Tabled at Hearing on 18 November 2015

Proposed Plan Change 3 (SCCS Area) to the Operative Canterbury Land and Water Regional Plan

Summary of Evidence of Donna Lee Sutherland

on behalf of Hunter Down Development Company Limited

1 My evidence centres around Wainono Lagoon and the proposed flow augmentation including the:

(a) Current state of water quality and primary productivity in Wainono Lagoon,

(b) Potential effects of increased nutrient loads on water quality and primary productivity in the lagoon, and

(c) Potential effects of flow augmentation on both the water quality and primary productivity in the lagoon.

Current state of water quality and primary productivity in Wainono Lagoon

2 Wainono Lagoon is characterised by high phytoplankton biomass. Phytoplankton are comprised of microscopic free-floating algae and cyanobacteria and their biomass is quantified using chlorophyll-*a* as a standard unit of measure. High phytoplankton productivity is, in part, strongly related to high water column nutrient concentrations. The 10 year (2000-2010) long-term mean chlorophyll-*a* in Wainono Lagoon was 23.7 mg m^{-3}, with a peak biomass of 240 mg m^{-3}. To place this in context, Lake Waitaki has a long-term mean chlorophyll-*a* biomass of 1.5 mg m^{-3}, and a peak biomass of 3.3 mg m^{-3}.

3 The trophic level index (TLI) is a numeric measure of the lake water quality, or the life-supporting capacity per unit volume of a waterbody. The TLI was developed for New Zealand lakes and is determined using measurements of total nitrogen (TN), total phosphorus (TP; both key growth nutrients), chlorophyll-*a* and, in most cases, Secchi depth (a measure of water clarity).

4 Wainono lagoon is currently classified as hypertrophic with a mean TLI_3 of 6.5. Hypertrophic is the highest level (the most nutrient-enriched state) under the TLI classification. This means that the waterbody has been excessively enriched with nutrients, which results in high phytoplankton biomass production and frequent blooms. In its present state, Wainono Lagoon exceeds the maximum TLI objective of TLI $\leq$6.0 (anticipated under PC3).

5 High turbidity, or low water clarity, is another key water quality feature of the lagoon. Suspended sediment gives rise to the characteristic brown coloured appearance of the water column. Between 2000 and 2010, turbidity ranged from 4 to 2,500 NTU, with a mean turbidity of 100 NTU. High turbidity in the lagoon is a result of the high sedimentation within the lagoon, the shallow water column (~ 1m) and frequent wind-driven mixing that results in re-suspension of bottom sediments.

Potential effects of increased nutrient loads under Scenario 2a to Wainono Lagoon

6 I first looked at Scenario 2a in my evidence – the development of irrigation without augmentation.

7 Under Scenario 2a we would expect increased phytoplankton biomass production, an increase the frequency of bloom formations and a further increase the TLI score, further degrading water quality in Wainono Lagoon. Both mesocosm enrichment experiments and coupled hydrodynamic-ecosystem models were used to predict the increase in phytoplankton biomass as a result of increased nutrient loads. The long term mean biomass would be anticipated to increase between 40 and 50%, while peak may exceed 370 mg m^{-3}. Such increases in biomass production are likely to result in more pronounced daily fluctuations in dissolved oxygen and pH and may negatively impact other biota.

8 While high phytoplankton biomass is often associated with turbidity in a waterbody, it is likely to be second to wind-driven re-suspended bed sediment as the primary driver of turbidity in Wainono Lagoon. Currently, there is only a very weak positive correlation (R^2 = 0.281) between turbidity and chlorophyll-*a* concentration in the lagoon. While increased phytoplankton biomass under the proposed Scenario 2a would further increase turbidity, this is likely to only be detected during extended calm periods when sediment has settled out of the water column.

Potential effects of flow augmentation under Scenario 2b to Wainono Lagoon

9 I then considered the effects of flow augmentation under Scenario 2b – being irrigation development **and** augmentation.

10 The principle behind flow augmentation is the reduction in nutrient (nitrogen and phosphorus) concentrations in Wainono Lagoon through dilution with lower nutrient waters. Flow augmentation will involve the removal of water from the Waitaki River, just downstream of Lake Waitaki, and add it to Wainono Lagoon's inflows. On the TLI scale, Lake Waitaki is currently regarded as being in an oligotrophic state, meaning that the lake has low biological productivity, and relatively high water quality i.e., low nutrients, highly valued colour and clarity, limited phytoplankton productivity, and no known blooms

of nuisance or toxic phytoplankton. Oligotrophic state is four orders of magnitude below the current hypertrophic state of Wainono Lagoon.

11 The dilution of nutrients is anticipated to reduce phytoplankton biomass in the lagoon - although potential physiological adaptations by the phytoplankton make it difficult to accurately predict the degree of reduction in biomass productivity in response to flow augmentation. A recent study I undertook on wastewater phytoplankton demonstrated that when nutrient loads were diluted by half there was only a 15-30% (seasonally dependent) reduction in phytoplankton biomass (i.e. the response is not necessarily proportion to the dilution that occurs). This was due to improved physiological performance of the phytoplankton in response to reduced nutrient load, meaning that the phytoplankton were better adapted at utilising available resources. For this reason, the degree of flow augmentation required to achieve TLI ≤6.0 was based on mass balances for TN and TP alone. These calculations predict that augmented inflows of approximately between 952 and 1270 L s^{-1} would result in sufficient dilution of both TN and TP to achieve TLI ≤6.0.

12 Increased inflow into the lagoon derived from flow augmentation will most likely result in a decrease in the residence time. Residence time is the time that a parcel of water remains in the lagoon and affects the accumulation of phytoplankton biomass, with accumulation decreasing as residence time decreases. Increased inflows will flush the lagoon on a more frequent basis than current, particularly during drier summer months. This will help contribute to reduced biomass accumulation.

13 Water originating from Lake Waitaki is typically low in turbidity relative to Wainono Lagoon. While suspended glacial flour gives rise to a slight milky blue appearance of the water, median turbidity in the lake is typically < 2NTU. Long-term (198-2014) records of turbidity in the Waitaki River show a slight increase in turbidity after the water leaves the lake. Long-term median and mean turbidity in the Waitaki River at Kurow was 2.4 NTU and 6.5 NTU, respectively. During this period, turbidity exceeded 6 NTU on 26% of the monitoring occasions, and exceeded the median turbidity of Wainono (100 NTU) < 0.3% of the time (1 occasion). In my opinion, given the very high natural turbidity in Wainono Lagoon relative to Waitaki derived water, a limit of turbidity of 6 NTU is not necessary, although flood flows in the Waitaki River, where turbidity exceeds that of the median turbidity of Wainono, should not be diverted to the lagoon as flood flows typically include sediment run-off from land high in TP.

14 The addition of the lower turbidity waters from the Waitaki River into Wainono Lagoon will most probably result in a dilution of turbidity within the Lagoon. Increased flushing may also help to reduce the suspended sediment in the lagoon over the long term.

However, suspended sediment is most likely to still be the main contributor to turbidity in the lagoon and the brown appearance to the water column likely to remain.

15 While mass balance calculations and model predictions suggest that flow augmentation into Wainono Lagoon will be sufficient to achieve TLI $\leq$6.0, I acknowledge that some uncertainty exists in the predicted response of phytoplankton, management of the water quality in the Upper Waitaki lakes, inter-annual climatic variability and improvements in on-farm management practices. For these reasons, I consider that flow augmentation needs to be monitored and managed adaptively (balancing dilution and residence time) to ensure that intended outcomes are met. Such an adaptive management plan should include but not necessarily be limited to):

a) Provision for monitoring-triggered bloom remediation flow,

b) Provision for flow adaption based on "lessons learnt" from previous years,

c) Cease augmentation flow during periods of high sediment load in the source (Waitaki) water.

16 In summary of my evidence, flow augmentation offers the most immediate solution to improving the water quality of Wainono Lagoon and, as discussed in my evidence, it appears on the assessments undertaken that there is a good chance that TLI $\leq$6.0 is achievable – especially if adaptive management is applied.

17 Given that the PC3 approach is dependent on augmentation delivering the outcomes anticipated and uncertainties acknowledged in my evidence, it should also be noted that there are other options that can be employed on smaller scales to assist with nutrient mitigation, both within the catchment and within the immediate lagoon vicinity. Such options can be used as a further compliment to flow augmentation and are discussed in my evidence.