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memorandum

TO	Logan Brown	FROM	Neil Thomas
	Horizons Regional Council	DATE	3 February 2023
RE	Arawhata Wetland AEE - Groundwater		

1.0 Introduction

Pattle Delamore Partners Limited has been engaged by Horizons Regional Council to assist with preparation of a resource consent application for the Arawhata Wetland, located adjacent to Lake Horowhenua (the "lake" or "Lake Horowhenua"). The applicant is seeking to fast track the proposal via a ministerial referred application. This memorandum provides a preliminary assessment of potential effects on groundwater. Further analysis will be completed to support an assessment of effects for an application.

In broad terms, potential effects on groundwater caused by creation of the wetland include effects on groundwater quality and quantity. Therefore, this memo is structured provide the following:

- A description of the hydrogeological setting of the proposed wetland;
- A brief outline of the proposed wetland and how it is currently intended to operate;
- A description of the current groundwater balance and groundwater quality in the area of the proposed wetland;
- A description of how the groundwater quantity and quality could change as a result of the proposed wetland.

2.0 Current hydrogeological setting

At a broad scale, the groundwater in the area is recharged by both rainfall (less evapotranspiration) and seepage loss from rivers and streams in the east of the area as they emerge from the Tararua Ranges, principally the Ōhau River. Groundwater flows westwards towards the coast and in the east of the area, close to the foot of the Tararua Ranges, the vertical hydraulic gradient is downwards. However, as westward flowing groundwater approaches the low permeability basement strata of the Poroutawhao High (upthrown by the Levin Fault) it is forced upwards, resulting in the increasing groundwater pressures with depth (i.e., an upwards vertical gradient) observed in bores around Levin township. As deep groundwater is forced upwards it discharges into the shallow strata, which subsequently discharges into the lakes and the spring fed streams that flow into the lakes. Groundwater in both the deeper and shallower strata are hydraulically connected and are therefore considered as a single leaky groundwater system where effects on groundwater and surface water are interrelated.

Figure 1 presents a conceptual cross section from the Tararua Ranges to the coast, running through Levin and Lake Horowhenua.

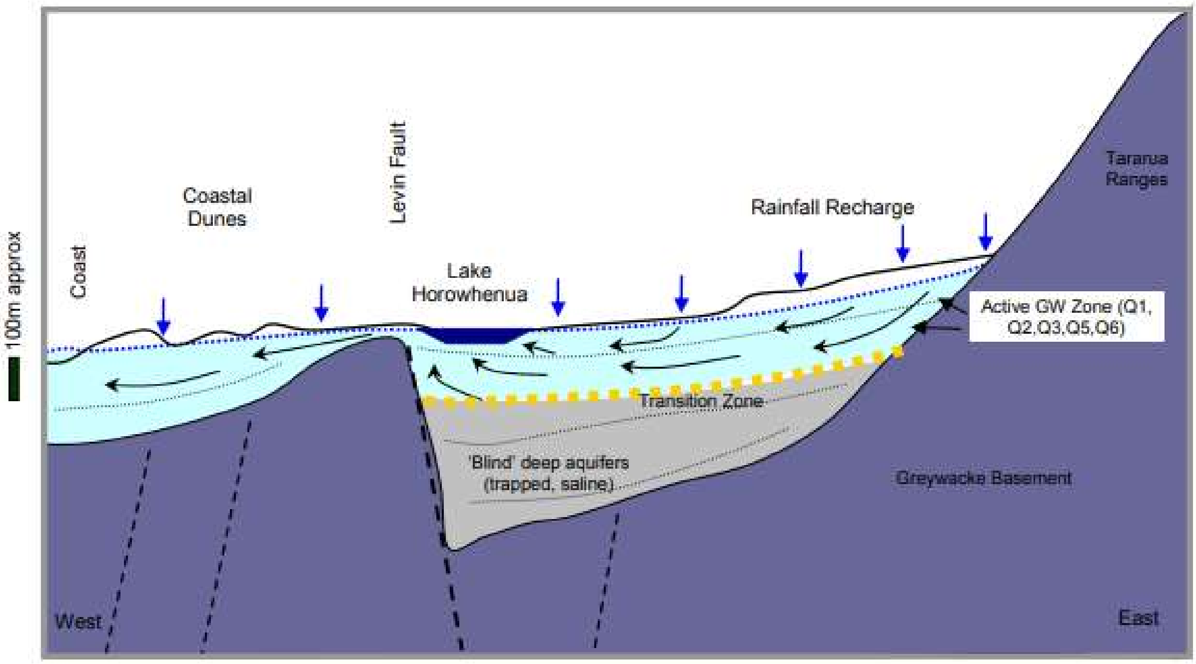

Figure 1: Conceptual cross section (after Phraetos, 2005)

In the general area around the proposed wetland, groundwater flow directions are likely to be generally towards Lake Horowhenua, which represents the main drainage point for groundwater in the area. Groundwater levels in the area around the proposed Arawhata wetland are close to the surface. As landuse around the area has changed through time, drainage has occurred to control and lower groundwater levels where required. In some cases, the drains are pumped, with the discharge directed to Lake Horowhenua or to nearby drains where the appropriate hydraulic conditions exist. Therefore, at a localised, small scale, groundwater flow directions will be variable due to those drainage effects.

3.0 The Arawhata Wetland

The aim of the proposed wetland is to intercept shallow groundwater flowing towards Lake Horowhenua and provide treatment to remove nutrients before discharging the water into Lake Horowhenua. The wetland is intended to be developed over three phases of work, with each phase extending and increasing the area of the wetland and the scale of treatment provided. As noted by the design team members at Jacobs, Phases 1 and 2 are anticipated to achieve the greatest gains in nutrient removal. The phasing summary below is adapted from the Jacobs memo accompanying the referral application.

Phase 1 focuses on the area immediately adjacent to the current alignment of the Arawhata Drain and involves the following main steps (note this is not an exhaustive list of proposed works under Phase 1):

- Development of a sediment basin where the Kohitere Stream enters the site.
- Development of wetlands along the western side of the Arawhata Drain with tributary drains directed into these wetlands.
- Installation of perforated pipes into the invert of the existing tributary drains within the proposed wetland boundary and backfilling with woodchips, bark and soil.
- Cleaning out and deepening of existing farm drains within the footprint of the proposed wetland, discharging into Arawhata Stream such that groundwater is intercepted.

Phase 2 extends the wetland areas to the eastern side of the Arawhata Drain together with a stopbank on the eastern side of the Arawhata Drain to contain the wetland.

Phase 3 will involve further wetland development, including the Paenoa Swamp on the western side of the Arawhata Drain. Further work is also planned to add an additional outlet from the existing sediment trap north of Hokio Beach Road.

4.0 Current groundwater balance and water quality

A summary of the components of the Lake Horowhenua water balance is provided in Table 1 (PDP, 2021). There are uncertainties within the values provided in Table 1, particularly with respect to groundwater inputs to the lake which cannot be measured directly. In Table 1, the groundwater component is calculated as the difference between the sum of surface water inflows plus rainfall, and the outflow from the lake into Hokio Stream. Surface water inflows/outflows are based on the median value of measured flows.

Based on the water balance for Lake Horowhenua in Table 1, direct groundwater inflows are likely to make up around 54% of the total water balance on average. Seasonally, the proportion is likely to vary, but it is also worth noting that the majority of the flow in the Arawhata Stream is derived from groundwater discharge, in which case the effective dependence of the lake on groundwater discharge is significantly more than 54%.

It is further noted that, in Table 1, not all the gauging locations are directly adjacent to the lake, for example the Patiki Stream and Heatherlea Swamp at Kawiu Road are both gauged upstream of the lake. Additional groundwater inflows to the stream may occur downstream of the gauging locations, but in Table 1, these are counted as part of the 'direct groundwater inflow' water balance component.

Table 1: Lake Horowhenua estimated water balance (L/s)

Component	Inflows	Outflows
Rainfall	107	
Arawhata Drain flow	217[1]	
Other stream flow	127.5[1]	
Direct groundwater inflow	531.2[2,3]	
Hokio Stream flow out		906
Evaporation		76.7
Groundwater flow out		?[2]
Total	**982.7**	**982.7**

Notes:

1. *Flows in these surface waterways are based on the median of gauging runs between 1975 and 2018*
2. *Calculated as the balance of outflows and gauged inflows. Any groundwater inflow greater than this number would be balanced by an outflow from the western side of the lake into groundwater, currently shown as a "?" in the water balance. Other seeps and any drain discharge into the lake which is not gauged is part of this number. Additional inflows to the streams downstream of the gauging point are also counted as groundwater inflow in Table 3.*
3. *There are some other inflows which are not listed in the table above, including the Makomako Drain, inflows at Bruce Road, and Inflows at Hokio Sand Road. Gauging of these flows amount to a few L/s and their contribution is included in the Groundwater inflow component.*

The flow listed in Table 1 for the Arawhata Drain is based on the median gauged flow at Hokio Beach Road; a plot of the gauged flows in the Arawhata Drain is provided in Figure 2. The Arawhata Drain at Kane Farm (blue line in Figure 2) represents the point where the Arawhata Drain enters the proposed wetland site, and the Arawhata Drain at Hokio Beach Road represents the point where the Arawhata Drain leaves the proposed wetland area and discharges into Lake Horowhenua.

The Arawhata Drain gains substantially from groundwater as it passes through the proposed wetland area and the Arawhata Drain is a natural drainage point. The current water balance for the wetland area is therefore likely to be heavily dominated by groundwater seepage.

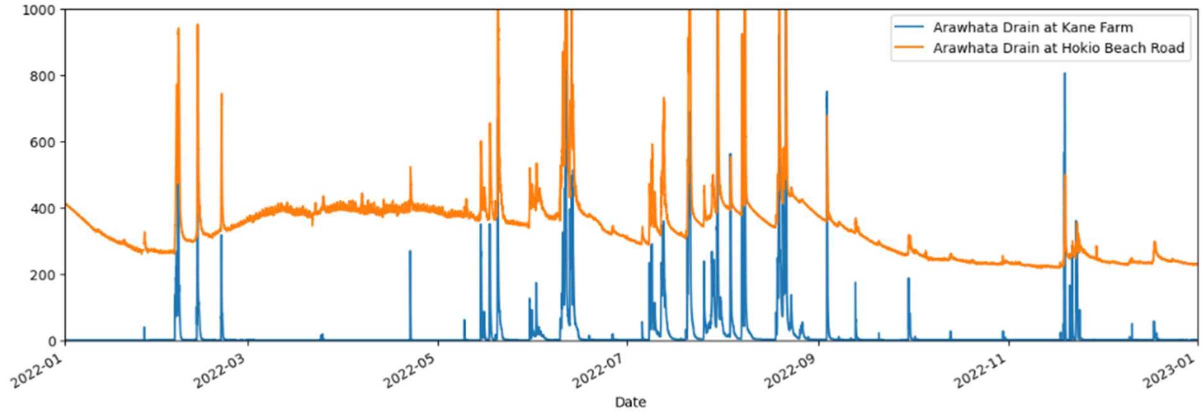

Figure 2: Flows (L/s) in the Arawhata Drain where it enters the wetland (Kane Farm, blue line) and exits the wetland (Hokio Beach Road, orange line)

The data available for water quality around Lake Horowhenua indicates that generally, surface water quality upstream of the proposed Arawhata wetland has relatively low nitrate nitrogen concentrations (around 1 - 4 mg/L). However, water quality within the proposed wetland area has much higher nitrate nitrogen concentrations (up to 13 mg/L mg/L). This is due to the surface water quality samples being taken at times when the drains are flowing with relatively good quality rainfall runoff, whereas surface water quality samples from the proposed Arawhata wetland area represent groundwater concentrations which have much higher nitrate nitrogen concentrations. These groundwater concentrations are representative of those that are entering Lake Horowhenua.

Other parameters such as dissolved reactive phosphorus (DRP) show inverse patterns, where concentrations of DRP are highest in the tributary drains to the main Arawhata Drain (up to 2.2 mg/L), but lower in the main Arawhata Drain (up to 0.4 mg/L). This likely reflects the absence of DRP in groundwater, but higher concentrations in runoff within the upstream drains.

5.0 Potential changes to groundwater quantity and quality

5.1 Groundwater quantity

At a general level, the proposed wetland will not include consumptive abstractions or additional discharges of groundwater and therefore substantial changes in the overall water balance in the area are not expected to occur. However, the proposed wetland will involve interception and diversion of groundwater (via deepened drains) and some localised changes to groundwater levels and patterns of flows will occur. These include:

- Deepening and cleaning of drains could result in localised groundwater level drawdown but based on the scale of the proposed work and the size of the drain flows, it is not expected that this would represent an adverse effect. Drawdown effects would be greatest adjacent to a deepened drain and are likely reduce rapidly with distance away from the drain. Given that the deepening is not likely to exceed 2 m, drawdown effects will be less than 2 m. Preliminary modelling indicates that drawdown effects of up to 1 m caused by deepening of a drain by 2 m could extend to up to 50 m to 100 m from the drain, depending on local aquifer properties.

- The closest bores to the drains that are expected to be deepened are at least 150 m away from the edge of the proposed wetland area and these bores are generally more than 20 m deep, with static water levels that are within a few metres of the ground surface. In general, drawdown effects of around 1 m are unlikely to restrict the use of these bores. However, appropriate consideration of bores where drawdown effects of around 1 m could occur can be undertaken during the detailed design of the wetlands. Mitigation of effects on neighbouring bores could include deepening of pumps where required.
- There is expected to be a general increase in groundwater flow into the proposed wetland compared to the current situation, which will cause a generalised lowering of groundwater levels. Other effects that can occur due to lowering of groundwater levels include ground settlement and reduction in flows in neighbouring drains. These effects cannot be quantified at this stage but will need to be assessed in detail during the design of the wetlands. However, given the localised scale at which groundwater levels may be lowered and the generally silty or gravelly strata in the area, widespread adverse effects are not expected. Any potential residual effect could be managed via monitoring conditions and a review process prior to the start of the subsequent phase of development.
- The Arawhata Drain acts as a groundwater discharge point, where the majority of that water is directed into Lake Horowhenua. Introducing the proposed wetlands as a groundwater discharge point in the area around the drain may mean that greater evaporation and evapotranspiration will occur from groundwater. As a result, smaller volumes of groundwater will be discharged to Lake Howowhenua. Open water evaporation effects currently represent around 8% of the outflows from Lake Horowhenua (see Table 1) so there is some potential for the current discharge from the Arawhata Drain to Lake Horowhenua to reduce by a generally similar proportion, although in terms of surface flows to the lake, that effect may be largely offset by the increased groundwater flowing into the drain/wetland system. This evaporation effect is likely to be more significant after Phase 2 (where a greater area of wetland is to be developed) and will be investigated further as part of the consenting process. Monitoring of flows in the Arawhata Drain where it discharges to Lake Horowhenua would help to quantify this effect.
- A final consideration is potential flood risk to adjacent properties. The increased flows into the proposed wetland (caused by deepening of the drains) will need to be balanced by sufficient outflow capacity to manage potential flood risk to adjacent properties. This aspect can be readily addressed by appropriate design of the wetlands together with careful assessment of potential inflow rates.

5.2 Groundwater quality

The intention of the proposed wetland is to improve groundwater and surface water quality at the end of the Arawhata Drain catchment by allowing phosphorus to settle out from surface water inputs and removing nitrates from groundwater. Therefore, the proposed wetlands are intended to generally improve water quality by reducing the nutrient load that would otherwise discharge into Lake Horowhenua. The performance of the proposed wetland in achieving that outcome will largely depend on the design, construction, and particularly future maintenance of that proposed wetland.

The only aspect where some caution should be exercised is where some drains are proposed to be backfilled with woodchips. Although there is evidence to demonstrate that this approach is likely to remove nitrate from groundwater that enters the drains by providing microbes to combine with the woodchip source of organic matter, the resulting low oxygen environment can result in other parameters becoming dissolved in groundwater, including iron, manganese, and arsenic. Therefore, any consent will need to ensure that regular groundwater quality sampling tests for this effect and consider appropriate mitigation strategies if unhelpful elevated concentrations of these elements is observed to occur.

6.0 Conclusions

The proposed wetland will result in some changes to the groundwater balance for the local area as well as some potential changes to groundwater quality. However, our opinion is that these effects can be quantified prior to the wetland development during the detailed design stage and appropriate mitigation and management strategies (for example monitoring and review conditions) can be put in place to avoid adverse effects.

7.0 Limitations

This memorandum has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Horizons Regional Council and others (not directly contracted by PDP for the work). PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the memorandum. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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8.0 Bibliography

Pattle Delamore Partners Limited. (2021). *Lake Horowhenua Groundwater Model. C02596522. Report prepared for Horizons Regional Council.* Christchurch.

Phraetos Limited. (2005). *Horowhenua Lakes: Assessment of groundwater - surface water interaction. Report prepared for Horizons Regional Council.* Welington.

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