BEFORE THE SOUTHLAND REGIONAL COUNCIL

UNDER THE	the Resource Management Act 1991
IN THE MATTER OF	Resource consent applications by Sanford Limited, APP-20157616-V1, APP-203236-V1, APP-203237-V1, APP-203240-V1, APP-203241-V1, APP-203242-V1, APP-207256-V1, seeking coastal permits associated with the operation of a Salmon Farm at Big Glory Bay, Stewart Island.

STATEMENT OF EVIDENCE OF PETER CLIFFORD LONGDILL
for the DIRECTOR-GENERAL OF CONSERVATION

Dated 15 March 2019

Department of Conservation
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1. INTRODUCTION

1.1 My full name is Peter Clifford Longdill.

1.2 My areas of expertise include coastal and marine physical processes along with their interaction with ecological processes and water quality. This includes field data collection programs and environmental monitoring programs along with the development and application of numerical modelling tools to quantify these processes. I have applied these skills to coastal and marine projects including aquaculture, port, and dredging projects, both within New Zealand and overseas.

1.3 My qualifications include:

(a) Bachelor of Science in Marine and Environmental Geoscience (University of Auckland);

(b) Master of Science in Coastal Oceanography (University of Waikato);

(c) Doctorate of Philosophy in Coastal Oceanography and Modelling the Water Column Impacts of Aquaculture (University of Waikato). The title of my thesis was 'Environmentally Sustainable Aquaculture: An Eco-Physical Perspective'.

1.4 I am a member of the New Zealand Coastal Society (the NZCS) and the Coastal Education and Research Foundation (the CERF).

1.5 I am the currently the Environmental and Sustainability Manager for the Hamad Port Project within the State of Qatar. The project is a greenfield mega-project involving major capital dredging works and water quality management. My employer is the Ministry of Transport and Communications. Previously, I held the position of Senior Project Manager and Senior Environmental Scientist for the consultancy COWI A/S, a position I held for over six years. I have also worked as an environmental and marine consultant for ASR Ltd and the University of Waikato in New Zealand. I have over 18 years' professional experience in the field of coastal oceanography.

1.6 My work and research areas focus on identifying and quantifying environmental impacts arising from coastal and marine development along with the subsequent identification and implementation of appropriate mitigation and compensation measures. A key feature within my work is

the application of both collected and remotely-sensed data, together with appropriate modelling tools to aid understanding and quantification of physical and ecological processes in coastal marine waters. I have been involved in coastal development (ports, commercial, residential) and aquaculture projects from an environmental control and management perspective throughout their planning, design, permitting, and construction/operation phases. As a result, I am well versed with the prevailing environmental issues, their best practice management, and the practicalities of field implementation of mitigation measures.

1.7 I have developed and implemented baseline monitoring programs for aquaculture development along with numerical models to simulate the effects of aquaculture development on the water column and seabed.

1.8 I have previously provided advice to the Department of Conservation in relation to other marine applications under the Resource Management Act 1991 and the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, including: New Zealand King Salmon Board of Inquiry, Trans-Tasman Resources, Chatham Rock Phosphate, and Coastal Resources Limited.

1.9 I have consulted on aquaculture projects both within New Zealand to the Department of Conservation and New Zealand King Salmon, and internationally to the United Nations Food and Agriculture Organisation.

1.10 I am a member of the "Peer Review Panel", tasked with review of the environmental monitoring and management plans for a selection of Salmon Farms within the Marlborough Sounds.

1.11 I have authored six published peer-reviewed scientific papers in my field of expertise in addition to numerous conference proceedings, consulting reports, and magazine articles.

1.12 I have been contracted by the Department of Conservation to provide advice services in relation to environmental effects and management of aquaculture projects.

1.13 This evidence is presented in relation to the Director-General of Conservation's ("D-G") submission on Sanford Limited's application.

2. CODE OF CONDUCT

2.1 I have read the code of conduct for expert witnesses as contained in the Environment Court's Practice Note 2014 ("the Code"). Although this hearing is not before the Environment Court, I have complied with the Code when preparing my written statement of evidence.

2.2 The data, information, facts and assumptions I have considered in forming my opinions are set out in my evidence to follow. The reasons for the opinions expressed are also set out in the evidence to follow.

2.3 Unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

3. SCOPE

3.1 I have been asked to present evidence on my technical assessment of the application and, in particular, the development of the revised set of conditions dated 18 December 2018 (see **Appendix PL2** of this evidence). These revised conditions were developed and agreed between the technical advisors for the Department of Conservation (myself and Mr Andrew Baxter) and Sanford Limited (Dr Mark James and Dr Neil Hartstein) with the assistance of planners from both parties.

3.2 My involvement in this process focussed primarily on water column and water quality aspects. While I also contributed to the discussions and agreements on the benthic ecology conditions, Mr Baxter was the Department's key advisor in this regard.

3.3 My evidence, therefore, focusses primarily on water quality matters. Mr Baxter addresses the benthic ecology conditions in detail in his evidence.

3.4 The key documents that I have relied on in forming my opinions are contained in **Appendix PL1**.

3.5 In preparing my evidence I have read, and where necessary refer to:

(a) Resource consent application and supporting documents from Sanford Limited;

(b) The D-G's submission;

(c) The Council Officer's section 42A Report;

(d) The evidence of Mr Andrew Baxter and Ms Nardia Yozin for the D-G; and,

(e) The statement of evidence of Sanford consultants for the applicant, notably that of Dr Neil Hartstein and Dr Mark James

4. EXECUTIVE SUMMARY

4.1 The D-G's submission raised concerns about the Sanford Limited application. Those concerns included the assimilative capacity of Big Glory Bay to cope with the increased nutrient loading and discharges, the clarity and workability of the conditions, and the absence of a step-wise staging over time of the proposed nitrogen load increase.

4.2 To address these concerns, the Department of Conservation's and Sanford's technical advisors (including myself) communicated via email and participated in a workshop, which resulted in the drafting of a revised set of conditions (see **Appendix PL2** of this evidence).

4.3 I am of the opinion that the revised set of conditions, as agreed during workshops and correspondence (see **Appendix PL2**), subject to minor modification as indicated in paragraph 11.3 of this evidence, address the D-G's concerns regarding water quality matters.

5. EFFECTS OF FISH FARMING – WATER COLUMN

5.1 Salmon farming has potential to affect water quality in several ways. Forrest *et al.* (2007) provides a comprehensive review and makes the following overall statements with respect to water column effects.

(a) "*Nutrient enrichment in the water column occurs in the vicinity of finfish farms. Although nutrient enrichment has the potential to stimulate algal blooms, studies in New Zealand and overseas have not linked blooms to fish farming activities*";

(b) "*Presently*[1]*, finfish farming in New Zealand is of a low intensity and appears to be well within the carrying capacity of the environment*."

[1] i.e. 2007, based on the publication date.

(c) "*Seabed and water column effects can be reduced by locating farms in well-flushed areas, in areas where species and habitats of special value are not present, or where flushing characteristics alter deposition patterns to a point where adverse effects do not occur*."

(d) "*The only two issues to emerge that may be of particular relevance to finfish farm developments in New Zealand are:*

(i) Depletion of dissolved oxygen (DO) in the water column.

(ii) *Nutrient enrichment of the water column*"

5.2 Depletion of Dissolved Oxygen occurs in the water column surrounding finfish farms as a result of the respiration of the typically large biomass of farmed fish, and due to the oxygen demand from degrading waste materials on and within the sediments beneath the farm. Excessive dissolved oxygen depletion in the water column can stress, and in extreme cases kill, fish (including the farmed fish) and other animals. Dissolved oxygen risks increase with higher stocking rates within farm pens or cages and at sites with weak water column flushing due to tides and/or wave effects.

5.3 Nutrient enrichment of the water column occurs primarily as a result of the feed product introduced to the environment and its subsequent release to the water column either through uneaten feed pellets, or after being processed and released in dissolved or particulate form by the farmed fish.

5.4 Nitrogen (N) is generally considered as the key nutrient limiting photosynthetic activity in coastal marine waters, and indeed this appears the case for Big Glory Bay[2]. Nitrogen (N) is released from fish farms in the form of dissolved inorganic nitrogen (DIN), predominantly as ammonium-N, and is also released from the locally enriched sediments via particulate matter decay and decomposition. Released dissolved nitrogen then becomes available for uptake by photosynthesisers often directly, or after conversion to different forms of dissolved nitrogen.

5.5 There are no hard and fixed guidelines for acceptable levels of nitrogen enrichment for coastal systems. Over availability of nitrogen, in a nitrogen limited system, can lead to over-enrichment and eutrophication, with further consequential impacts to water quality. The specific carrying capacity, or assimilative capacity, for a receiving environment to nitrogen enrichment is

[2] Paragraph 56 of the Statement of Evidence of Dr Neil Hartstein on behalf of Sanford.

a function of many physical and ecological factors, including, tidal movement, flushing rate, light, temperature, nutrient cycling processes, phytoplankton species structure, zooplankton grazing pressure etc, which will all vary over time.

6. THE SUBMITTED APPLICATION

Water quality model

6.1 The numerical water quality model submitted within the application was relatively simplistic, using a conservative tracer released from the farms and described to represent "Total Ammonia Nitrogen, TAN". Current best practice, and indeed guidance from the Ministry for Primary Industries (Hartstein and Oldman, 2015) suggests that the use of a fully coupled, N-P-Z-D (Nutrient-Phytoplankton-Zooplankton-Detritus) type water quality model would be more appropriate. Such a modelling approach could have directly considered the buffering effects of mussel farms within the model itself (mussels remove water column nitrogen through mussel feeding and subsequent harvesting). The inability of the conservative tracer TAN model to quantify mussel farm nitrogen process leaves the TAN model's representation of the Big Glory Bay nitrogen levels being (almost unrealistically) conservative, and conditioned by a rather coarse and unquantified explanatory statement, that mussel farms will dampen the potential water quality effect.

6.2 The calibration of the water quality "TAN" model is poor (refer Figure 3 of Appendix C to the AEE). The model's replication of "TAN" does not replicate the seasonal pattern of measurements. While water quality models are typically very challenging to calibrate, I suspect the cause of such a poor calibration in this instance is the simplicity of the model itself; i.e. the model does not attempt to replicate key important biogeochemical processes such as nitrogen chemical transformations, nitrogen uptake by photo-synthesisers, etc. The model results are not in reasonable agreement with the measurements from the water quality monitoring program. However, despite this, the model result still provides a somewhat useful indicator of the dispersion and dilution of dissolved wastes from the farms. Caution must be taken with respect to any inferences from the model result on phytoplankton effects however.

Dissolved oxygen

6.3 Farmed salmon require a minimum level of dissolved oxygen to maintain health and quality (~6 mg/l). The greatest zone of depletion for dissolved oxygen is within the cages themselves, hence the farm operator has an interest in not allowing oxygen levels below those thresholds.

6.4 Vaquer-Sunyer and Duarte (2008) provides an extensive review of dissolved oxygen requirements for marine animals, the mean sub-lethal concentration for fish (the least tolerant group to hypoxia) is ~4.4 mg/l as an acute level, and 5.5 mg/l as a chronic effect level. These levels are less than that required to maintain farmed salmon health. Dissolved oxygen minima can be expected to occur very close to the cage (effect due to respiration of the farmed fish), and also close to the seabed (oxygen demand from re-mineralising farm wastes in the benthos). Accordingly, I found the proposed consent condition for dissolved oxygen, as submitted within the application inadequate, as it required compliance only "*at the surface*", and not throughout the water column. My concerns have been subsequently addressed through updated consent conditions (see **Appendix PL2**).

Chlorophyll-a

6.5 The water quality model submitted with the Application predicts that with the proposed intensification in salmon farming in Big Glory Bay there could be 'an associated increase' in Chlorophyll-a of up to 2.5 to 4 µg/l. That increase is incremental, on top of what is already the present setting for Chlorophyll-a. Chlorophyll-a is an indicator for phytoplankton biomass and, therefore, water quality enrichment. Substantial changes in phytoplankton biomass can affect water column nutrient cycling, with associated changes in the trophic state of the water column. In a simplistic sense, and subject to nutrient cycling processes, increased Chlorophyll-a is representative of a water body which is closer to a eutrophic state.

6.6 The model prediction for Chlorophyll-a increase is significant with respect to the existing environment and existing Chlorophyll-a measurements, representing a potential chronic increase[3] of ~40% - 83%. It is noted that as a result of the simplistic model formulation (see earlier paragraphs) the

3 Typical recent (2011-2017) values of Chl-a reported in Figure 6 of Sanford (2017) are less than 3 µg/l, though it is notable that some records exceed that value, up to 6.2 µg/l, and there is a history of infrequent 'single measurement' values exceeding that.

model likely represents a (unrealistic) conservative and 'worst case' prediction with respect to general water quality parameters.

6.7 The potential increase in Chlorophyll-a, of 2.5 to 4 µg/l, represents a substantial and concerning potential change to the water column environment. That level of change relative to the existing environmental setting, and without staging, is far greater than the levels of environmental change determined to be reasonable for other salmon farming expansion/intensification projects within New Zealand (e.g. Increases in other areas are typically staged at predicted ~10-20% increases for Chlorophyll-a at a single time, in accordance with discussions and workshops of technical specialists). The consent conditions proposed at the time the Application was submitted did not include for any staging, and did not provide, in my opinion, as an alternative or supplementary level of control, appropriate conditions for Chlorophyll-a as the primary indicator of water column enrichment. My concerns have been subsequently addressed through updated consent conditions (see **Appendix PL2**).

Copper and Zinc

6.8 Typically, salmon farms can affect sediment copper concentrations though the use of anti-fouling compounds on farm nets and pens, whilst zinc is an ingredient within salmon feed. Monitoring reports submitted within the Application confirmed that concentrations of copper and zinc beneath farm sites 338 and 339 had substantially exceeded ANZEEC (2000) Interim Sediment Quality Guidelines (ISQG)-High levels[4]. In the case of copper, there were regular and persistent exceedances. Copper and zinc concentrations within the sediments at Big Glory Bay farms reflect the relatively long period of salmon farming within the Bay.

6.9 Current 'best management practice' guidelines for the seabed beneath salmon farms in the Marlborough Sounds[5], set trigger values which, if exceeded, require management action at ANZEEC ISQG 'low' levels, and require that concentrations anywhere within the vicinity of the farm, including directly beneath the farm do not exceed the ANZEEC ISQG 'high' levels. The Application and the conditions attached at the time of submission did not include any clear requirement, nor management plan to

[4] ANZEEC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2000. Australian and New Zealand Environment and Conservation Council.
[5] Best Management Practice guidelines for salmon farms in the Marlborough Sounds: Benthic environmental quality standards and monitoring protocol: November 2014

address, remediate or rectify the sediment copper and zinc concentrations. My concerns have been subsequently addressed through updated consent conditions (see **Appendix PL2**).

7. D-G'S SUBMISSION

7.1 The D-G's submission opposed 'in part' those aspects of the Sanford application "*relating to the assimilative capacity of Big Glory Bay (water quality generally and the benthic environment under and near the farms) to cope with the proposed increases in nutrient loadings and discharges of other contaminants*."

7.2 Specifically, with respect to water quality, the D-G's submission:

(a) sought clarity in relation to the scale of the proposed nitrogen increase and how it was to be allocated across various farms,

(b) identified the absence of staged implementation for the increased nitrogen inputs (i.e. staged/step-wise farm expansion),

(c) identified the absence of adaptive management approach in relation to water quality effects,

(d) raised some concerns in relation to the water quality modelling, and the absence of information relating to the nitrogen performance of the farms, and

(e) highlighted concern in relation to the proposed consent condition conditions for water quality, and their monitoring.

7.3 The D-G's submission also noted concern relating to the management of copper and zinc concentrations within sediments surrounding the farms.

7.4 I provided technical input towards, and concur with, the concerns raised in the D-G's submission.

8. POST SUBMISSION CONDITION DISCUSSIONS WITH SANFORD LIMITED

8.1 Following the submission on the application, Mr Baxter and I engaged in a series of technical meetings and discussions with Sanford's advisors with the objective of reviewing the application, its assumptions, and the proposed consent conditions to address the concerns raised in the D-G's

submission. This process proved very fruitful and ultimately lead to a revised set of conditions being agreed (see **Appendix PL2** of this evidence)[6].

9. TERM OF CONSENT

9.1 During the discussions and workshopping in relation to the proposed consent conditions, the term of the existing consent, and the subject application, was advised as 2025. My technical discussion in relation to the water column issues and proposed consent conditions was undertaken on that basis. That time period provided a level of 'comfort' in relation to the proposed activity, as there would be a complete review of the consent and conditions in six years' time, i.e. a comprehensive review of the activity and associated conditions could be performed at that time, with the benefit of several years of water quality monitoring data of the 'expanded/intensified' farm operation. My inputs during technical discussions did not consider a 20-year consent period as now proposed in the Council Officer's section 42A Report.

10. AGREED CONDITIONS

10.1 In the below paragraphs I highlight the key matters in the revised conditions relating primarily to water quality and water column effects (see **Appendix PL2** of this evidence) and how those revised conditions address my earlier technical concerns and the associated matters raised within the D-G's submission.

Staged approach

10.2 Staged increases in nitrogen loading are now required in accordance with Condition A4(a) and Condition B8 (see **Appendix PL2**). The inclusion of the staging approach limits the initial increase in nitrogen discharge, and only permits further increase to the full load if:

(a) Actual measured data confirms that benthic and water column environmental performance limits are being met, and are not showing trends toward greater impacts; AND

[6] Condition numbering within this evidence document refers to those Conditions attached to this evidence as Appendix PL2

(b) The farms have been discharging close to their allowable nitrogen limit for the preceding 3 years – this to ensure that the measured data (above) is a meaningful representation of the current nitrogen discharge limit.

10.3 The implementation of the staged approach to increases in nitrogen discharges is a practical methodology to manage environmental effects of farm expansion/intensification and has been proposed and applied in salmon farm consents within the Marlborough Sounds. In the absence of a staged approach, consideration of environmental effects (water quality and benthic) for the full proposed increase must rely almost wholly on numerical model predictions. Numerical model predictions are by their very nature subject to uncertainty. Effects assessment approaches and decision making frameworks which reduce reliance on extended model forecasts, in favour of actual measurements, can act to reduce risks and increase precaution. The staged approach requires that nitrogen discharge increases are implemented step wise and requires that actual measured data are evaluated prior to a progression to the next phase of nitrogen discharges. Accordingly, I am supportive of the staged approach as it represents a practical way to address model uncertainty and the scale of potential environmental change.

Water quality objectives and standards

10.4 The revised conditions (**Appendix PL2**) now include high level "Water Quality Objectives" (Condition A4(b)) which identify environmental 'bottom lines' with respect to water quality. Those objectives are generally consistent with those included in recent Salmon Farm consents within the Marlborough Sounds.

10.5 The revised conditions (**Appendix PL2**) now identify 'tier one' and 'tier two' water quality standards for a primary water quality effect indicator, Chlorophyll-a (Condition A4(c)). Associated with those 'tier one' and 'tier two' standards are defined responses in the event they are breached, within the context of an adaptive management framework (Conditions A4(i)).

10.6 The revised conditions (**Appendix PL2**) identify 'tier two' standards for excess nutrient (as ammonia), and dissolved oxygen (Condition A4(c)). In addition to Chlorophyll-a, these are relevant water quality indicators with respect to salmon farm related effects.

10.7 The specific concentrations set for the water quality objectives and standards (Condition A4(b) and A4(c)) has been discussed extensively between myself, Mr Baxter, Dr James, and Dr Hartstein. The standards included within the Conditions (see **Appendix PL2**) necessarily allow for a certain level of environmental change relative to existing monitoring data, while recognising that any activity sit within the context of a variable natural environment.

10.8 Whilst allowing a defined level of environmental change, the water quality standards (Condition A4(b) and A4(c)), will in my opinion, provide a framework to best ensure appropriate management of water quality effects associated with the proposed increases in nitrogen discharge. It is my opinion that the water quality objectives and associated standards act to substantially reduce[7] the risk of wide scale or chronic detrimental water quality effects and associated consequential impacts.

Copper and Zinc

10.9 The existing concentrations of copper and zinc in sediments beneath the Big Glory Bay Farms could be considered a legacy issue. Sanford have confirmed[8] that the company ceased the use of copper based anti-fouling materials since 2006, and that the company is involved in developing technology to speed up seabed recovery and remediation. The revised permit conditions (**Appendix PL2**, Condition B3(e)) now require that the consent holder include procedures, practices and monitoring to reduce those concentrations over time. That condition, combined with the requirement to evaluate, report on, and adopt where feasible updated technology to reduce effects of deposition (Condition B5), represent, in my opinion, an appropriate framework to progressively address, and over time to improve, the legacy copper and zinc concentrations.

10.10 I believe the revised conditions (see **Appendix PL2**) adequately address the concerns raised in the D-G's submission regarding water quality effects and copper/zinc concentrations within the sediments.

[7] Relative to the consent conditions proposed within the initial application.
[8] Sanford letter to the Department of Conservation dated 19 July 2018.

11. CHANGES RELATING TO THE 18 DECEMBER CONDITIONS (SEE APPENDIX PL2) AND KEY ASSUMPTIONS

11.1 The intention of Condition A4(c)(ii) is to identify the number of and sequence for the Chlorophyll-a water quality standard. In recognition of the natural variability of water column Chlorophyll-a levels, the condition intends to allow for (without necessarily triggering a response) limited short term exceedances, or exceedances which occur only within a very limited geographic space.

11.2 After the 18th December 2018, it was noticed that the wording of Condition A4(c)(ii) could potentially allow a single monitoring result (i.e. a result from one site for one month) to be counted under both A4(c)(ii)a and A4(c)(ii)b at the same time. The intention when drafting that condition was that individual monitoring results would be considered only once when determining compliance, and that 'double counting' of single result would not be possible.

11.3 Accordingly, after the 18th December 2018 myself and Mr Baxter for the Department of Conservation and Dr James for Sanford Limited subsequently agreed to the following refinements to this condition to improve clarity (amendments in red font):

> ii. Tier two standard (see condition 4(e)): for three consecutive months, the concentration of chlorophyll-a in the water column (monthly median at any sampling site within Big Glory Bay) exceeding 5 µg/L:
>
> a) at two or more sites for any two of those three consecutive months; and
> b) at one or more sites for the remaining month ~~one of those three consecutive months~~.

11.4 In reviewing the water quality conditions and management, I have relied on an assumption that, if the consent is granted, the total number of water quality monitoring sites, along with the frequency of sample collection, would not be decreased from that which has been used from 2016-2017. i.e. I have assumed that there would be a minimum of 6 monitoring stations which are sampled at least once per month.

11.5 In accordance with Condition A4(f) (see **Appendix PL2**), the specific details of the monitoring plan are anticipated to be developed within the "Big Glory Bay Salmon Farm Environmental Management Plan, and that the monitoring locations would be specified therein. That monitoring plan is to be prepared post-consent, and is subject to the approval of Environment Southland (Condition B1).

12. CONCLUSION

12.1 The D-G's submission raised numerous concerns about the Sanford Limited application including the proposed consent conditions.

12.2 Department of Conservation and Sanford technical advisors (including myself) drafted a revised set of conditions to address these concerns.

12.3 I believe the agreed set of conditions (see **Appendix PL2** of this evidence), with modification as indicated in paragraph 11.3 of this evidence, address the D-G's concerns.

Peter Clifford Longdill

15 March 2019

APPENDIX PL1 - DOCUMENTS CONSIDERED

(a) Sanford Limited, Big Glory Bay Salmon Farms, Change of Conditions Application and Assessment of Environmental Effects, 16 November 2017.

(b) Aquatic Environmental Sciences, Assessment of ecological effects of expanding salmon farming in Big Glory Bay, Steward Island – Part 1 Description of aquatic ecology, Prepared for Sanford Ltd, 26 April 2018.

(c) Aquatic Environmental Sciences, Assessment of ecological effects of expanding salmon farming in Big Glory Bay, Stewart Island – Part 2 Assessment of effects.

(d) NIWA, Big Glory Bay Salmon Farms – Change of Conditions Application by Sanford Ltd. Technical Review prepared for Environment Southland, Invercargill, May 2018.

(e) Sanford Limited, Sanford Big Glory Bay Salmon Farm Resource Consent Variation – Response to Section 92 Request, 23 May 2018.

(f) Data file of Big Glory Bay Water Quality Monitoring Data 2016/2017 (provided by email, electronic file of data which was summarised within the "*Change of Conditions Application and Assessment of Environmental Effects, 16 November 2017* – and its appendices"

(g) Forrest B, Keeley N, Gillespie P, Hopkins G, Knight B, Govier D. 2007. Review of the ecological effects of marine finfish aquaculture: final report. Prepared for Ministry of Fisheries. Cawthron Report No. 1285. 71p.

(h) Hartsein, N.D and Oldman, J.W. 2015. Nitrogen Levels and Adverse Marine Ecological Effects from Aquaculture, New Zealand Aquatic Environment and Biodiversity Report No. 159, prepared for Ministry for Primary Industries.

(i) Vaquer-Sunyer, R., and Duarte, C.M. 2008. Thresholds of hypoxia for marine biodiversity. Proceedings of the National Academy of Sciences, November 2008.

(j) Best Management Practice guidelines for salmon farms in the Marlborough Sounds: Benthic environmental quality standards and monitoring protocol. Final: November 2014.

APPENDIX PL2 –CONSENT CONDITIONS AGREED BETWEEN SANFORD AND DOC, DATED 18 DECEMBER 2018

Big Glory Bay Salmon Farm Resource Consent Variation Proposed Conditions:

A. CONDITIONS PROPOSED IN VARIATION FOR EACH INDIVIDUAL EXISTING CONSENT

Resource Consent AUTH-20157616, relating to MF 246

4. (a) The total nitrogen input from feed at the marine farm site for salmon between 1 July and 30 June each year shall be restricted to 415.1 tonnes provided that:

(i) the total nitrogen input from feed used in Big Glory Bay between 1 July and 30 June each year does not exceed 659 tonnes across all farms in Big Glory Bay, irrespective of ownership; except that

(ii) until such time as the requirements of Condition YY have been satisfied, the total nitrogen input from feed used in Big Glory Bay between 1 July and 30 June each year shall not exceed 583 tonnes across all farms in Big Glory Bay, irrespective of ownership.

Water Quality Objectives:

(b) The marine farm shall be operated in such a way to achieve the following water quality objectives for the water column:

(i) To not cause a shift in the trophic state of the water column (i.e. change towards a eutrophic state), beyond that which is likely to occur naturally.

(ii) To not increase the frequency, intensity, or duration of phytoplankton blooms (i.e. chlorophyll-a concentrations ≥5 µg/l).

(iii) To not cause elevated nutrient concentrations outside the confines of established natural variation for the location and time of the year, beyond 250m from the edge of the farm.

(iv) To not cause reduction in dissolved oxygen concentrations to levels that are potentially harmful to marine biota beyond 250 m from the edge of the farm.

Environmental Quality Standards-water (EQS-water):

(c) Activities authorised by Condition 4(a), in combination with activities authorised by consents [insert all the other consent numbers] shall not result in any one of the following:

(i) Tier one standard (see condition 4 (e)): the monthly median concentrations of chlorophyll-a in the water column within

Big Glory Bay (monthly median from a data set of all monitoring sites) being greater than 3.5 µg/l for three consecutive months; or

(ii) Tier two standard (see condition 4(e)): for three consecutive months, the concentration of chlorophyll-a in the water column (monthly median at any sampling site within Big Glory Bay) exceeding 5 µg/L:

a. at two or more sites for any[9] two of those three consecutive months; and

b. at one or more sites for the remaining month. ~~one of those three consecutive months.~~

(iii) Tier two standard (see condition 4 (e)): an increase in the average monthly excess total ammonia nitrogen in Big Glory Bay of more than 30 µg/L at the surface of the water column, when compared with baseline data from the same or comparable sampling sites from the period July 2015 to December 2017; or

(iv) Tier two standard (see condition 4 (e)): the dissolved oxygen saturation in the water column at any sampling point more than 250 metres from the farm falling below 70% for three consecutive months (measured using 1 metre bins to 2 metres from the seabed).

Environmental Quality Standards-seabed (EQS-seabed):

(d) Tier two standard (see condition 4 (e)): Activities authorised by Condition 4(a) shall meet the following Environmental Quality Standards (EQS) for the seabed within 10 metres of the edge of the pens:

(i) The benthic community retains a diversity and abundance of-marine taxa (other than one or two opportunistic enrichment-tolerant taxa such as Capitellid and Dorvillea worms, and nematodes) at levels which allow for sustained farm waste assimilative capacity and sufficient seabed recovery to support a farm rotation cycle with a fallowing period of not less than 5 years.

(ii) No more than 20% of the not less than 5 replicate cores collected have no taxa present (azoic). In any assessment under this condition, the effects of mussel shell substrate on benthic communities are to be ignored.

(iii) No obvious, spontaneous out-gassing (H_2S/methane)

(iv) Bacteria mat (*Beggiatoa*) coverage not greater than 50% of the sampled area.

(e) Two tiers of responses in support of maintaining the Environmental

[9] Marked changes as agreed with Sanford AFTER 18 December 2018, and summarised within paragraph 11.3 of the evidence of Dr Peter Longdill

Quality Standards (EQS) specified in Conditions 4 (c)(i) – (iv) and 4 (d) shall apply.

(i) Tier one: a breach of Condition 4(c)(i) shall trigger further water quality monitoring, consideration of the wider environment, and investigations aimed to determine any contributing effect from farm operations on chlorophyll-a levels. Where relevant, this Tier one response shall also include the consideration of, and planning for, future management responses to avoid further breaches.

(ii) Tier two: a breach of any of the Tier two standards (Conditions 4 (c)(ii), (iii) and (iv), and 4(d)) shall require reduced stocking and/or fallowing of the marine farm following the next harvest of salmon on that farm to achieve full compliance with the EQS-water or EQS-seabed within 24 months of the date the consent holder receives confirmed notice of such a EQS result through its monitoring. A substantive improvement within 12 months of that date is required.

(f) Water quality monitoring will be detailed in the Big Glory Bay Salmon Farm Environmental Management Plan ("BGBSFEMP") required by the conditions of this consent and shall include monthly sampling of nutrients (total ammoniacal nitrogen, NO_3-N, NO_2-N, DRP, TN and TP), chlorophyll a, phytoplankton composition (reference sites), temperature, dissolved oxygen (DO), water clarity, salinity at the locations specified in the BGBSFEMP. A new "Reference" site outside Big Glory Bay shall be established.

(g) Seabed monitoring will be detailed in the BGBSFEMP and shall include annual monitoring at the locations specified in the BGBSFEMP for sediment grain size, total organic matter (TOM), total organic carbon (TOC), copper and zinc, appearance of sulphide depth and general colour, depth of redox layer, obvious outgassing, mat forming bacteria, epifauna and infauna. If any benthic sample contains a large number of mussel shells or the grab is prevented from closing due to the presence of mussel shells, the sample shall be retaken. In the event that three grab samples at any one location all contain a large number of mussel shells or the grab is prevented from closing due to the presence of mussel shells the sampling location shall be relocated approximately 10 metres distant.

(h) Notwithstanding any other condition of this consent, a suitably qualified, experienced and independent person shall prepare a monitoring plan, the purpose of which is to enable compliance with the standards in Conditions 4(c) and 4 (d) to be assessed.
The monitoring plan shall be submitted to Environment Southland for approval in a technical certification capacity two months before the total nitrogen input from feed in Big Glory Bay authorised by consents [list to come] is increased above 483 tonnes/year.

(i) In addition to the requirements of conditions 4(f) and (g), the BGBSFEMP shall set out the details of:

(i) Possible responses to a Tier one standard breach requiring further monitoring and/or analysis to determine whether the operation of the marine farm is causing the relevant EQS-water not to be achieved; and

(ii) Possible management responses to a Tier two standard breach requiring a clear decision process and plan of action, with clear

timeframes to reduce effects on the water column or seabed and achieve full compliance with the EQS-water or EQS-seabed in accordance with Condition 4(e)(ii).

Advice note: This consent expires in 2025, following which the on-going efficacy of the conditions of this consent, and especially Conditions 4 (b), 4 (c) and 4 (d), will need to be reassessed, having particular regard to the monitoring undertaken in accordance with Condition XXX.

DETAILS OF THE OTHER FARM SPECIFIC CONSENTS HAVE BEEN DELETED – TO AVOID REPETITION.

B. ADDITIONAL CONDITIONS PROPOSED TO BE INCLUDED ON EACH INDIVIDUAL CONSENT

Big Glory Bay Salmon Farm Environmental Management Plan

1. Notwithstanding any other conditions of this consent, the consent holder shall, no later than [insert date], submit to Environment Southland, a Big Glory Bay Salmon Farm Environmental Management Plan ("BGBSFEMP") for approval in a technical certification capacity.

2. The BGBSFEMP required by Condition 1:

    a. May be updated by the consent holder at any time; and
    b. Shall be updated by the consent holder at least once in every two year period;
    c. Address relevant matters identified in the latest Technology Update Report;

    provided that any updated provisions shall only apply, once the updated BGBSFEMP has been approved in a technical certification capacity by Environment Southland.

3. The purpose of the BGBSFMP required by Condition 1, or any updated BGBSFEMP prepared in accordance with Condition 2, is, as a minimum, to set out:

    a. The procedures and practices to by implemented by the consent holder in order to ensure compliance with Conditions 4(c), 4(d) and 4(e) of consent AUTH-20157616 [and the other consents having the same requirement];] of this consent; and
    b. The proposed layout of each salmon farm site and how this is expected to change over each two year period; and
    c. The maintenance procedures to be followed to ensure the ongoing efficacy of all salmon farm structures; and
    d. The procedures and practices to be implemented to minimise, to the extent practicable, the interactions of marine mammals and seabirds with the farm site; and
    e. The procedures, practices and monitoring to be implemented to meet the objective of reducing historically elevated concentrations of copper and zinc in sediments beneath the farm site to those that satisfy the ANZECC (2000) Interim Sediment Quality Guidelines; and
    f. How the results of the monitoring required by the conditions of this consent will be utilised to adapt, as quickly as practicable, operational farming practices, including but not limited to the fallowing of individual sites, in the event that monitoring indicates that unforeseen environmental effects may arise;

g. Any changes in salmon farming technology and/or farm management practices identified in the Technology Update Report required by Condition 5 that the consent holder proposes to implement: and
h. Provide robust environmental data to inform the applications for replacement consents once these consents expire in 2025.

4. When determining practicability for the purposes of Condition 3 f), the following factors will be considered:

a. The requirements of Conditions 4(c), 4(d) and 4(e) of consent AUTH-20157616 [and the other consents having the same requirement]; and
b. Fish should be allowed to grow to market ready size before being harvested; an
c. Salmon cage relocation to allow fallowing should not compromise fish health or the scheduling of fish harvesting.

Technology Update Report

5. At three yearly intervals during the term of this consent, the consent holder shall engage an appropriately qualified and experienced professional to prepare a Technology Update Report and, following consultation with Environment Southland, provide it to Environment Southland.

The purpose of the Technology Update Report is to:

a. Evaluate and report on any new developments in salmon farming technology and/or farm management practices that have the potential to reduce the deposition on the seafloor of:
   i. Uneaten salmon feed; and
   ii. Salmon faeces.
b. Any environmental benefits that could be expected by adopting that technology and/or farm management practice; and
c. The feasibility of adopting that technology and/or farm management practice, including, but not limited to financial implications.

Advice Note

Conditions 1 – 4 are included on each of the consent holder's salmon farming resource consents in Big Glory Bay. It is envisaged the one BGBSFEMP and one Technology Update Report will be prepared that addresses all the consent holder's salmon farms in Big Glory Bay, rather than having a number of individual documents.

Add the Following to the Monitoring Condition of each Consent

6. The annual monitoring report required by Condition [y] of this consent shall include:
   a. A comparison with the results of previous monitoring at the same salmon farm site;
   b. Identification of any potential environmentally significant monitoring trends, at both the site and Big Glory Bay scales; and
   c. Identification of any proposed additional monitoring, including the rationale for it, and the proposed scale, extent and timeframes involved.
   d. An evaluation of the potential implications of the monitoring results from all salmon farming operations undertaken in Big Glory Bay by the consent holder on the environmental quality of Big Glory Bay;
   e. The extent to which the monitoring results indicate that farming practices may need to be adapted in order to address unforeseen environmental effects indicated by the monitoring results.

Add the Following to the Review Condition of each Consent

7. Adding or amending conditions in order to address any matter raised in:

i. The annual monitoring report insofar as it relates to Condition [X immediately above]; or
ii. The Technology Update Report required by Condition 5.

Add the Following Condition to each Consent

Staging

8. The total nitrogen input from feed used in Big Glory Bay between 1 July and 30 June each year shall not exceed 583 tonnes across all farms in Big Glory Bay, irrespective of ownership until:
   a. At least 1 July 2021; and
   b. The total nitrogen in feed used in Big Glory Bay between 1 July and 30 June in each of three successive years has been at least 466 tonnes; and
   c. The relevant farm(s) has operated for a period of three successive years at levels of between 85- 100% of its allowable individual nitrogen input; and
   d. Monitoring results of the past two successive years for both seabed and water quality are not indicating results and/or statistically significant trends towards progressively greater environmental effects of the farms.
   e. A suitably qualified, experienced and independent person has confirmed, in writing, that the increased input of nitrogen in feed should meet the requirements of Conditions 4(c) and 4(d) of consent AUTH-20157616 [and the other consents having the same requirement] and that the requirements of a – d above have been satisfied; and
   f. Environment Southland certifies that the requirements of clause b and c of this condition have been satisfied.