output with measured data at specific locations. The model performance was variable but at times it showed that the model underpredicted the measure of suspended sediment by five or ten times.

[2.30 pm]

These were usually during large increases in the observed SSC, suspended sediment concentration. I think you've heard that acronym enough. These spikes in SSC are what defined the higher percentile estimates. So when you see those 99th percentile plots, they're really summarising those peaks. It's not quite the maximum but you're looking at those larger values. If the model is missing those peaks, then it reduces your confidence in those 99th-percentile results.

DR DE LUCA: So there are five spikes where the observed is quite a lot higher than the modelled?

MR GREER: Yes, and that's over a period of, say, four months, I guess, in this particular one here.

DR DE LUCA: Okay.

MR GREER: Then in terms of model calibration and model confidence, I would say there's been a lot of talk about the 3-kilometre zone around moving the plume. I'll just highlight that Dr Dearnaley points out that within approximately 3 kilometres of the plume the bulk dry density, which is a measure of the density of the material, can be poorly represented by ROMS, the far-field model. Consequently, the sedimentation rates should be increased by a factor of five in this region.

This effect will not end abruptly at the 3-kilometre boundary. I don't know exactly how far it will go but it's unclear how much sedimentation rates should be increased beyond this point, but I just wanted to highlight that, that it's something that ecologists should possibly be sentient of.

Another thing I would say about the calibration is within the conditions there is talk of the operational model being within 10 per cent of the measured signal 95 per cent of the time. Now, if that is possible - that's certainly not what's shown in these calibrations - but if that is possible now, if they're confident that they can do that, I'm not sure why that level of scrutiny and that level of accuracy isn't demanded of the hindcasted model that's been used for this.

DR DE LUCA: Are these peaks that you're showing us where representative of the whole time series?

MR GREER: This is the time series that they present. This is the data that they had, and they compared with. If there was a longer measured period, then I guess you could have a wider view.

Should I carry on? I would highlight as well that when considering this kind of accuracy, there's the pre-commencement monitoring. If those two years of data were available, they would be here to be able to quantify that a little bit better.

Sorry, I'm going to go back actually. Just relating to the results, the 12-hour averages of the model output, that is -- the modelling is -- there's a time step within the model and the model creates output. Well, really it might be every second or every five seconds or something, but you choose how often to output the model to disk. Now, for this model, the output was created as 12-hour averages, and I think I've highlighted before that the spikes are quite important for defining the 95th percentile, and likewise with the near-field modelling any variability is important for creating those spikes. Now, in some of the calibrations

you see spikiness in the measured data, and it's attributed to tidal fluctuations. So, you get these spikes over those short term - kind of 6 hours – and that's attributed to tides. By doing 12-hour averages, you're smoothing those peaks out, so you're doing further smoothing of the model output, which again will reduce those 99th percentile estimations.

So, the reason, as I understand it, for putting out 12-hour averages for the model was that back then it was for disk space. Now, changes in disk space have changed a lot since then and for context, I've just completed a project where I ran a model for 20 years and output hourly data for that entire period. That was for a model domain that was much higher resolution than this, and that's done quite routinely now. So, I kind of think that if it had been done now, hourly data probably wouldn't have been such a problem. To that point, when you look at large developments in the ocean, let's say windfarms for example, they routinely now ask for 20 years of simulations and you can understand why, right? There's El Niño and La Niña fluctuations, so how do these -- how would the results change over different time scales and under different long-term conditions.

[2.35 pm]

DR BYROM: May I just ask a point of clarification on that, though? My understanding of why those model runs are shorter is because you want to understand the relatively short-term dynamics of where the plume will go in that 180-day period, or whatever it was. So, running a 20-year model in that instance wouldn't be very useful.

MR GREER: I think it would be. I think you'd see interannual variability.

DR BYROM: Right.

MR GREER: So, during El Niño and La Niña years I think you'd say, "Oh, actually in El Niño conditions it goes more up the coast or down the coast" or this kind of thing.

DR BYROM: Thank you.

MR GREER: Shall I crack on? What have I done?

DR BYROM: Other way.

MR GREER: So, I've got myself completely lost. There we are. So, where are we up to now? So, we understand that the content of fines that will be released is not to exceed 1.8 per cent over a 48-hour period. There was a point of concern in the joint witness group of what would happen if they came across higher percentages of fines over a shorter period, let's

say for a day -- let's say it was a day preceding another day of large swells, so they know that tomorrow they're not going to be operating, but there's going through some high percentage of fines. We don't know a lot about what they won't do, but would they just plough through a lens of 10 per cent fines? Maybe, maybe not. That again would cause a spike in the data, but I think we felt in the joint witness group that we just weren't really equipped to answer those questions. We didn't really know what the limits were of what they would do.

As I say there, the experiments to determine the characteristics of the fine material, so that's things like erosion, threshold and settling characteristics, were based on only three samples as you are aware, and I think it's just worth putting into context the scale of the area that we're looking at here. It's very easy to lose sight of that when it's out in the marine environment without landmarks. It's over half the size of Hamilton city and I think if I was to take three samples of an area like that to characterise the sediment of -- granted it's a terrestrial area, but I think you would probably think that that wasn't enough to characterise the sediment throughout that area.

CHAIR: So, is your criticism there that only three of the 10 were used?

MR GREER: Yeah.

CHAIR: Because there were 10 weren't there?

MR GREER: There were 10, but even 10 would be very few for an area this large -- of this size. You would expect over that kind of an area quite a lot of variability.

CHAIR: Dr Dearnaley, you would have heard, said that the characteristics of the three samples were essentially the same, or similar.

MR GREER: Similar, yeah.

CHAIR: Yes.

MR GREER: Yes, and that's fair on those three samples, but that may not be the case throughout so I don't think we can be confident that that is a description of the entire area, would be my concern.

DR DE LUCA: So, would that have been grain size analysis that they did?

MR GREER: They did more than that. They did a lot of flocculation tests. I think he presented some of it where there were tubes and you put in sediment and you see how it flocculates and how fast those flocs fall, so there was a lot of that kind of work.

DR DE LUCA: Okay.

MR GREER: Yes.

DR DE LUCA: Cool. Thank you.

MR GREER: So, relating to the new areas that have been found and presented in Morrison 2022. As an oceanographer and a modeller, I am often asked to provide data to ecologists from models, and my understanding is that time series were extracted at areas of interest. Since the modelling was undertaken there have been many more sites discovered, and as pointed out here, there are many more awaiting discovery as well. Now, from projects I've worked on – and I've worked on quite a few of these types of projects – I don't think I've ever had it where you do the modelling, look for consent and then look for new areas of interest. That to me is very much backwards and I find it quite an unusual approach to putting in an application.

DR DE LUCA: Sorry, so did Morrison find these reefs and then he suggests that you do multibeam sonar mapping on them? So, they have been identified, but he wants to multibeam map them?

[2.40 pm]

MR GREER: Some have been found and they were presented in the work of Morrison --

DR DE LUCA: Yes.

MR GREER: -- and as he makes a suggestion there that there are many more awaiting discovery.

DR DE LUCA: How does he know that?

MR GREER: Because in the places where they looked, they found them quite easily, so he imagined that there are probably more out there.

DR DE LUCA: Okay.

MR GREER: But we don't know.

DR DE LUCA: So, he doesn't know either.

MR GREER: He doesn't know either, no but they're kind of saying you don't have to look very hard to find them, so there's probably more out there.

DR DE LUCA: Okay.

MR GREER: Now, I might have got my slides jumbled up in my attempt to -- my slides at the end -- so I have a few more points that I'd like to make. Throughout the modelling and the reporting there are references to background and natural background suspended sediment, so in a lot of the results there's a comparison of the background versus the plume, right? And the reality is that that background is a combination of natural SSC as well as anthropogenic influences, which are considerable in this area. So, the anthropogenic effects mainly take the form of sediment added to the river network due to current land use practices.

Comparing the model with the modelled plume failed to provide a proper treatment of the cumulative effects of anthropogenic influences and I could point to -- I was just trying to think about this in terms of best practice, there was a project that I was involved with in 2019 in Long Bay, north of Auckland. It was a housing development, reasonably sizeable but small compared to this. In that situation, there were concerns about sediment entering the marine environment. The approach that was taken was to identify all of the industries in the area and estimate what their contribution was to the rivers. They then considered what might happen in the future with those businesses. They considered the effects of the development itself and they also considered climate change and they ran a bunch of climate change scenarios.

Now, the modelling that we're looking at here is 10 years old. Climate change investigations happened back then (inaudible) but now they're standard. You rarely do a project without putting in a line item for a climate change scenario as well and I just note that consideration of anthropogenic effects and the cumulative effects of climate change have not been considered in this modelling. Sorry, just give me two seconds, I'll find myself again.

CHAIR: What would you predict would show up if you took climate change considerations into account?

MR GREER: There are things like changes to storminess, so increases in wave height are something that is sometimes predicted. I am not sure for this area. You have to look and do a literature review on what's predicted for currents. For example, in the North Atlantic, which is a place of concern to me, you've got things like the Gulf Stream, there's concerns that that's shutting down, so changes to oceanic currents. I don't know what changes are predicted for the D'Urville current or around there, but there may be some changes and whether you can model them directly, but you can at least put them in context.

So, yeah, just a couple of extra points which have come to me over the -- while we've been watching all of these presentations. One is Dr

MacDiarmid brought up about -- or it was brought up to her about the fate of the sediment of the mounds that would be generated. I'm not aware of any long-term model runs that have investigated what will be the fate of those, and I don't necessarily agree that they will just go back to the way they were. If the fines have been removed, they may be well consolidated. We don't quite know how they will return to their natural form or not.

I noticed that I've concentrated a lot of my work here on the modelling work, but obviously you have, commendably focused a lot on the conditions as well. And I wanted to just briefly talk to that. I have worked on previous projects of this type, looking at things like say dredging for example, there are obvious parallels there.

[2.45 pm]

And I would say that in those applications there is normally a report, which details the methodology and the justification for the trigger value methodology. And it's often its own separate stream. So, just as we have a stream talking about the plume modelling or talking about the benthic ecology, there is a physical report and a decent report which specifies why the trigger values have been chosen, what areas, how they've been defined so that they take into account any ecological receptors. And I just noticed that that report, as far as I'm aware, and correct me if I'm missing something, I haven't seen it as part of this application. I mean I guess it's addressed as much as possible in the conditions document, which I've been through to some degree. I would note schedule 3 in particular, I'd draw your attention to that. There's parts of that which seem to me very ambiguous in their wording.

CHAIR: Just pause, please, while we have a quick look.

MR GREER: Thank you.

CHAIR: All right. Do you want to explain which parts you're concerned about?

MR GREER: Well, looking at paragraph 3, for example, there's -

CHAIR: Starting, "If the actual"?

MR GREER: So:

"If the actual suspended sediment concentration values do not fall within 10 per cent of the model values listed in schedules 2 for 95 per cent of the time, within each of the six-month review period."

Now with that there's reference to schedule 2, which is above. Now schedule 2 lists eight numbers for each location and those are

percentiles. And I'm not sure if it's how the measured and modelled values are to be compared with one another, and how that relates to schedule 2. I'm just unclear about what it means. This could be me misinterpreting it, but I just don't think it's written very clearly:

"The model will be revised using the actual data to update the compliance limit values."

So the limit values in schedule 2 are to be updated using the measured data I presume. Now with that in mind, as I said, I would imagine that those percentiles would change quite a lot year on year. As I say, El Niño, La Niña – there'd be quite a lot of variability there. I don't think you land on a static value.

So, yes, I feel like, rather than going through a sort of a full document describing the trigger values and the rationale for coming up with them, it's here in the conditions and it's a little bit vague and so I feel like there's a step in the application which is missing. And if you look at, let's say, dredging applications, you would pretty much always have a separate document which relates to trigger values and how they come up with them and why they satisfy people's concerns.

Should I move on? Where is that? Yes. So really my final closing point is that many of these points were made clear in the JWS and in the previous application as well, and they haven't been addressed since then. So that's a list of basically my concerns around the modelling. I'm sorry I got myself a bit jumbled with my slide order, so apologies for that.

CHAIR: Just reverting back to your comment about the differences in wave data and you said that running the model again would take or could take weeks, is that right?

MR GREER: I guess so. I didn't run those specific models. They might be quite quick now because time has passed, and they might be faster to run. But I actually think there's some bigger wholesale changes that need to be made to the modelling anyway to bring it up to date. For example, running for a longer period of time anyway.

CHAIR: What sort of cost is involved in running a model like that?

MR GREER: It's computer time. So it's tying up a computer, and maybe in NIWA it might be using their supercomputer, so that might be there's a cost associated with that. For running it for 20 years, I mean there would be a cost of person power as well. You know, there's several weeks of people's time in setting up the models and post processing the results and, if my recommendations were to be taken through to model more

like 20 years, they'd have to go off and get the boundary data and there'd be a good bit of work in setting that up.

CHAIR: Yes. Well, let's think of what's possible, given that we don't have unlimited time for a hearing.

MR GREER: Yes, true.

[2.50 pm]

CHAIR: But you could change the numbers, the 7 and 13 numbers.

MR GREER: Yes, yes.

CHAIR: And run it.

MR GREER: Yes.

CHAIR: Yes. And you predict that would make a significant difference or moderate?

MR GREER: To the fines leaving the pit, yes.

CHAIR: Yes.

MR GREER: Yes, I think so.

CHAIR: What other known and available information would you put into the model as additional data that you think might change the outcome?

MR GREER: I would be interested to look at hourly output. Let's see, I'd have to go back through my slides to be precise about it, I think longer model runs would be really -- I know that that's in the available time, but it's something that I would be quite concerned about is interannual variability. I think looking at climate change, predicted climate change effects. How would you put the modelling into context? And yes, that's, yes, another point is the variability in in ultra-fines, what would happen if you go through a kind of a bigger lens. I mean definition of how ultra-fines will be dealt with is something that I think is ill defined. There is something about how much will be mined over a 48-hour period, you know, releasing 1.8 per cent of ultra-fines. But I think that, you know, what happens over a day.

CHAIR: Thank you.

MR GREER: Thanks.

DR BYROM: Kia ora, Mr Greer. Thank you. I've got really just a couple of questions for you. One of the questions that I have is you've listed a number of concerns that you've got with the models, all of which have been very interesting to listen to. Thank you. And by the way, the jumping around wasn't a problem at all, you made some very interesting points for us. Of the things you've listed, for example, waves versus the percentage of fines, ultra-fines, some of the longer model runs in order to pick up climate change effects, which of those are a top priority for us to understand as a Decision-making Committee in order to be assured of no material harm off-site, I suppose?

MR GREER: Off-site?

DR BYROM: Off-site as in the coastal marine area, for example, away from the immediate mining site.

MR GREER: Away from the site, right, there's a few listed there, isn't there?

DR BYROM: What's your top pick for what we must look at further?

MR GREER: I think cumulative effects are important. That's something that is, if you don't understand that, you're comparing the plume against a really impacted area. The land use means that there's a lot of sediment in the rivers and it makes the plume look very small, because the area is already impacted. And it kind of sends a message that if an area is impacted then it's okay to impact it further. So I think that's something to understand, how might land use change, how might the background change in the future, would be interesting. I think looking at the wave period effect would be of interest as well. Longer model runs would be very useful. Which is most important, I realise I'm just kind of listing them again, but I know you're trying to say which ones, I just --

DR BYROM: I understand you've got a number of concerns, and you've listed them really clearly. What I'm trying to get to, I suppose, is, as a Decision-making Committee, we need to make an assessment of potential material harm, in other words the impacts that might occur away from the mining site. So what we really need to know is some of the things you've alluded to, which is these high peaks in suspended concentrations in areas that could potentially have a really high impact. And I'm just wondering what would help us get to that point.

MR GREER: Yes. I suppose it feels unhelpful to say that I feel like there -- there's quite a lot of points and that I feel like in the time that's passed since the last application they could have been addressed. And really, I feel like the modelling kind of isn't up to best standard, best practice, at the moment to be perfectly honest. And I hope that's not too unhelpful, but I feel like because there's quite a list of issues, I feel like they need to go back and address some of those.

DR BYROM: Okay. Thank you.

MR GREER: Quite a few of them, to really bring the whole thing up to -- this is a really big project, it's, you know, when we talk about dredging projects as a parallel, I mean they're dwarfed by the size of this.

[2.55 pm]

So you really think that the modelling should be up to scratch and with the Ts dotted -- Ts crossed.

DR BYROM: Okay. Thank you. And my other question to you is, and I apologise, I should know this, but have you published the criticisms that you've alluded to here? And I realise it's quite difficult to publish criticisms of other people's publications or reports, but I am just interested and maybe it's in the mountain of stuff we've already received, but if you can point me to something that would be very helpful.

MR GREER: Have I brought these points up before?

DR BYROM: No. Have you published it anywhere in the scientific literature?

MR GREER: Criticism of this specific work?

DR BYROM: Yes.

MR GREER: No, it's all been just confined to the hearings and, yes, I haven't put it out anywhere else.

DR BYROM: Okay.

MR GREER: You mean also published in terms of peer-reviewed?

DR BYROM: Yes.

MR GREER: No, no, I haven't. It's not really a publishable result. It's just --

DR BYROM: Yes, I understand. I understand that. I was just clearly, you know, we've got to rely on the highest --

MR GREER: I understand. I understand your motivation there, yes.

DR BYROM: -- standard of evidence. Thank you.

DR DE LUCA: You mentioned the riverine inputs. They were in the original model done by Dearnaley.

MR GREER: Yes, by Dr MacDonald.

DR DE LUCA: Sorry, by -- yes. So what was your concern with them, that they weren't part of the model?

MR GREER: No, that they're present in the modelling, but that they contain both natural and anthropogenic impacts, both mushed in together. And my concern is that they haven't been separated out, so you can't see what the cumulative impact of the mining is on top of other anthropogenic impacts.

DR DE LUCA: But in terms of the background, which is anthropogenic and natural sediments, that's the background.

MR GREER: Yes.

DR DE LUCA: So the mining on top of that is a cumulative effect?

MR GREER: It is a cumulative effect.

DR DE LUCA: Whether you separate the natural and anthropogenic?

MR GREER: True, but there is this thing that happens with applications and it kind of happens quite often that you see this kind of justification of an activity because an area is already highly impacted. When you look at all those images in the reporting, the fact that the area is highly impacted and you're not separating out how much of this is anthropogenic, yes, it does, it's cumulative in that it is adding up everything that's happening, but you're not kind of saying, well, if we actually manage to tidy things up here, or if this gets worse, what's the future of land use in this area?

DR BYROM: Yes, I don't get the relevance. I think the background is the background, whether it's anthropogenic or natural. I think that's the background and then the mining would be on top of that.

MR GREER: I think you're correct to say that it is the total cumulative amount, that's correct. But I think it's important to distinguish how much of the background is natural, and that's a that's a contentious word in itself in a way, and how much of it is anthropogenic, to understand how much are you further impacting an area. You know, if we were to improve land use practices around here, how much would -- yes, I think they're quite different things, natural and anthropogenic.

DR DE LUCA: And future anthropogenic effects and land use change, that's crystal ball gazing, isn't it?

MR GREER: Future?

DR DE LUCA: Yes, that's crystal ball gazing.

MR GREER: I guess there's an element of that. It's difficult to do, yes.

DR DE LUCA: Yes, okay. That's all for me.

CHAIR: And, Ms Lovell, do you have any questions of Mr Greer?

MS LOVELL: No, I don't, thank you.

CHAIR: Well, it remains for me to thank you very much -- sorry.

DR BYROM: Sorry, I do have one more question now. Are you familiar with the Berthot and Petch analysis that was asked for in 2017 in order to try and get to the heart of some of the issues that you've raised, not you specifically, but some of the previous criticisms of this modelling?

MR GREER: Was that an independent review? I think you referred to it yesterday.

DR BYROM: Yes. Yes, we did, yes.

MR GREER: If I was familiar with it then, I haven't seen it on this round, so I apologise if I'm not totally familiar with it.

DR BYROM: So you can't comment any further on whether that work would be useful for us to have a look at and whether further work would be useful for this DMC to get an updated view. Can I ask you, would you mind having a look at that Berthot and Petch report and giving your opinion, your expert opinion, on that after the hearing, if that's okay?

MR GREER: No, not a problem, okay, sure thing.

DR BYROM: It is available, I believe it's actually publicly available on the website.

MR GREER: Great, I'll have a look.

CHAIR: It's prepared by a company called GHD.

[3.00 pm]

MR GREER: I'm familiar with that.

CHAIR: A consulting company. And I think Dr Berthot and Dr Petch were the authors.

MR GREER: Yes.

CHAIR: So it is available, and it raises issues around assumptions and limitations of modelling.

MR GREER: Yes.

CHAIR: And make some suggestions about what else could be done and so on. So it might be helpful if, having read that, you were able to, through your counsel, make available any further information that you think might help us.

MR GREER: Great stuff. Is it a review in the context of the JWS.

CHAIR: No, it was --

MR GREER: It's separate?

DR BYROM: It's a review of the sediment plume modelling that was done in 2016.

CHAIR: It was commissioned by the last DMC, as I understand it.

MR GREER: Okay, before the hearing?

CHAIR: Before, yes.

MR GREER: Anyway, yes, I'll have a look and get back to you.

DR BYROM: Thank you.

CHAIR: Thank you.

MR GREER: All right, are we done?

CHAIR: I think we're done. Yes, yes.

DR DE LUCA: Get away.

MR GREER: Thanks very much.

CHAIR: Have a nice weekend.

DR BYROM: Thank you.

MR GREER: Thanks a lot.

(witness excused)

CHAIR: Yes.

MS HAAZEN: Sir, I'm in your hands, but I suspect we've got half an hour, so we would like to call Mr Cockrem.

CHAIR: Yes, very good. And on the basis that perhaps once his -- is he going to do a presentation for us?

MR COCKREM: I have some slides.

CHAIR: Thank you. I'd like to get him underway at least.

MS HAAZEN: So perhaps just the presentation and then we'll see how far we are.

CHAIR: Yes, because we're going to have a short karakia to round out the proceedings.

MS HAAZEN: Thank you, sir.

MR CURRIE(?): So Mr Anderson and I are going to take our leave.

CHAIR: Yes, thank you very much indeed. And we'll see you back in April, very good.

(Mr Cockrem affirmed)

MS HAAZEN: Mr Cockrem, can you confirm your name is John Cockrem and that you produced a statement of evidence dated 6 October 2023?

MR COCKREM: I can.

MS HAAZEN: And that you also participated in the joint witness conferencing for seabirds?

MR COCKREM: I did, yes.

MS HAAZEN: Thank you. Can you now answer any questions and go through your PowerPoint presentation?

JOHN COCKREM PRESENTING

MR COCKREM: Thank you. So, as noted, this is not a comprehensive presentation of my written evidence. Instead, I've got some slides to serve as discussion points in essence. Now, does this device have some way or maybe with the mouse, I'll just take a moment to activate the pointer. Where are we? So I'm just going to come in here. Now the question is -- does this -- no, sorry. The challenge that I'm having is that in this map, for example, I'm really keen to be able to point to particular parts of it. All right, well I'll wiggle it. Sorry. Thank you.