BEFORE THE EPA
OMV NEW ZEALAND LIMITED APPLICATION FOR MARINE DISCHARGE CONSENT TO DISCHARGE OFFSHORE PROCESSING DRAINAGE (HARMFUL SUBSTANCES FROM DECK DRAINS)

IN THE MATTER of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012

AND

IN THE MATTER of a Decision-making Committee appointed to consider a marine discharge consent application made by OMV New Zealand Limited for the discharge of trace amounts of harmful substances from deck drains in the South Taranaki Bight

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STATEMENT OF EVIDENCE OF REID WILLIAM FORREST FOR OMV NEW ZEALAND LIMITED

Discharge and dilution

Dated: 30 July 2018

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EXECUTIVE SUMMARY

1. Substances that could be harmful to aquatic environment are classified as 9.1 under Hazardous Substances and New Organisms Act 1996 (**HSNO**). After reviewing the harmful substances used during previous drilling campaigns and those approved for use in the Maari Field by the Environmental Protection Authority (**EPA**), OMV New Zealand Limited (**OMV New Zealand**) chose representative substances from class 9.1A-D with which to calculate the expected concentrations in deck drainage discharges.

2. My calculations used the best available information contained within the Safety Data Sheet (**SDS**) provided for each substance and assumed a maximum total volume of 250ml of a hazardous substance left as a residue on the Mobile Offshore Drilling Unit (**MODU**) following clean-up of a loss of containment, which was then immediately entrained in the deck drainage system.

3. It was also assumed that the MODU selected for the Exploration and Appraisal Drilling Programme (**EAD Programme**) would have a deck drainage system settling capacity of at least $5m^3$, and under normal operations this would only reach a half full state before it began to pass water through an Oil Water Separator (**OWS**) and/or discharge.

4. Concentrations of the most ecotoxic substance selected (Class 9.1A – CI-111), were calculated to be 106mg/L in the $2.5m^3$ settling tank at the point of discharge, with the most toxic active ingredient within this substance having a concentration of 31.8mg/L. While these concentrations are above the known Lethal Concentration (**LC50**) and Effects Concentration (**EC50**) ecotoxicity values for this substance, and higher than the Predicted No Effects Concentration (**PNEC**) developed for the same substance by the EPA (for the Maari application), this concentration would only be present at the very point of discharge and would rapidly decrease upon discharge to the surrounding ocean where significant rapid dilution would occur.

5. Due to lack of available rainfall data for locations in the offshore Taranaki environment, ten years of rainfall measurements at representative onshore locations was investigated to determine likely and worst-case rainfall scenarios along with rainfall frequencies. Calculations of the total possible rainwater discharge from a MODU were made based on the surface area of the largest MODU included in the OMV New Zealand rig selection process (5826m^2), and used three possible drilling programme length scenarios (30, 40 and 50 days). The highest calculated rainwater discharge occurred when drilling took 50 days to complete in near-torrential rain intensity every day (75.7m^3/day for the Northern Area of Interest (**AOI**)), while the more likely rainfall scenario at the same location (average rainfall intensity at the average frequency) produced an estimated rainwater discharge of 10.9m^3/day.

6. The zone of influence around the MODU from harmful substances within deck drainage was conservatively estimated at 200m. This value was based on modelling undertaken on the discharge of much larger volumes of water from the Floating Production, Storage and Offloading Vessel (**FPSO**) Raroa in the Maari field where the maximum daily discharge volume (10,300m^3/day) was at least 140 times greater than the highest daily rainwater discharge estimates for the MODU (75 m^3/day). Water sampling undertaken at Maari in 2018 found results showed there was approximately 5000 times dilution of produced water occurring at 50m from the FPSO Raroa. Applying similar dilution to the MODU deck drainage discharge showed that even a 50m zone of influence is conservative.

7. The most ecotoxic substance assessed in the calculations (CI-111) has previously been approved for use in the Maari field by the EPA in much greater volumes and concentrations than those that will occur from the MODU deck drainage discharge. The risk to marine organisms from the larger volumes and concentrations possibly being discharged in the Maari Field were assessed by the EPA as being negligible, and thus I asses the risk to marine organisms beyond a zone of reasonable mixing/influence from the MODU are likely to be de minimis (trivial).

INTRODUCTION

Qualifications and experience

8. My full name is Reid William Forrest.

9. I have a Bachelor of Science in Zoology and a Post Graduate Diploma and Master's degree in Marine Science from The University of Otago. My research for my Postgraduate Diploma and Master's Degree was in marine chemistry. I investigated sources, fates and effects of contaminants entering marine environments within harbours and coastal areas. I am also a certified and experienced scientific diver, having logged over 1200 dives.

10. I am currently employed as an Associate Consultant for SLR Consulting NZ Limited (**SLR**), based in Nelson. I have held that position since October 2014. Prior to that, I worked for nine years at the Cawthron Institute as a Coastal Ecologist.

11. My principal role is to lead field operations for coastal and offshore monitoring and assessments being undertaken by SLR. I am also responsible for:

    (a) the planning, organisation, undertaking and completion of fieldwork, specifically assessments of the benthic and water column environments in the coastal and offshore areas where SLR executes required monitoring projects and/or site assessments;

    (b) overseeing and completing the production of robust, concise scientific reports on the findings of such surveys;

    (c) the Health and Safety considerations relevant to both our fieldwork and onshore/office operations.

Code of Conduct

12. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2011 and that I have complied with it when preparing my evidence. Other than when I state that I am relying on the advice of another person, this evidence is entirely within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

13. I confirm that this statement is true and correct to the best of my knowledge.

Abbreviations

14. I use the following abbreviations in my evidence:

- AF – Assessment Factor;
- AOI – Areas of Interest;
- CCID - Chemical Classification and Information Database
- CHARM model - Chemical Hazard Assessment and Risk Management model
- EAD Programme - Exploration and Appraisal Drilling Programme;
- EC50 – Effects Concentration 50%;
- EPA – Environmental Protection Authority;
- FPSO – Floating Production, Storage and Offloading Vessel;
- HSNO – Hazardous Substances and New Organisms Act 1996;
- IA – Impact Assessment;
- LC50 - Lethal Concentration 50%;
- MODU – Mobile Offshore Drilling Unit;
- OMV New Zealand – OMV New Zealand Limited;
- OWS – Oily Water Separator;
- PNEC – Predicted No Effects Concentration;
- SDS – Safety Data Sheet;
- SLR – SLR Consulting NZ Limited; and
- TRC – Taranaki Regional Council.

Role in marine discharge consent application

15. SLR was engaged by OMV New Zealand to assist with the regulatory applications (Notified Marine Discharge Consent (deck drainage), Non-notified Marine Consent, Non-notified Marine Discharge Consent, Resource Consent for float-off/float-on) required to enable the

commencement of the Taranaki EAD Programme in addition to undertaking a Benthic Baseline monitoring programme.

16. I was part of the SLR Project Team and associated sub-consultants who were engaged to provide the technical reports and baseline datasets to support the applications.

17. I was also the voyage leader for the Benthic Baseline Survey of the twelve proposed wells in offshore Taranaki. I oversaw the planning, execution and successful completion of this fieldwork, along with the production of the baseline environmental reports for each well.

18. I have been engaged by OMV New Zealand to provide calculations for the concentrations of harmful substances that could potentially be discharged as part of deck drainage from the MODU during the EAD Programme.

19. I have also completed pre and post-drill benthic monitoring for OMV New Zealand around previous exploration wells in the offshore Taranaki area, as well as undertaking ongoing benthic and water column monitoring around OMV New Zealand's existing facilities in the Maari Field.

Scope of Evidence

20. In this brief of evidence, I will discuss:

(a) A correction to the rainfall data used in the Impact Assessment (**IA**);

(b) The dilution of the possible substances within discharges from the deck drainage system of a MODU, on a worst case scenario;

(c) How the dilution figures were calculated and the assumptions that were made to reach these figures;

(d) What might happen when such concentrations reach the receiving environment; and

(e) The calculation of maximum and likely volumes of discharge based on rainfall events and the possible size of a zone of influence around the MODU from deck drainage discharges.

CORRECTION

21. I have noticed some minor errors within the IA that require correcting. These errors relate to rainfall calculations within Table 6 of the application document. The revised figures are shown in the updated table 6 below (at paragraph 233 where it is shown with the same table numbering as the IA) where the revised figures are shown underlined and the previous figures have been struck through. These revised figures are also shown in Table 4 of this evidence.

22. The errors relate to incorrect cross referencing in a cell within the calculations spreadsheet which incorrectly used the number of days rainfall did not occur, rather than the number where rainfall did occur. The calculations for the Central and Southern AOI were also incorrectly locked to the cell for the Northern AOI rainfall days.

23. The amended rainfall volumes make minor changes to calculations of the most-likely and worst-case scenarios for possible rainwater discharge volumes from the MODU.

Table 6 Rainfall Calculations (Updated)

Location	m³ over 30 days (p90)	m³ over 40 days (p50)	m³ over 50 days (p10)
Motonui (North AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (3.96 mm/day)	693	925	1,156
90th percentile (13 mm/day)	2,272	3,030	3,787
Assuming rainfall occurs only at the average frequency (~~53~~47%) for this site			
Average daily rainfall rate (3.96 mm/day)	326 ~~367~~	435 ~~490~~	543 ~~612~~
90th percentile (13 mm/day)	1,068 ~~1204~~	1,424 ~~1605~~	1,781 ~~2006~~
Kapoaiaia (Central AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (3.67 mm/day)	642	856	1,070
90th percentile (11.2 mm/day)	1,958	2,610	3,263
Assuming rainfall occurs only at the average frequency (50%) for this site			
Average daily rainfall rate (3.67 mm/day)	323 ~~319~~	430 ~~425~~	539 ~~532~~
90th percentile (11.2 mm/day)	984 ~~1037~~	1,313 ~~1383~~	1,641 ~~1728~~
Patea (South AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (2.89 mm/day)	506	674	843
90th percentile (9 mm/day)	1,573	2,097	2,622
Assuming rainfall occurs only at the average frequency (~~56~~46%) for this site			
Average daily rainfall rate (2.89 mm/day)	233 ~~251~~	311 ~~335~~	389 ~~419~~
90th percentile (9 mm/day)	725 ~~833~~	967 ~~1111~~	1,209 ~~1389~~

HARMFUL SUBSTANCES DILUTION CALCULATIONS

Background

24. The substances that could be harmful to the aquatic environment are classified as 9.1 under HSNO.

25. OMV New Zealand reviewed the harmful substances used during previous drilling campaigns and those that were approved for use by the EPA in the current marine discharge consent for the Maari Field (EEZ300004).

26. The harmful substances used in the calculations within this evidence are based on those approved harmful substances. The calculations in this evidence assumed a worst case scenario for a range of harmful substances (i.e. 9.1A, 9.1B, 9.1C and 9.1D classified harmful substances) in trace quantities within the deck drainage to determine potential adverse environmental effects on the marine environment.

27. A representative substance from each of the classifications 9.1 A to D which will likely to be used during drilling activities was selected for these calculations. Information about each substance and its ecotoxicological limits are provided in Table 1.

28. Although the specific harmful substances used in the calculations below may differ to the actual harmful substances utilised during the EAD programme, the results of this assessment will, in my opinion, closely reflect the dilutions and possible environmental effects of any similar class 9.1 harmful substances with similar ecotoxicity that might be selected and used for the EAD Programme.

Table 1 Ecotoxicity Data for 9.1 HSNO Classified Harmful Substances Typically used in Drilling Operations

Product Name	Intended Use	Form	HSNO Classification	Algae	Fish	Invertebrate
CI-111	Organic acid corrosion inhibitor	Liquid Easily soluble in cold water	9.1A	EC50 (48 hr) 0.22 mg/L (no species provided in SDS)	LC50 (96 hr) 21 mg/L (no species provided in SDS)	EC50 (48 hr) 2.9 mg/L (no species provided in SDS)
NALCO® EC6145A	Scale inhibitor	Liquid Complet ely soluble	9.1B	EC50 (96 hr) 1.88 mg/L (*Selenastrum* sp.)	No appropriate information available	EC50 (48 hr) 242 mg/L (*Daphnia* sp.)
FR-46	Friction reducer	Liquid Soluble in water	9.1C	No available information	LC50 (96 hr) 48 mg/L (*Catla catla*)	LC50 (96 hr) 81 mg/L (*Crangon crangon*)
FE-1A Acidizing Composition	Additive	Liquid Soluble in water	9.1D	EC50 (48 hr[1]) 90 mg/L (*Microcystis aeruginosa*)	LC50 (96 hr) 75 mg/L (*Pimephales promelas*)	LC50 (96 hr) 32 mg/L (*Artemia salina*)

1 – No exposure time was provided; however, 48 hr is assumed as a conservative figure to provide a worst case scenario.

29. LC50 and EC50 values in Table 1 are based on 48 or 96 hour exposure times at the listed concentrations. This means the test subject was subjected to the stated concentration of the particular harmful substance in question, over the time period defined (i.e. 48 or 96 hours). LC50 is the statistically derived dose at which 50% of the test organisms would be expected to die. EC50 is the concentration of a harmful substance which results in a 50% reduction in algae growth rate or invertebrate mobilisation.

30. The classification and ecotoxicity values in Table 1 are largely those listed in the SDS provided to OMV New Zealand by the substance suppliers.

31. However, for the substance ‘NALCO® EC6145A’ (Class 9.1B), the EPA provided updated ecotoxicity information that differed from the manufacturer’s original SDS so this information has been utilised. In addition, the substance FR-46 is classified as a class 9.1D substance in the SDS provided by the manufacturer. However, the EPA re-classified FR-46 as a class 9.1C based on confidential, proprietary information from the substance manufacturer. This change classes this substance as more ecotoxic than the original manufacturer’s specifications (Haliburton SDS showed 9.1D classification). Calculations within this evidence used the EPA classification of 9.1C.

Calculations

32. In order to provide a conservative assessment based on a worst case scenario for the potential environmental effects from discharging trace amounts of a harmful substance from the deck drains of a MODU, such as the substances selected in this evidence, a number of assumptions were required:

(a) A maximum total volume of any harmful substance left as a residue on the deck of a MODU following clean-up is 250 ml and this volume is immediately entrained within the deck drainage system. This is a conservative assumption – in reality, any substance contained on the deck would slowly be washed off the deck and pass through the settling tank system and be diluted further. The 250ml volume itself is conservative as it would likely be less than this volume remaining following clean-up of a loss of containment;

(b) The 9.1 classified harmful substances onboard the MODU will be the most ecotoxic substances present, with substances classified as 9.1A being the most ecotoxic of these. The most ecotoxic constituent (active ingredient) within the four selected harmful substances is listed in Table 2. This information is based upon the best available data within the SDS provided. However, it was noted that the CAS number for Pyridinium-1 provided in the SDS for CI-111, could not be found with the EPA's Chemical Classification and Information Database (**CCID**). As such the ingredient 2-mercaptoethanol, which is classified as being 9.1A in the EPA CCID, was chosen as the most ecotoxic constituent (active ingredient) within CI-111;

(c) A deck drainage system settling tank capacity of $5m^3$ has been assumed. However, it has also been assumed that under normal operations this tank would only reach a half full state (i.e. $2.5m^3$) when discharge begins. This assumption is based on the tank that was present on the ENSCO-107[1] ($5m^3$ maximum volume), being at 50% capacity. I understand that OMV New Zealand will contract a MODU for the EAD Programme which will have similar or larger sized settling tank capacity;

(d) I understand that settling tanks onboard the MODU will allow oily water to float at the surface for skimming and removal via the OWS. Thus, discharge of the remaining liquid would occur from lower in the tank. Based on this, harmful substances that sink will have a higher chance of being discharged than harmful liquids or powders that float. However, in this evidence it has been assumed that any harmful substance entering the settling tanks will be discharged, rather than removed. As I understand the system, the OWS does not provide any sort of treatment of harmful substances; and

(e) To give the most conservative concentration estimates, the active ingredient proportions were assumed to be at the highest levels of the ranges given by the manufacturer in the SDS (see paragraph 35 and 36 for further detail).

[1] ENSCO-107 was the jack-up rig used by OMV at the Maari field during the Maari Growth Project.

Table 2 Concentrations of the harmful substance and its active ingredient within the deck drainage system settling tank.

Product Name and HSNO Classification	Active Ingredient and the Conservative Percentage within the Product	Specific Gravity	Maximum Concentration (250mL contained within 2.5m^3 tank)	Maximum Concentration of Active Ingredient
CI-111 (9.1A)	2-mercaptoethanol (30%)	1.06	106mg/L	31.8mg/L
NALCO® EC6145A (9.1B)	Sodium Diethylenetriaminepenta (Methylenephosphonate) (30%)	1.148	114.8mg/L	34.4mg/L
FR-46 (9.1C)	Ammonium Sulphate (30%)	1.30	130mg/L	39.0mg/L
FE-1A Acidising Composition (9.1D)	Acetic acid (60%)	1.0753	107.53mg/L	64.5mg/L

33. As ecotoxicity values within the SDSs are provided in mg/L units, the maximum volume of harmful substance needs to be converted. Assuming 250ml of harmful substance within the 2,500L (2.5m^3) settling tank and using the specific gravity of the substance provided in the SDS, we can calculate a weight for the maximum volume of each substance (Table 2).

34. For example, using the specific gravity of 1.06 obtained from the SDS for CI-111, 250ml of CI-111 would have a mass of 265g, or 265,000mg. Therefore, there could be 265,000mg of CI-111 within the 2,500L deck drainage system settling tank, giving a concentration of 106mg/L. Maximum concentrations for the remaining substances were calculated in the same manner and are provided in Table 2.

35. The harmful substances chosen for these dilution calculations are generally made with a variety of components and not all of the volume comprises of substances that would be actively harmful or ecotoxic. Manufacturers' SDSs for each substance give a percentage value for the proportion of the substance which is the harmful component or 'active ingredient'. Due to manufacturers protecting their intellectual property around the exact composition of the substance these proportions are normally given as a range.

36. To continue the example calculations above, the active ingredient within CI-111 that had available ecotoxicity information is 2-mercaptoethanol, which, according to the manufacturer's SDS makes up 10-30% of this harmful substance. In order to give the most conservative estimates (i.e. the most harmful) we have assumed the highest concentration of active ingredient, 30% in this situation. Therefore, assuming a loss of containment to deck of CI-111 occurred and, at most 250ml of residue remained following clean-up, which was all then washed off the deck into the drainage system, the overall concentration for the active ingredient (harmful component) within the 2,500L deck drainage system settling tank is 30% of the substance's total concentration of 106mg/L, or 31.8mg/L (Table 2).

37. When this maximum concentration of the active ingredient in CI-111 within the discharge is compared to the available ecotoxicity data (Table 3) the following conclusions can be made:

(a) Algae - EC50[2] (48 hours) 0.22mg/L. Maximum concentrations within the discharge would be 144 times greater than the concentration required to reduce 50% of the algae growth rate after 48 hours of constant exposure;

(b) Invertebrates – EC50 (48 hours) 2.9mg/L. Maximum concentration within the discharge is approximately 11 times greater than the concentration required to stop the movement of 50% of test invertebrates after 48 hours of constant exposure; and

(c) Fish – LC50 (96 hours) 21mg/L. Maximum concentration within the discharge is approximately 1.5 times greater than the concentration required to kill 50% of the fish test subjects after 96 hours of constant exposure.

[2] EC50 and LC50 values used in this section come from the Ecological Information contained within section 12 of the SDS for CI-111. This data was the best available information at the time of undertaking the calculations. Comparing final concentrations to EC50 and LC50 values will not be as conservative as comparing to a Predicted No Effects Concentration (**PNEC**), as it is comparing a lethal end point or a point where there is a definite effect, but these were the known points for this substance that were available in the SDS. Comparisons of calculated maximum concentrations to a PNEC for the same substance, determined by the EPA during the Maari application, has been undertaken in the final section of this evidence.

Table 3 The maximum concentration of the active ingredient of the harmful substances in the drainage system settling tank and its comparison to the ecotoxicity values for three groups of marine test-organisms.

Product Name and HSNO Classification	Active Ingredient and the Conservative Percentage within the Product	Maximum Concentration of Active Ingredient (250mL of parent substance contained within 2.5m^3 tank)	Maximum concentration compared to Algal EC50	Maximum concentration compared to Invertebrate EC50	Maximum concentration compared to Fish LC50
CI-111 (9.1A)	2-mercaptoethanol (30%)	31.8mg/L	144 x higher	11 x higher	1.5 x higher
NALCO® EC6145A (9.1B)	Sodium Diethylenetriaminepenta (Methylenephosphonate) (30%)	34.4mg/L	18 x higher		7 x lower
FR-46 (9.1C)	Ammonium Sulfate (30%)	39.0mg/L		1.2 x lower	2 x lower
FE-1A Acidising Composition (9.1D)	Acetic acid (60%)	64.5mg/L	1.4 x lower	1.2 x lower	2 x higher

Effects on the Environment

38. The calculations in this evidence are based on the maximum concentrations of harmful substances within the deck drainage settling tank. However, the liquid within the settling tank that might contain the harmful substance only has the potential to affect aquatic life upon its discharge into the surrounding ocean.

39. LC50 values are derived from mathematical calculations of the concentration of a harmful substance at which 50% of the test subjects would die after being exposed to the harmful substance for a prolonged period of time (96 hours).

40. However, the maximum concentration of the harmful substance within the discharge calculated above will effectively be an instantaneous concentration at the point where the discharge enters a much larger receiving environment, i.e. the surrounding ocean. Upon entering the marine environment, the discharge, and any harmful substance within it, would be immediately diluted, and become even further diluted with time and mixing.

41. Therefore, organisms within the marine environment at this point would not be continuously exposed to the calculated concentrations, as test subjects are during ecotoxicity testing. Upon discharge to the surrounding marine environment the active ingredients within the harmful substances would be immediately diluted to the extent that ecotoxicity risk to the marine environment would be considered negligible. The high energy nature of the offshore Taranaki areas would assist in the rapid dilution of materials discharged into the marine environment (as detailed in paragraph 60).

42. As an example, in the Maari Field during February 2018, samples were taken of water discharged from the FPSO 'Raroa' into the surrounding ocean in offshore Taranaki. The concentration of benzene (an aromatic hydrocarbon compound naturally occurring with crude oil) was shown to decrease from a mean of 7.55g/m^3 in samples collected before the point of discharge, to 0.0015g/m^3 in samples collected 50m down-current - a 5,000 times decrease in concentration.

43. The daily discharge of produced water from the FPSO Raroa at the time this sampling was undertaken was 1,866.8m^3 (11,742bbl), whereas the calculation in this evidence assumes a discharge of 2.5m^3. Thus, the dilution of the much smaller volume of deck drainage water upon entering the surrounding ocean would be even greater than the 5,000 times seen at 50m from the point of discharge for the FPSO Raroa produced water.

RAINFALL

44. Discharge volumes from the MODU will depend on volume of water entering the deck drainage system from sources including rainwater, wash-down water, sea spray and water from deluge operations.

45. Ten years of rainfall data from the Taranaki Regional Council (**TRC**) monitoring stations was utilised to develop rainfall parameters for the Northern, Central and Southern AOIs. However, caution must be applied when using these calculated parameters as the rainfall data was from onshore monitoring stations which could have somewhat different rainfall to areas off the coast. Onshore stations were used as the best available rainfall information as there is currently no long term rainfall monitoring stations located at any of the oil and gas facilities in the offshore Taranaki area.

46. Rainfall data parameters calculated included:

(a) Average daily rainfall;

(b) 90^{th} percentile rainfall (90% of daily rainfalls were below this volume); and

(c) Average frequency of rainfall events (percentage of days rain occurred).

47. To quantify the potential volume of rainwater discharge, the largest MODU included in the OMV New Zealand rig selection process was utilised, which has a main deck surface area of 5,826m^2.

48. I understand that the drilling programme for each well is expected to take up to 50 days; however, given that the exact time to complete drilling activities at each site is unknown, three possible scenarios were provided by OMV New Zealand:

(a) 90% of the time, the drilling would be completed within 30 days (p90);

(b) 50% of the time, the drilling would be completed within 40 days (p50); and

(c) 10% of the time, the drilling would be completed within 50 days (p10).

49. Highest theoretical volumes of rainwater discharge would occur when all of the associated drilling activities took 50 days to complete, with near torrential rain (90^{th} percentile) occurring every day (green cells in Table 4).

50. The most likely theoretical volumes were predicted from the most likely drilling period (30 days), where the average daily rainfall occurred at the average frequency (yellow cells in Table 4).

51. The likelihood of the 90th percentile scenario occurring, where torrential rain would be experienced every day for 50 straight days needs to be put in context. From the TRC rainfall data this level of rainfall only occurred for approximately 10% of the days in the 10 years of data analysed. So the realistic chances of having rain this heavy every day for 50 straight days is very unlikely.

52. Therefore, my colleagues and I considered it most appropriate to utilise the 'most likely' scenario for the Taranaki region to predict more realistic rainwater discharge volumes from the MODU. This most likely scenario also gives a more conservative scenario for the concentration of harmful substances that might be discharged, because less rainfall (and therefore lower volume of discharge) would mean a lower level of dilution and higher concentration of the harmful substances at the point of discharge.

53. To follow an example through; the Northern AOI predictions are based on rainfall data from Motonui, where the average daily rainfall was calculated at 3.96mm/day, and the 90^{th} percentile was 13mm/day. Rain occurred on 47% of the days within the 10 years of data that were analysed. Assuming that every part of the main deck surface area 5,826m^2 caught the rainfall that occurred the highest stormwater volume is determined by;

(0.013m x 5,826m^2) x 50 days = 3,787m^3 (total for all 50 days)

And the most likely stormwater volume is determined by:

(0.00396m x 5,826m^2) x the number of the 30 days where rain occurred based on average frequency (47%) = 326m^3 (total for all 30 days)

Table 4 Total rainwater discharge volumes for Northern, Central and Southern AOI based on 10 years of rainfall data from representative onshore Taranaki locations.

Location	m³ over 30 days (p90)	m³ over 40 days (p50)	m³ over 50 days (p10)
Motonui (North AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (3.96 mm/day)	693	925	1,156
90th percentile (13 mm/day)	2,272	3,030	3,787
Assuming rainfall occurs only at the average frequency (47%) for this site			
Average daily rainfall rate (3.96 mm/day)	326	435	543
90th percentile (13 mm/day)	1068	1424	1781
Kapoaiaia (Central AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (3.67 mm/day)	642	856	1,070
90th percentile (11.2 mm/day)	1,958	2,610	3,263
Assuming rainfall occurs only at the average frequency (50%) for this site			
Average daily rainfall rate (3.67 mm/day)	323	430	539
90th percentile (11.2 mm/day)	984	1313	1,641
Patea (South AOI) - Assuming rainfall every day of campaign			
Average daily rainfall rate (2.89 mm/day)	506	674	843
90th percentile (9 mm/day)	1,573	2,097	2,622
Assuming rainfall occurs only at the average frequency (46%) for this site			
Average daily rainfall rate (2.89 mm/day)	233	311	389
90th percentile (9 mm/day)	725	967	1,209

Note: Green highlight is highest rainfall scenario for stormwater discharge, while yellow highlight is most likely stormwater discharge scenario. Rainfall data used to calculate the possible rainwater volumes was taken from 10 years' worth of rainfall data collected by Taranaki Regional Council at three onshore stations at Motonui, Kapoaiaia and Patea.

54. These volumes are for the entire drilling period at one well location and assuming the most likely rainfall scenario for a 30 day drilling programme in the Northern AOI, a total discharge of 326m^3 would equate to 10.8m^3/day. In the Southern AOI a total discharge of 233m^3 under the most likely rainfall scenario would equate to 7.8m^3/day. I understand that a typical MODU OWS treatment system is capable of treating approximately 10m^3 per hour (240m^3 per day). The volume of rainfall predicted is well within the parameters supplied by OMV New Zealand of a typical OWS.

55. Taking this information and relating it to the possible discharge of harmful substances; a loss of containment that leaves at most 250ml of the harmful substance on the deck could be washed into the deck drainage system by a rainfall event. Calculations provided in paragraphs 34 and 36 were based on a maximum volume of 2.5m^3 for dilution in the settling tank, and the entire 250ml of harmful substance immediately entering this tank and being immediately discharged as a 2.5m^3 parcel. Whereas if all 250ml of the hazardous substance was gradually washed into the deck drainage system over a typical day of rainfall as calculated for the Northern AOI (10.9m^3/day, paragraph 53), and then discharged to the ocean, this would result in the concentrations within the deck drainage discharge of that substance being around 4 times further diluted than what was determined in paragraphs 34 and 36 at the point of discharge.

56. This scenario in itself is still highly conservative as it is more likely that not all of the 250ml of the harmful substance (at maximum) would be washed into the deck drainage and be discharged as a single event. Rather, the remaining harmful substance on deck following the loss of containment would be gradually washed through the system with subsequent rainfall events, deck wash-down and deluge testing events, and further diluted as water is discharged from the settling tank which I understand is only ever partially emptied.

ZONE OF INFLUENCE FROM DECK DRAINAGE DISCHARGES

57. In order to calculate the area of ocean surrounding the MODU where deck drainage discharges, including those potentially containing harmful substances, will likely have a detectable effect, data from known and modelled discharges occurring in the offshore Taranaki area were reviewed.

58. Discharge from the deck drainage system is assumed to have a 200m radius zone of influence from the discharge point, but this 200m distance is highly conservative as it was based on modelling of the discharge of produced water from the FPSO Raroa (MSL, 2011) - the consented daily discharge for the FPSO Raroa (10,300m^3/day) is over 1300 times greater than the predicted total daily rainwater discharge for this consent application, compared with the lowest calculated most likely rainwater volume (i.e. 10,300m^3/day vs 7.8m^3/day - as predicted in paragraph 54 and Table 4, or 130 times greater than the highest calculated rainwater discharge (90^{th} percentile - 75.8m^3/day).

59. As such, the dilution rates of any harmful substance entering the same sized receiving water mass (the surrounding ocean) would be much greater for the predicted rainwater discharge volumes that could be discharged from the MODU under the most-likely rainfall scenarios (e.g. 10.9 m^3 per day for the Northern AOI and 7.8m^3 per day for the southern AOI).

60. Due to its exposure to long period swells originating from the Southern Ocean, as well as locally generated seas, and frequent strong winds from the southwest, southeast and north, the offshore Taranaki area is considered to be a high energy environment (ASR, 2004; ASR, 2014a; Hume, et al., 2015; MacDiarmid et al., 2015). The winds, waves and the tidal and wind-driven currents impart the most energy to the upper part of the water column resulting in a generally well mixed water column. Extended periods of more settled weather in the summer months can sometimes lead to some thermal stratification in the water column, but this is often broken down by passing storm events.

61. The modelling of the FPSO Raroa plume assumed a large temperature differential between the plume and the receiving water (up to 65^{o}C for the discharge vs 14^{o}C for the receiving environment) which due to the lower density of warm water meant the plume spread more along the surface with little vertical mixing. While it is likely that deck drainage liquids onboard the MODU would be relatively similar in temperature to the surrounding sea prior to discharge, rainfall discharges are likely to have much lower salinities than the surrounding ocean and could therefore still spread as a surface layer. However, this upper portion of the water column is exposed to the high energy wind and waves that occur in offshore Taranaki which would aid in mixing a surface plume.

RESPONSE TO EPA REPORTS

Stantec Uncertainty Report

62. This report was commissioned by the EPA and concluded that "*while some impacts may be possible on some marine organisms in the immediate vicinity of the point of discharge, the impacts of such a small volume discharge containing relatively low concentrations of harmful* *substances will be limited both spatially and in time"*. The report also concluded that "*the risks associated with the current application are de minimis (trivial) at and beyond the zone of reasonable mixing…*". I agree with this conclusion but would like to address some points within the Stantec report that are relevant to this evidence.

63. At section 6.12, Mr Lieffering states that "*while the IA defines the zone of influence, it does not present any information on likely dilution rates that the discharge from the MODU(s) would be at the edge of the zone*". A similar statement was made at the end of paragraph (f) within this section. I agree this information was not provided within the IA. I have provided this information within paragraph 42 and the other conclusions of this evidence.

64. At Appendix 1 the EPA's answers to Mr Liefferings questions do not give details about the Assessment Factor (**AF**) that was used when calculating the Predicted No Effects Concentration (PNEC) for CI-111. A PNEC is the estimated highest concentration of a chemical in a particular environment at which point no adverse effects of that environment are expected.

65. The PNEC was estimated by the EPA using the Chemical Hazard Assessment and Risk Management (**CHARM**) model in an assessment of the risk from the discharge of this substance in relation to its use downhole in the Maari field. The EPA's review included confidential ecotoxicity information from the supplier of CI-111 which was not available to OMV New Zealand. Without the confidential ecotoxicology information and an indication of the AF selected by the EPA, it was not appropriate to arbitrarily select an AF (e.g. 1, 10, 100 or 1000) value based on the information available in the SDS. As an example, should I have chosen an AF of 100 and applied this to the lowest available toxicity value (as detailed in the CHARM User Guide) this would have given a PNEC of 0.0022mg/L (EC50 Algae 0.22mg/L divided by 100). This would have been over 20 times lower than the EPA derived PNEC. .

66. PNEC assumes that organisms are exposed to this same concentration of the substance over the entire test period (e.g. 48 hours). This is a highly conservative assumption as upon discharge to marine environment there would be significant rapid dilution of substance, lowering concentration organisms were exposed to.

67. The PNEC for CI-111 previously estimated by the EPA was 0.047mg/L of a component comprising 60% of that substance.

68. I accept that directly comparing predicted harmful substance concentrations within the settling tanks to the EC50 and LC50 values may not have been as conservative compared to using a PNEC, but these comparisons were based on the best available information at the time, that being the ecotoxicity information within the SDS provided for the selected harmful substances.

69. At section 6.14, Mr Lieffering noted that there was a difference in the active ingredient compounds that were chosen in the risk assessments for Maari vs. the current application. 2-mercaptoethanol (10-30%) was chosen in the current OMV New Zealand IA as there was ecotoxicology information readily available for this substance. Whereas Pyridinium, 1-(phenylmethyl)-, alkyl derivs., chlorides CAS Number 100765-57-9 (listed in the provided SDS as 30-60%), could not be found with the EPA's CCID. However, as Mr Lieffering points out, the conclusions drawn around the environmental risks associated with either compound are essentially the same. This is because, despite 2-mercaptoethanol being used at half the volume, according to the ecotoxicology information he had available, 2-mercaptoethanol was twice as ecotoxic.

70. Using these new figures and following the same calculations as earlier in this evidence, the most abundant active ingredient in CI-111 (Pyridinium, 1-(phenylmethyl)-, alkyl derivs., chlorides) would have a concentration of 63.6mg/L in the 2.5m^3 of liquid within the settling tank. In order to reach the PNEC the liquid in the settling tank containing the harmful substance would need to be diluted 1343 times. Whereas 2-mercaptoethanol would need to be diluted 677 times in order to reach the PNEC.

71. As also stated in section 6.14, the EPA has previously assessed the risks associated with the discharge of CI-111 during the Maari Marine Discharge Consent application. In this consent, CI-111 was approved to be applied downhole at 8000mg/L concentration with up to 5 treatments per year and up to 250L of the substance being used in any given treatment event. Risks to the marine organisms from this volume of harmful substance being discharged were assessed by the EPA as being negligible. The assumed volumes of harmful substances possibly being discharged as part of deck drainage from the MODU (250ml) are orders of magnitude less than the amounts that were consented by the EPA for the Maari application. I therefore agree with Mr Lieffering's conclusion that the environmental risks are *de minimis* (trivial) at and beyond the zone of reasonable mixing.

RESPONSE TO SUBMISSIONS

72. Te Rūnanga o Ngāti Ruanui Trust's submission comments on the use of most likely vs worst-case rainfall scenarios. Wording around the parameters used in the rainfall discharge calculations has possibly added some confusion.

73. If we take the highest rainfall events (assuming raining every day for 50 days at the 90^{th} percentile rate – torrential rain) as the 'worst-case' scenario, this would indeed give the highest rainfall volumes that the MODU would be subjected to. For example 50 days on site at northern AOI gives 3,787m^3 of rainfall discharge over 50 days (75.7m^3/day). If the typical OWS has the ability to treat 10m^3 per hour (240m^3/day) this would be well within the MODU ability.

74. However, while this is 'worst-case' for the amount of volume the MODU has to handle, it is a much larger volume of rainfall compared to the 'most-likely' rainfall scenario, and therefore in terms of harmful substances the 'worst-case' rainfall scenario would give much greater dilution. Whereas a 'worst-case' scenario in terms of harmful substance dilution is actually the more-likely rainfall scenario where less rainfall discharge occurs and therefore less dilution occurs.

CONCLUSION

75. Using the dilution measured at the Maari Field as a model (5000 times dilution at 50 m), and using the maximum concentration of the active ingredient of CI-111 (as used in this evidence – 30% 2-mercaptoethanol, 31.8mg/L) within 2.5m^3 of liquid in the settling tank, we could assume that the concentration of this active ingredient would drop to 0.00636mg/L at 50m from the MODU discharge. Using the PNEC from Stantec report (0.047mg/L)[3] the concentration of the active ingredient in the class 9.1A substance CI-111 at 50m from the MODU discharge, would be 7.3 times lower than the PNEC. Thus, at 50m from the MODU discharge and beyond it would be predicted that there would be no effects on marine organisms from the discharge of these trace amounts of CI-111.

76. The lowest 'most-likely' rainwater discharge (the Southern AOI – 7.8m^3/day) gives the least dilution of the 250ml volume remaining on the deck as it entered and passed through the deck drainage system. This volume would give around 3 times further dilution than just the 2.5m^3 in the settling tank (detailed above), and assumes the entire 250ml would be gradually washed off the deck and pass into and through the drainage system within that one days rainfall. Thus, during a rainfall event the concentrations of the active ingredient in CI-111 at 50m from the MODU discharge would be even further below the PNEC.

77. The Maari Field Marine Discharge Consent contains approval for CI-111 to be applied at 8000mg/L concentration in up to 5 treatments per year with up to 250L of the substance being used in any given treatment event. Risks to marine organisms from this volume of harmful substance being discharged were assessed by the EPA as being negligible. Thus, the risk of discharging far lower volumes (250ml) of far lower concentration solutions of this substance in deck drainage from the MODU would be significantly less – de minimis.

Reid Forrest

30 July 2018

[3] The calculated PNEC value from the Stantec report was from the CHARM model and was of a component which made up 60% of the CI-111 substance. Based on the information available within the SDS for CI-111 this component is assumed to be Pyridinium, 1-(phenylmethyl)-, alkyl derivs., chlorides. This is different to the 2-mercaptoethanol which was the active ingredient used in the calculations within this evidence and the IA as it was the most ecotoxic compound. Comparisons within the Stantec report state that despite the difference in approach, calculations around environmental risks of either compound will be similar as 2-mercaptoethanol is around twice as ecotoxic, but present in half the quantity.