Date: 7 April 2017

MEMORANDUM

FROM: Ned Norton (LWP)

TO: James Palmer (Group Manager Strategic Development, Hawkes Bay Regional Council)

SUBJECT: REVIEW OF THE RUATANIWHA WATER STORAGE SCHEME: ISSUE 12

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Summary of key findings:

a) Environmental monitoring tells a complex story of how achievement of several Plan Change 6 (PC6) environmental objectives and limits currently varies in time and across the catchment. The two key measurable environmental objectives for periphyton and macroinvertebrate community index (MCI) health do not always comply and improvement is necessary.

b) Many factors influence achievement of periphyton and macroinvertebrate health objectives including; river flows, the nutrients nitrogen and phosphorus, sediment, organic contaminants, physical habitat quality, and riparian condition and shading.

c) In general, there is no headroom to increase dissolved reactive phosphorus (DRP) at a whole catchment scale; rather there is a need to reduce DRP in order to i) meet PC6 instream DRP limits and ii) as part of a multi-pronged approach to achieve periphyton and MCI objectives.

d) There is considerable headroom for further nitrogen losses under the Land Use Capability (LUC) leaching rates set in Ruataniwha Water Storage Scheme (RWSS) consent conditions and in PC6 Policy Table 5.9.1D. It is estimated this headroom allows for an increase on current nitrogen losses in the order of 30-50% on a whole catchment basis (e.g. above Red Bridge). The amount of this headroom for nitrogen loss varies considerably between sub-catchments.

e) In contrast there is no headroom for further increase in dissolved inorganic nitrogen (DIN) concentrations in the upper catchment (i.e. above Shag Rock) when assessed against the 0.8 mg/L PC6 instream DIN limit. Reductions to current nitrogen loss would be needed in several catchments in the RWSS area to meet this limit.

f) I have discussed the apparent disconnect between the 30-50% LUC-based headroom for nitrogen and the nil (or negative) DIN limit-based headroom in the upper catchment, and the lack of clarity this creates for resource use. Planning and legal issues around the extent to which the RWSS is responsible to the 0.8 mg/L DIN limit are being addressed under review Issue 17.

g) The 0.8 mg/L DIN concentration is not a defensible threshold between healthy and unhealthy ecosystems. I have described it as a point on a risk spectrum, where increasing concentrations mean increasing risk of uncertain negative effects on periphyton blooms and macroinvertebrate community health (e.g. MCI). Other factors such as flow, phosphorus, sediment, physical habitat and riparian condition also influence whether periphyton and macroinvertebrate health objectives will be met.

Summary answers to three key questions:

QUESTION 1: What land uses and on-farm management practices would be required to meet LUC-based nutrient leaching allocation rates?

1. I think it would be relatively straight forward for the RWSS to operate with any of a wide range of possible land uses, using currently available good on-farm management practices, and meet its current consent conditions relating to LUC leaching rates, albeit with considerable management effort.

QUESTION 2: What land uses and on-farm management practices would be required to meet an instream DIN concentration of 0.8 mg/L?

2. In contrast I think it would be very difficult for the RWSS to operate within the significantly smaller nitrogen losses implied by the instream DIN limit of 0.8 mg/L. If the RWSS increased nitrogen losses under its LUC-based allocation and then had to subsequently reduce to meet the DIN limit of 0.8 mg/L by 2030, then it would need to: i) change land use to significantly lower nitrogen losses and/or ii) innovate to find new N-loss technologies and/or catchment-scale mitigations such as a network of wetlands and/or iii) revise the DIN limit upwards. There are unavoidable risks for RWSS in relying on any or all of these.

QUESTION 3: Could the water quality objectives of PC6 still be achieved in the event that the PC6 DIN limit of 0.8 mg/L is not met by 2030?

3. My answer is: Yes maybe, but it is undeniably and unavoidably uncertain; there are risks that periphyton and ecosystem health (MCI) objectives will not be achieved everywhere. Achieving them would rely on many things in addition to the effects of the RWSS total nitrogen loads and associated instream DIN concentrations. The multi-pronged strategy proposed by RWSS would need to be relied on, that includes:

a) reducing instream DRP from both diffuse sources and community wastewater treatment plant point discharges,

b) provision of flushing flows from RWSS storage to manage the frequency and duration of nuisance periphyton in some river sections (see review Issue 16),

c) riparian habitat enhancements that could improve habitat quality, shading and reduce fine sediment loss to streams,

d) an ability for the RWSS to adaptively manage local hotspots for nutrients by requiring extra phosphorus mitigations and lower than LUC-based nitrogen leaching rates in parts of the scheme area, in response to any monitoring that shows local breaches of periphyton and/or MCI outcomes, and

e) improved flows in some stream sections due to i) PC6 higher minimum flows, ii) migrating some current groundwater extractions onto RWSS stored water, and iii) the potential for providing some flow augmentation to some stream sections from RWSS storage.

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1. The scope of this review of Issue 12

1 The scope of this review is to assist with addressing “Issue 12” of the “Review of the Ruataniwha Water Storage Scheme [RWSS]” (the Review) as described in a paper to Council on 14 December 2016 which scoped Issue 12 as:

> “*Assessment of on-farm management practices, including stocking levels and associated land-use constraints, required to meet the nutrient leaching and groundwater water quality requirements of Plan Change 6* [PC6] *and the Regional Policy Statement. Estimate of current compliance within existing land uses and the extent of headroom for intensification and land use change will be provided. Estimate implications for the RWSS in meeting consent conditions relating to scheme water users and nutrient limits.*”

2 This scope has evolved as the work has proceeded. In particular the review of Issue 12 has expanded to include consideration of questions submitted in a letter from a joint submitter group comprising the Environmental Defence Society, Forest and Bird, and Fish and Game New Zealand dated 25 November 2016 (the EDS-F&B-F&G letter). The scope may also expand to take on any feedback and/or questions that may arise from a meeting with the Community Reference Group on 30 March 2017.

3 The assessment of Issue 12 requires a range of expertise that has been provided by several parties who have been engaged in consultation with Hawkes Bay Regional Council (HBRC) and is being led by HBRC staff. Other key contributors are Lachie Grant and Ian Millner (both external providers), Shane Lambert (HBRC Senior Planner), Nathan Heath (HBRC Acting Manager – Land Management) and several HBRC technical staff including Dr Andy Hicks and Mr Dougall Gordon. In brief, the assessment of on-farm management practices required to meet nutrient leaching rates and groundwater quality requirements of PC6 has been undertaken by Lachie Grant and Ian Millner, an assessment of current environmental state (based on monitoring data) compared to environmental objectives and limits in PC6 has been undertaken by Andy Hicks and Dougall Gordon.

4 I have assessed the current environmental state in relation to the concept of headroom for intensification and land use change, and assessed possible consequences of the RWSS on that headroom and for the water quality objectives defined in PC6 - specifically the periphyton and aquatic ecosystem health (macroinvertebrate) objectives.

2. Expertise

5 I do not have specialist expertise in assessing the on-farm management practices needed to achieve specific nitrogen and phosphorus loss rates from properties. However I am familiar with the methods used by others, such as Lachie Grant and Ian Millner, who do have this expertise. I am familiar with interpreting results of farm nutrient management assessments in order to assess effects on water quality and related environmental outcomes. I have specialist expertise in assembling and integrating information from multiple technical disciplines, including water quality and aquatic ecology, in order to assess consequences of land and water development scenarios on environmental outcomes. I also have expertise in relating such assessments to policy and planning requirements.

3. My approach to tackling Issue 12

6 I understand that I have been asked to provide a 'fresh eyes' review of matters around Issue 12 in order to assist the Council in understanding, overall "…*the costs and benefits of the scheme, as well as risks and opportunities with decisions to proceed, abandon or shelve the scheme*…". I understand that the purpose of the review is not to recommend to Council whether to proceed, abandon or shelve the RWSS but to objectively facilitate informed decision making by the Council.

7 I have read a large amount of information about the RWSS and PC6 in a short period of time. It has been challenging to read all this material and to sort the 'wood from the trees' in order to respond to Issue 12. While I have read everything I thought relevant, it is possible I could have missed something that has a bearing on my review conclusions. I am anticipating that this risk will be managed by the review process. This process will allow for feedback from the Community Reference Group and/or Council, and the opportunity to raise questions if something important has been missed.

8 I have found it necessary to explore a number of interrelated topics and give my view on them in order to establish sufficient background to answer the questions that arise from Issue 12. I cover these topics first under the following sub-headings, before returning to answer three specific questions arising under Issue 12 at the end:

- Current environmental state and the concept of headroom
- A disconnect between 2 types of headroom for nitrogen
- Confusion around the environmental significance of a 0.8 mg/L DIN concentration
- Dealing with issues of uncertainty, and thus risk
- Answering the questions that arise out of Issue 12

4. Current environmental state and the concept of headroom

9 Several HBRC technical staff[1] assisted this review by providing up to date summaries of current environmental state with respect to several relevant environmental measures that appear in PC6 in either the objectives (OBJ TT1) or policies (Limits and Targets Tables 5.9.1A-D and 5.9.2).

10 The relevant objectives appearing in OBJ TT1 are:

- "*The frequency and duration of excessive periphyton growths* [i.e. growths that exceed the Table 5.9.1 numeric periphyton limits as shown below] *that adversely affect recreational and cultural uses and amenity are reduced*".

- "*Groundwater levels, river flows, lake and wetland levels and water quality maintain or enhance the habitat and health of aquatic ecosystems, macroinvertebrates, native fish and trout*". [Numeric indicators of the habitat and health of macroinvertebrates are then provided in terms of Macroinvertebrate Community Index (MCI) scores in Table 5.9.1 as shown below].

11 The relevant measures appearing in policy Tables 5.9.1(A-D) and 5.9.2 are:

- Periphyton biomass limits of a maximum of 50 mg Chlorophyll a/m^2 for Zone 4 (Upper Tukituki and Waipawa Rivers) and 120 mg Chlorophyll a/m^2 everywhere else (i.e., Zones 1, 2, 3 and 5).

- Other periphyton limits for measures of visible percentage bed cover by filamentous algae, diatoms and/or cyanobacteria mats, the latter of which typically picks up the well-known potentially toxic *Phormidium* species mats.

- Dissolved Reactive Phosphorus (DRP) limits ranging from 0.004 to 0.015 mg/L depending on which of five management zones is considered.

- Dissolved Inorganic Nitrogen (DIN) limits of 0.150 mg/L for Zone 4 (Upper Tukituki and Waipawa Rivers) and 0.8 mg/L everywhere else (i.e., Zones 1, 2, 3 and 5).

[1] Dr Andy Hicks and Mr Dougall Gordon

- Nitrate-nitrogen limits for chronic toxicity protection of 2.4 or 3.8 mg/L (as a median and depending on zone) and acute toxicity protection of 1.5, 3.5 or 5.6 mg/L (as a 95^{th} percentile and depending on zone).

- MCI minimum indicator scores (as an average calculated over 5 years) of 100 or 120 depending on zone and whether at a main-stem or tributary site.

- Tukituki Land Use Capability (LUC) Natural Capital Nitrogen Leaching Rates ranging from 3 kgN/ha/year for LUC Class VIII land, to 30.1 kgN/ha/year for LUC Class I land.

- Groundwater quality limits and indicators applicable 10m or more below ground level in productive aquifer systems: a maximum 95^{th} percentile concentration of nitrate-nitrogen of 11.3 mg NO_3-N/L and a maximum annual average concentration of 5.65 mg NO_3-N/L.

12 Detail of the assessment of current environmental state with respect to the above indicators is provided in the memoranda attached by Dr Andy Hicks and Mr Dougall Gordon. Detail concerned with estimates of current compliance of existing land uses with the LUC-based nitrogen leaching rates are contained in the material provided by Mr Lachie Grant and Mr Ian Millner.

13 In this review I have found it necessary to examine and clearly define the notion of 'headroom' because this term is used in the definition of the scope of Issue 12 quoted above and is also used in the EDS-F&B-F&G letter. It seems to me that there is potential for confusion and parties talking past each-other if the concept of headroom and the different ways it can be assessed are not clarified here.

14 I will use the concept of 'headroom' here to mean the difference between a prescribed desired indicator state (whether it be a plan objective or a limit) and the current state for that indicator as estimated using monitoring data. If the current state for an indicator is within (i.e., achieves) the desired state then we say there is some headroom available in the catchment, nominally for use of land and water resources that might put pressure on that environmental state. In other words headroom can be thought of as available capacity for use. If the current state is at or beyond (i.e., not achieving) the desired state then we say there is no headroom, or indeed there may be negative headroom (sometimes called 'shortfall'), implying that some improvement is needed in the way that land and water resources are being managed in order to achieve the desired state. The size of the headroom (or negative headroom) is indicated by the size of the difference between the current state and the desired state, recognising the uncertainties involved in estimating this for any given indicator.

15 The following is a high level, whole catchment scale summary of the current situation with regard to current environmental state and headroom associated with each of the relevant indicators. The detail behind this summary is shown in the memoranda attached by Dr Andy Hicks and Mr Dougall Gordon. The situation is complex in that it varies in time and space (i.e., monitoring results vary from site to site across the catchment and across days, seasons and years); the following summary is intended to provide context for addressing the review questions at a broad scale (i.e., at the whole RWSS and catchment scale).

16 **Periphyton**: There are regular “excessive” periphyton growths (i.e., growths that exceed the numeric biomass limits) at many sampling sites. There is no headroom for further deterioration of this indicator because the objective established in OBJ TT1 is to reduce (i.e., improve) the current frequency and duration of these growths.

17 **MCI** (as the indicator of aquatic ecosystem health used in PC6): While 10% of sites currently meet the MCI indicator target scores, many sites currently regularly fail. There is no headroom for further deterioration of this indicator because the objective established in OBJ TT1 is to maintain or enhance ecosystem health.

18 ***Phormidium***: Approximately 90% of sites currently meet the relevant limits but *Phormidium* is sometimes an issue in some areas. In round terms, because *Phormidium* is a sub-part of meeting periphyton objectives, there is no headroom for further deterioration of this indicator.

19 **DIN**: Approximately 65% of sites currently meet the relevant DIN limit. The amount of potential headroom or negative headroom varies spatially. In general there is negative headroom in the upper catchment (i.e., above the Shag Rock monitoring site, with a few sub-catchment exceptions)[2], but due to attenuation that reduces DIN concentrations further downstream there is theoretically limited headroom downstream of Shag Rock. For example the EDS-F&B-F&G letter points to a valid estimate by the Board of Inquiry (BOI) of headroom of around 69 tonnes/yr of DIN at Red Bridge[3]. This is equivalent to approximately a 6.5% increase on current nitrogen losses from land in the catchment above that point.[4] In practice if the DIN limit of 0.8 mg/L is to be achieved everywhere then in round terms there is no headroom for further increase in nitrogen losses in the catchment above Shag Rock.

20 **Nitrate toxicity**: All sites meet the acute toxicity limits and almost all sites always meet the chronic toxicity limits. While there are a few exceptions that will require local reductions to fully achieve chronic toxicity limits (i.e., some areas of negative headroom)[5], in round terms there would theoretically be some headroom for further increases in instream nitrate concentrations in the catchment while staying within chronic and acute nitrate toxicity limits. However this headroom would only be available if nitrate did not need to be managed at a lower concentration in order to achieve periphyton objectives. The 0.8 mg/L limit for DIN (which is largely comprised of nitrate) effectively makes the nitrate toxicity limits and any theoretical headroom associated with them redundant.

21 **DRP**: Approximately 25% of sites currently meet the relevant instream DRP concentration limit. In general there is negative headroom for DRP at a catchment scale;

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[2] As illustrated in data and maps provided in an Agreed Joint Statement to the Board of Inquiry by Water Quality Experts (Olivier Ausseil, Adam Uytendaal, Kate McArthur) dated 10 February 2015.

[3] EDS-F&B-F&G letter paragraphs [7]-[8]

[4] I have deliberately expressed headroom in terms of allowable percentage increases on current N losses in order to avoid i) the confusion that is generated by use of absolute tonnages that change when new versions of OVERSEER come into play, and ii) confusion around the difference between tonnages of ‘source’ loads lost from land (which relate to LUC and OVERSEER-based nitrogen loss rates) and the related post-attenuation tonnages of ‘receiving environment’ loads which are relevant for testing likely compliance with instream DIN concentrations. For the purpose of broadly assessing the relative sizes of different amounts of headroom I consider that use of percentage increases/decreases compared to current are appropriate and are likely to be most helpful for Council in the context of informing broad decision-making from this review.

[5] For example as identified in the evidence of Bob Wilcock and Dr Kit Rutherford to the BOI hearings (September 2013)

i.e., there is a need for a reduction in instream DRP concentrations in order to i) meet the PC6 DRP limits everywhere, but also ii) as part of a necessarily multi-pronged approach to try and achieve the PC6 periphyton objectives, as will become clearer later in this review.

22 **LUC-based nitrogen leaching rates**: Details about the current extent of compliance with LUC-based leaching rates are provided in the attached memorandum by Lachie Grant who assessed farm plan data from 96 properties. He found that while 14 of the 96 properties leached higher than the LUC rates the other 82 properties leached lower, and the total amount of nitrogen currently leached across the 96 properties was 29% lower than the total amount permissible under the LUC rate allocation regime; i.e., there was 29% headroom[6]. This estimate is close to the estimate of 30% headroom that I calculated from the figures offered in the EDS-F&B-F&G letter[7]. A third line of evidence which supports an estimate of about 49% headroom under the LUC-based allocation rates can be found in modelling results produced by Kit Rutherford for the BOI hearings[8]. There are uncertainties with all these estimates but together they suggest that the amount of headroom is considerable and in the order of 30-50% on a whole catchment basis above Red Bridge.

23 **Groundwater nitrate**: All sites currently meet the11.3 mg NO_3-N/L groundwater quality limit (i.e., as a 95th percentile). About 36 % of sites have 95th percentile nitrate nitrogen concentrations between the ½ Maximum Acceptable Value (MAV) of 5.65 mg/L and the MAV of 11.3 mg/L which indicates emerging higher nitrate concentrations in shallower sections of the aquifer system; although all but one site met the 5.65 mg NO_3-N/L PC6 indicator as an annual average. In round terms this indicates that there would be some headroom for further increases in groundwater nitrate concentrations while staying within the relevant PC6 limits, although assessing the size of this headroom is confounded by uncertainty around lag times for nitrate from land use appearing in groundwater and variable attenuation rates (i.e., substantial attenuation in the Tukituki sub-catchment zone but little in the Waipawa sub-catchment zone)[9]. There are clearly risks with assuming that there is any headroom for increased groundwater nitrate concentrations. A pragmatic and conservative response is to strive to ensure that nitrate concentrations in drainage water leaving the root zone from farm operations are less than 11.3 mg NO_3-N/L so that after any dilution and attenuation the groundwater limit would always be met. Commentary has been provided by Lachie Grant (memorandum

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[6] In his memorandum (attached) Lachie Grant described uncertainties around this estimate and illustrated the variability in headroom between sub-catchments; he estimated that the Papanui sub-catchment has headroom of 44%, the Tukipo 17%, the Waipawa 48% and the Maharakeke 29%.

[7] To explain: the EDS-F&B-F&G letter offered that LUC-based leaching requirements amount to an additional RWSS consented nitrogen load of 624 tonnes/yr which I have estimated to represent approximately 312 tonnes/yr after catchment attenuation at Red Bridge[7], which is approximately a 30% increase on current and is approximately 4.5 times the size of the DIN-based headroom estimated for that site earlier in this review.

[8] In Dr Kit Rutherford's evidence presented to the BOI he estimated that application of LUC-based limits would lead to increased DIN concentrations of between 19% and 120% at 10 sites and small decreases (3 to 9%) at three of the thirteen sites modelled compared to current. While it was not the purpose of that evidence to estimate catchment nitrogen loads and headroom under an LUC-based allocation regime, I asked him that question during this review and he was able to extract results from the earlier modelling exercise to produce an estimate of 49% headroom for the catchment as a whole above Red Bridge, with sub-catchment headroom estimates ranging from -5% to 150%.I note that this is not greatly different to the 30% increase in nitrogen losses predicted in Dr Rutherford's BOI evidence for the catchment as a whole (and between 30% and 70% in zones 2, 3 and 5) under the RWSS operating as originally proposed rather than under LUC-based leaching limits.

[9] Memorandum provided by Dougall Gordon (HBRC)

attached) which suggests that this is likely to be achievable on a whole farm average basis if farms use good management practices and are compliant with the PC6 LUC-based leaching rates.

5. A disconnect between 2 types of headroom for nitrogen

24 It is necessary, in order to address the requirements of Issue 12 and the questions raised in the EDS-F&B-F&G letter, to address both the notion of LUC-based allocation headroom ('LUC-based headroom') and of headroom associated with achieving the PC6 instream DIN concentration limits ('DIN-based headroom'). I think this is necessary in order to transparently explore the questions that arise from Issue 12.

25 While discussing these two types of nitrogen headroom, I make no inference about the extent to which the RWSS is enabled by its consent conditions to operate up to its maximum allocation (i.e., LUC-based headroom) versus requirements to contribute to achieving the instream PC6 DIN limits. It is clear from reading the available material[10] that different planning and legal views have been expressed by various parties on this matter. Legal and planning implications of this are being addressed elsewhere under Issue 17 of the wider Review. Here I will assess possible consequences for environmental outcomes in either case, which is essentially what has been requested by questions 3a(ii) and 3a(iii) in the EDS-F&B-F&G letter.

LUC-based headroom

26 As already identified in the previous section, the LUC-based nitrogen leaching headroom is substantial; in round terms it is in the order of a 30-50% increase on current estimated total nitrogen leaching losses from land on a whole catchment basis above Red Bridge.

DIN-based headroom

27 In contrast, the DIN-based headroom is negative in some upper parts of the catchment; i.e., reductions in nitrogen losses are required above the Shag Rock monitoring site in order to meet the instream DIN limit of 0.8 mg/L at that site. At best the data used by the BOI suggest there is headroom for around a 6.5% increase on current total nutrient leaching losses in the catchment upstream of Red Bridge in order to meet the instream DIN limit of 0.8 mg/L at that site, but not necessarily at sites upstream.

28 I will return to these two types of headroom for nitrogen and the apparent disconnect between them in PC6 shortly, after first discussing some confusion around the environmental significance of a DIN concentration of 0.8 mg/L.

6. Confusion around the significance of a 0.8 mg/L instream DIN concentration

29 Much has been said about the environmental significance of an instream DIN concentration of 0.8 mg/L, both during the BOI hearings and subsequently in relation to

[10] Multiple legal opinions, letters and meeting notes on the interpretation of RWSS consent conditions – see review of Issue 17.

both the Tukituki situation, and whether this DIN concentration is relevant for other parts of the country. Four observations are useful here:

a) The BOI sourced the DIN limit concentration of 0.8 mg/L from a model[11] provided in the evidence of Professor Russell Death to the BOI hearings, which was based on correlation relationships between desired MCI scores and DIN concentration data.

b) I have not been able to find any statements in the BOI evidence or in related material that demonstrate the strength or statistical significance of the correlation relationships used between MCI and DIN data in the Tukituki or other catchments.

c) In any case, even if a correlation relationship is statistically strong it is incorrect to infer cause and effect from that relationship. This is a basic and widely understood scientific principle.

d) Many factors influence the health of macroinvertebrate communities in addition to instream DIN concentration (e.g. other nutrients such as phosphorus, organic pollutants, physical habitat quality, stream flows, sediment and riparian shading). Many of these factors co-vary with DIN[12]. A correlation relationship between DIN and MCI may be influenced by these other factors. It is not possible to tell from the correlation which of the many co-varying factors is the dominant cause of the MCI observed.

30 These matters have been well discussed in a report by Young and Clapcott (2015)[13] who considered relevant New Zealand research in this area and offered that: "*The Macroinvertebrate Community Index (MCI) provides an excellent indicator of ecological health in wadeable rivers and is regularly used in regional and national environmental reporting on river condition*"; and "*Consideration of the effects of multiple stressors is important when considering mitigation approaches for maintaining overall stream health*"; and *"Clearly, the MCI does not indicate only nutrient levels either in Hawke's Bay, or anywhere else*"; and, in answer to the question of whether ecological health can be maintained or improved over the long term without a 0.8 mg/L DIN target being achieved and if so how?, "*Yes, the ecological heath of waterways is dependent on multiple factors including temperature, sunlight, nutrients, sediment, organic matter, flows and upstream-downstream connectivity, which in their turn are influenced by climate, catchment and riparian vegetation, land use, geography, stream morphology and the presence or absence of fish barriers. There is minimal scientific evidence to suggest that a [DIN] concentration of 0.8 mg/L represents a threshold between healthy and unhealthy ecosystems".*

31 Following from this, it is very important to clarify that the inference made in the EDS-F&B-F&G letter that *"…the PC6 objectives (which rely on achievement of the DIN limit/target) are unachievable"*[14] is incorrect because it is a statement that is built on

[11] In his evidence to the BOI Dr Russell Death refers to the Freshwater Animal Thresholds (FAT) model and discussions around this also appear in transcript quotes given in the BOI 2014 Final Report and Decision at [354-358].
[12] For example see discussion in section 2.2 of Young & Clapcott (2015) and in particular their Figure 2.
[13] Young, R., & Clapcott, J. (2015). Ruataniwha Water Storage Scheme: Monitoring and managing ecological health. Cawthron Institute Report No. 2759
[14] EDS-F&B-F&G letter paragraph 15

drawing a cause and effect conclusion from the correlative relationship between MCI and DIN. Similarly I am dubious about the statement that "*The Board of Inquiry set that concentration as the maximum level of nitrogen pollution that would preserve ecological health.*"[15] I have not been able to find a statement worded in exactly this way in the BOI paragraphs referenced in the EDS-F&B-F&G letter. I did find statements in the BOI Decision that link the preservation of ecological health to the indicator MCI, and that recognise the correlation relationship between MCI and DIN provided to them by Dr Death, and that "*as water quality science advances a different DIN limit may emerge as a more appropriate level*" and *"In the meantime the Board sees the DIN limit of 0.8 mg/L as a pragmatic level that appropriately protects ecological health while enabling more intensive land use."* [16]

32 It is very important to be clear about the difference between the EDS-F&B-F&G letter statements and the BOI statements because they amount to whether the ultimate test of meeting desired environmental objectives is achieving ecological health, as indicated by an agreed MCI score, or meeting a DIN of 0.8 mg/L regardless of MCI score. In my view the MCI score is definitely the more appropriate ultimate ecological test and a DIN limit in a plan is but one of several parallel policy and management approaches to try and achieve that end, albeit an important one. I note that the PC6 objectives (OBJ TT1) listed above include specific mention of both periphyton and macroinvertebrate health outcomes but no mention of nitrogen being an outcome in its own right; the DIN concentration limits appear in policy tables. This is important when I come later to answering the question posed in the EDS-F&B-F&G letter as to whether the water quality objectives of PC6 can be achieved, even if the DIN concentration limit of 0.8 mg/L is not.

33 The 0.8 mg/L DIN concentration is not a defensible threshold between healthy and unhealthy ecosystems. It is perhaps more helpfully described as a point on a risk spectrum spanning from very low risk, low DIN concentrations (e.g., in the order of 0.2 mg/L that might limit periphyton growth[17]) to higher concentrations that bring multiple risks. As DIN concentration increases above 0.2 mg/L this may stimulate increasing periphyton growth which increases the risk of indirect follow-on negative effects on habitat quality for invertebrates, and thus MCI scores. At some DIN concentration, periphyton becomes saturated and growth rate is not affected by further increases in DIN concentration. At this point the associated indirect risk to MCI stops increasing. However, the risk associated with chronic nitrate toxicity continues to increase with DIN increases. DIN concentrations that risk direct chronic nitrate toxicity effects on macroinvertebrates are in the order of 1.0 to 6.9 mg/L depending on the species[18].

34 The actual state of ecosystem health measured as an MCI score at any given site is a response to not only the risks arising from the DIN concentration at that site but also the

[15] EDS-F&B-F&G letter paragraph 5c
[16] BOI 2014 Final Report and Decision at [357-358]
[17] Young and Clapcott (2015) state that limitation of aquatic plant growth is only likely if DIN concentrations are below 0.2 mg/L and attribute this to an earlier reference by Biggs (2000): New Zealand Periphyton Guideline: detecting, monitoring and managing enrichment of streams, Ministry for the Environment. 122p.
[18] For example as shown in the National Objectives Framework tables in the National Policy Statement for Freshwater Management and as reflected in the nitrate toxicity limits defined in PC6 policy Table 5.9.1, as summarised in paragraph 11 of this memorandum.

confounding interacting effects of the multiple other factors mentioned in paragraphs 29 and 30 above.

7. Dealing with issues of uncertainty, and thus risk

35 As already identified the RWSS proposal involves an increase in nitrogen losses from land in the catchment and an associated increase in instream DIN concentrations in the order of 30% for the catchment as a whole. This creates an undeniable but uncertain level of risk of not achieving periphyton and related macroinvertebrate health (e.g., MCI) outcomes. This risk is acknowledged in one way or another in evidence and other material by all of the various experts for both the RWSS applicant and the submitters that I have read[19]. All other things being equal one would not choose to create a situation where DIN increases; one would only consider doing that in order to achieve the other positive outcomes (e.g., economic and social outcomes) that could be gained by implementing the RWSS. So a strategy has been proposed by RWSS, that I would describe as a multi-pronged risk management strategy, that involves:

a) reducing instream DRP from both diffuse sources and community wastewater treatment plant point discharges,

b) provision of flushing flows from RWSS storage to manage the frequency and duration of nuisance periphyton in some river reaches,

c) riparian habitat enhancements that could improve habitat quality, shading and reduce fine sediment loss to streams,

d) an ability for the RWSS to adaptively manage local hotspots for nutrients by requiring extra phosphorus mitigations and lower than LUC-based nitrogen leaching rates in parts of the scheme area, in response to any monitoring that shows local breaches of periphyton and/or MCI outcomes, and

e) improved flows in some stream reaches due to the PC6 requirement to meet higher minimum flows, migrating some current groundwater extractions onto RWSS stored water, and the potential for providing some flow augmentation to some reaches from RWSS storage.

36 The crux question is whether the risk of allowing DIN to increase, but mitigating detrimental effects with the multi-pronged strategy described above, is justified in light of the wider benefits of the scheme. The answer to this question necessarily involves the need for decision makers to weigh risks and benefits, and then make value judgements. To some extent the constraint placed on how much DIN can increase by affects the risk-benefit balance; a tighter constraint (lower DIN limit) is less risky than a more resource-use-enabling (higher) DIN limit such as that originally proposed by the RWSS applicants in material put to the BOI hearings.

[19] For example the BOI evidence of Dr Bob Wilcock, Dr Kit Rutherford, Dr Adam Uytendaal, Dr Olivier Ausseil, Ms Kate McArthur, Ms Corina Jordan, Professor Russell Death and Dr Jonathan Abell.

37 The BOI Decision appears at first glance to have landed on an instream DIN limit of 0.8 mg/L as an appropriate level of risk by setting that number as a limit in Table 5.9.1. However the BOI has also simultaneously granted the RWSS consent with an LUC-based nitrogen load allocation that allows for a significantly greater increase in DIN, indeed one more in line with that originally proposed in the RWSS applicant's material that was assessed as likely to lead to approximately a 30% increase on current instream DIN concentrations (i.e., going well over 0.8 mg/L instream)[20]. Furthermore the same amount of LUC-based allocation granted to the RWSS in consent conditions has been set in the PC6 limits Table 5.9.1, meaning that all other non-RWSS land users in the catchment have also been given sufficient collective allocation to push instream DIN concentrations above the 0.8 mg/L limit.

38 From the material I've read I have not been able to reconcile this apparent disconnect between the LUC-based load allocated to RWSS and all other users in the catchment, and an apparent intention to manage environmental risk by setting the DIN limit at 0.8 mg/L. Setting the DIN limit at 0.8 mg/L is quite constraining for resource use and suggests a lower appetite for risk, while the LUC-based allocation rates are more enabling and amount to a greater appetite for environmental risk in order to achieve the other benefits offered by the scheme. It is therefore unclear where the value-based decision on an appropriate level of risk has landed. Much appears to hinge on the planning and legal question of the extent to which RWSS is responsible to both the LUC-based leaching rate allocation and the PC6 DIN limits. That question is being addressed elsewhere under Issue 17 of the wider Review.

8. Answering key questions that arise out of Issue 12

39 Having discussed and provided my views on current environmental state and the concept of headroom, the apparent disconnect between the two types of nitrogen headroom, confusion around the environmental significance of a DIN limit of 0.8 mg/L, and the resulting need to deal with issues of uncertainty and therefore risk, I can now identify and attempt to answer three key questions that arise out of Issue 12, as follows:

QUESTION 1: What land uses and on-farm management practices would be required to meet LUC-based nutrient leaching allocation rates?

40 Based on the attached assessment by Lachie Grant and other material I've read, I think it would be relatively straight forward for the RWSS to operate with any of a wide range of possible land uses, including a significant proportion of high nitrogen emitting land uses like dairying, using currently available good on-farm management practices to minimise nitrogen and phosphorus losses, and comfortably stay within the consented LUC-based nitrogen leaching rate allocation on a whole catchment basis[21]. I understand from the assessment provided by Lachie Grant and Ian Millner that the available on-farm measures to manage P losses make the RWSS intention to be P-neutral or better plausible. When this is combined with reductions in non-scheme diffuse and point

[20] Evidence of Dr Kit Rutherford to the BOI hearings (September 2013)

[21] I note that my answer here assumes that there will ultimately be a system for updating the LUC-based leaching rates to make them equivalent for testing with new versions of OVERSEER. Without such a system it is not possible to predict whether the RWSS could operate within the existing LUC leaching rates when tested using future unknown OVERSEER versions.

source wastewater discharges, the PC6 Table 5.9.1 DRP limits seem potentially achievable in future. It therefore seems achievable for RWSS to meet consent conditions relating to the LUC-based leaching rates, albeit with considerable management effort through time.

QUESTION 2: What land uses and on-farm management practices would be required to meet instream DIN concentration of 0.8 mg/L? (Note: this also partly addresses question 3a(ii) of the EDS-F&B-F&G letter)

41 In contrast to the first question, I think it would be very difficult for RWSS to operate within the significantly smaller nitrogen allocation implied by the instream DIN limit of 0.8 mg/L. Only low nitrogen emitting land uses would be possible, and in some sub-catchments where instream DIN already currently exceeds 0.8 mg/L, nitrogen loss reductions rather than intensification would be required. Indeed I understand that the BOI accepted HBRIC's arguments and concluded that requiring RWSS to immediately comply with the 0.8 mg/L DIN limit would frustrate (i.e., negate) the grant of the RWSS consent[22]. I understand that instead the BOI concluded that *"…if the RWSS is a material contributor to an exceedance of that DIN limit, the 'use' component of the consents is to be managed in a manner consistent with achieving the DIN limits and targets in Table 5.9.1B of PC6 by 31 December 2030."*[23]; although I note again that legal and planning considerations around this are being handled under Issue 17 of the wider review, and so question 3a(i) of the EDS-F&B-F&G letter is handled there.

42 Taken at face value it seems that if the RWSS was to develop initially with land uses that utilise all or most of their LUC-based allocation, and then strive to meet the PC6 instream DIN limit of 0.8 mg/L later by 2030, then at least one of the following would need to happen:

a) The RWSS would need to subsequently instigate a significant change in land use types in its area to land uses with lower nitrogen losses, in order to bring the scheme's total nitrogen losses to levels that would achieve the 0.8 mg/L DIN concentration instream; and/or

b) Significant innovation would be required to develop new on-farm nitrogen loss reduction technologies and/or catchment scale mitigations such as a network of treatment wetlands[24], to help reduce the nitrogen losses from the land use distribution that had developed under the greater headroom associated with the LUC-based allocation; and/or

c) The PC6 DIN limit of 0.8 mg/L would need to be revised upwards.

43 Clearly there are unavoidable uncertainties and therefore risks for the RWSS associated with relying on any or all of the bullets above.

[22] BOI Decision [91]
[23] BOI Decision [91]
[24] For example Dr Andy Hicks (HBRC) has described to me a concept to construct trial treatment wetlands that could help reduce DIN concentrations in some sections of streams and also offer biodiversity and amenity benefits.

44 I note that it seems the disconnect between the LUC-based nitrogen leaching rates in PC6 Table 5.9.1D and the instream DIN limit of 0.8 mg/L in Table 5.9.1B is ultimately untenable for planning and management purposes in the long term; one or the other or both will need to change. Until then, HBRC is in the position of trying to manage to achieve an instream DIN concentration of 0.8 mg/L under circumstances where all land users, irrespective of whether they are in the RWSS or not, are allowed to emit nitrogen at the LUC-based rates, which if taken up in total could not achieve the instream DIN concentration of 0.8 mg/L. I understand from the assessment provided by Lachie Grant that even if the RWSS did not go ahead it is quite plausible that significant intensification could occur within the PC6 LUC-based rates that would frustrate achievement of the instream DIN 0.8 mg/L limit.

QUESTION 3: Could the water quality objectives of PC6 still be achieved in the event that the PC6 DIN limit of 0.8 is not met by 2030? (Note: this addresses question 3a(iii) of the EDS-F&B-F&G letter)

45 Building on the earlier discussion around the environmental significance of the 0.8 mg/L DIN limit and the conclusions provided by Young and Clapcott (2015)[25], I agree with their conclusions and in my view the answer to this question is: Yes maybe, but it is undeniably and unavoidably uncertain; there are risks that periphyton and ecosystem health (measured as MCI) outcomes will not be achieved everywhere. Achieving them would rely on many things in addition to the effects of the RWSS total nitrogen loads and associated instream DIN concentrations. The multi-pronged strategy proposed by RWSS already described in paragraph 35 above would need to be relied on.

46 If I was asked about the likelihood of achieving the PC6 water quality objectives under a scenario which assumes that an instream DIN concentration of 0.8 mg/L is achieved throughout the catchment, my answer would still be: Yes maybe, would still be uncertain, and would still rely on other parts of the described multi-pronged strategy being successful. All other things being equal I would be more confident of achieving the PC6 water quality, periphyton and ecosystem health (MCI) objectives if instream DIN was at 0.8 mg/L than at some higher level, mostly because this reduces risk of bigger problems if attempts to reduce DRP and/or other parts of the multi-pronged strategy fail.

47 If the tighter constraint on DIN meant that some other parts of the multi-pronged strategy were not able to be carried out, then my confidence that objectives will be achieved would reduce. In particular, I think that measures to reduce phosphorus losses and improve instream habitat quality by increasing summer flows, riparian enhancements and reduced fine sediment will be crucial. Flushing flows may also be important for achieving periphyton and ecosystem health (MCI) objectives in some sections of the main-stem, although I defer to the outcome of Issue 16 of the wider Review as to the likely success of these.

48 Striving to achieve the water quality objectives of PC6 by focussing solely on reducing nitrogen loads would be very risky. The science available today suggests that phosphorus is the predominantly limiting nutrient in much of the upper catchment much

[25] Young, R., & Clapcott, J. (2015). Ruataniwha Water Storage Scheme: Monitoring and managing ecological health. Cawthron Institute Report No. 2759

of the time, acknowledging that nutrient limitation is variable in time and space and is uncertain[26]. Therefore a narrow strategy focussing solely on reducing nitrogen loads would almost certainly not achieve the periphyton and ecosystem health (MCI) outcomes.

Sincerely

Ned Norton

[26] Evidence of Bob Wilcock, Kit Rutherford, Adam Uytendaal, Olivier Ausseil, Roger Young, Kate McArthur, Jonathan Abell