Memorandum

To:	Russell Aggregates	**Of:**	
From:	Rose Edkins	**Date:**	8 December 2022
Reviewed by:	Helen Rutter & Neal Borrie	**Job no:**	CC23003
Subject:	**Russell Aggregates Quarry Expansion Project**		

1 Introduction

Russell Aggregates Limited (Russell Aggregates) operates an existing quarry located at the end of Maraekakaho River Road, Hastings, on the Heretaunga Plains next to the Ngaruroro River (see Figure 1.1). Aggregate is currently locally sourced from Ngaruroro River and imported from the Central Hawkes Bay and processed (washed, crushed, mixed and sorted into stockpiles) on-site before being transported off-site by truck.

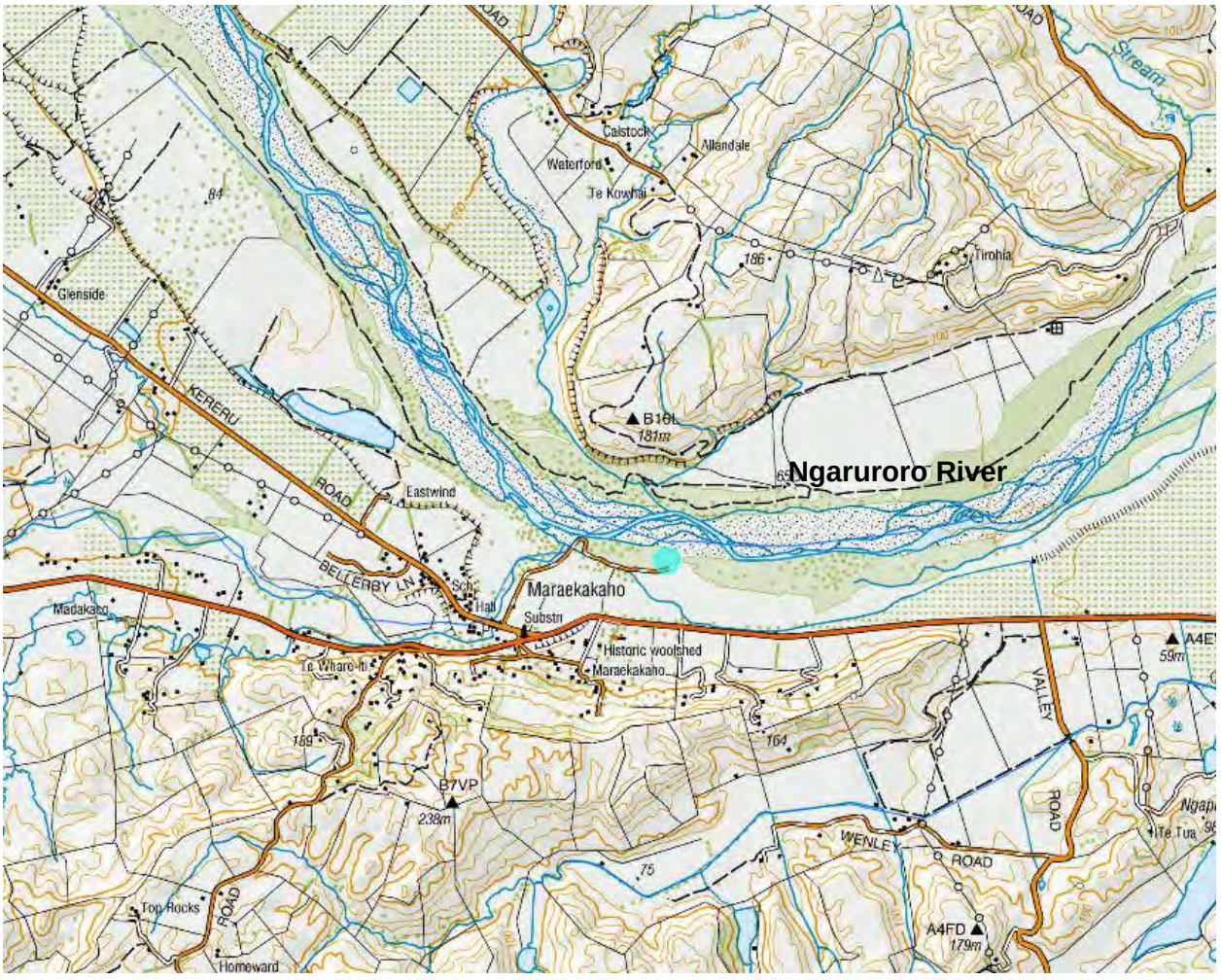

Figure 1.1: Location of Russell Road's existing quarry site (see blue dot)

Due to growing gravel requirements, combined with Hawkes Bay Regional Council (HBRC) reducing the volume of gravel allocated for extraction from the Ngaruroro River, Russell Aggregates plan to apply for resource consent under the Covid-19 Recovery (Fast-track Consenting) Act 2020 to enable the land-based extraction of aggregate. This is proposed to occur on land adjacent to the existing quarrying site, with the aggregate extracted from the land processed at the existing quarrying facility. No dewatering of the site is proposed, so much of the quarrying will occur within the groundwater table. Once the quarrying is complete, it is proposed that the excavation will become two lakes with landscaping on and around the lakes. No backfill or lining of the lake is proposed.

The existing and the proposed quarry site is shown in Figure 1.2.

Figure 1.2: ***Location of Russell Road's existing and proposed quarry sites***

Russell Aggregates has requested that Aqualinc Research Ltd (Aqualinc) undertake a preliminary desktop assessment of the aquifer in the vicinity of the site, including:

- Assessing the nature of the aquifer
- Determining whether there are any risks to the aquifer and groundwater associated with undertaking the proposed activities including puncturing a confined layer when quarrying
- Identifying what further investigations may be required, and how any risks can potentially be managed.

The purpose of this report is to support an application to the Ministry for the Environment for referral of this application to an expert consenting panel under the Covid-19 Recovery (Fast-track Consenting) Act 2020. The intention is that any further investigations are undertaken at substantive resource consent stage in the event that the project is referred to an expert consenting panel.

To summarise, our findings are:

- There is no evidence of a very shallow confining layer, and the risk of puncturing a semi-confining / confining aquifer layer is considered low to a depth of approximately 5 m. Beyond a depth of 5 m, it is difficult to quantify the risk, based on existing information. Thus, until further investigation is completed, it is considered prudent to assume a higher risk below a depth of 5 m. Further investigation is required to locate these layers (if present) beneath the site and ensure that quarrying does not occur below this depth, including a suitable buffer distance above these layers.

- Appropriate on-site management procedures are required to mitigate the potential high risk to groundwater if there is a spill or fuel leak on-site associated with the machinery used for quarrying on-site.
- Nearby wells and the Ngarururoro River are unlikely to be affected by turbidity resulting from the quarrying activity. However, minimal steps can be undertaken to minimise turbidity within the lake itself. To minimise the effects of turbidity on the Ngarururoro River, it will be important to ensure that there is no direct outflow from the lake into the river.
- We understand the project can be modified to respond accordingly if the further detailed investigations proposed confirm that there is a confining or semi-confining layer beneath the site.

The following further work will be undertaken:

- Drill additional exploratory wells to a depth of 30-40 m, to assess the lithology of the site, and to confirm (or not) the presence of semi confining / confining layers. Sonic drilling would enable the best logs to be obtained.
- In order to establish baseline groundwater and surface water quality at the site prior to excavations starting, carry out water quality monitoring and groundwater levels in the nearest well (3262) and the on-site well 17214, and the Ngarururoro River on a regular basis.
- Prepare a management plan to mitigate the risk of possible fuel spills / leaks due to the usage of machinery on-site.

2 Aquifer System

The Heretaunga Plains were formed by river sediments deposited by the Tutaekuri, Ngarururoro and Tukituki Rivers (Dravid & Brown,1997). The Heretaunga Aquifer underlies the Heretaunga Plains and includes several connected peripheral valley aquifers (HBRC, 2018). The Heretaunga aquifer is described to be a multi-layered leaky system, formed mainly from alluvial gravels (HBRC, 2018). Drilling in the western part of the aquifer shows a shallow unconfined aquifer, whereas the eastern part of the main Heretaunga aquifer is confined and artesian (HBRC, 2018).

Aquifers are typically described as confined, semi-confined (leaky) and unconfined. Confined aquifers are bounded by impermeable layers causing the water to be under pressure, so when a bore is drilled into the aquifer, the groundwater level will rise. Semi-confined aquifers are similarly bounded by layers that are leaky (partially impermeable), and again, the water level will rise though possibly not as high as for a confined aquifer. The semi-confining layers allow some water to leak through. The upper, shallow groundwater surface, that is unbounded (has no overlying impermeable layers) is referred to as an unconfined or water table aquifer.

The existing and proposed quarry site is located on the Heretaunga aquifer close to the boundary between this aquifer and the Upper Ngarururoro aquifer, as shown in Figure 2.1. The Heretaunga aquifer at the location of the quarry site is shown to be unconfined (HRBC GIS). The upper Ngarururoro aquifer is identified to be hydraulically connected to the Heretaunga aquifer (HBRC, 2018). This means that activities in the Heretaunga aquifer may affect the upper Ngarururoro aquifer.

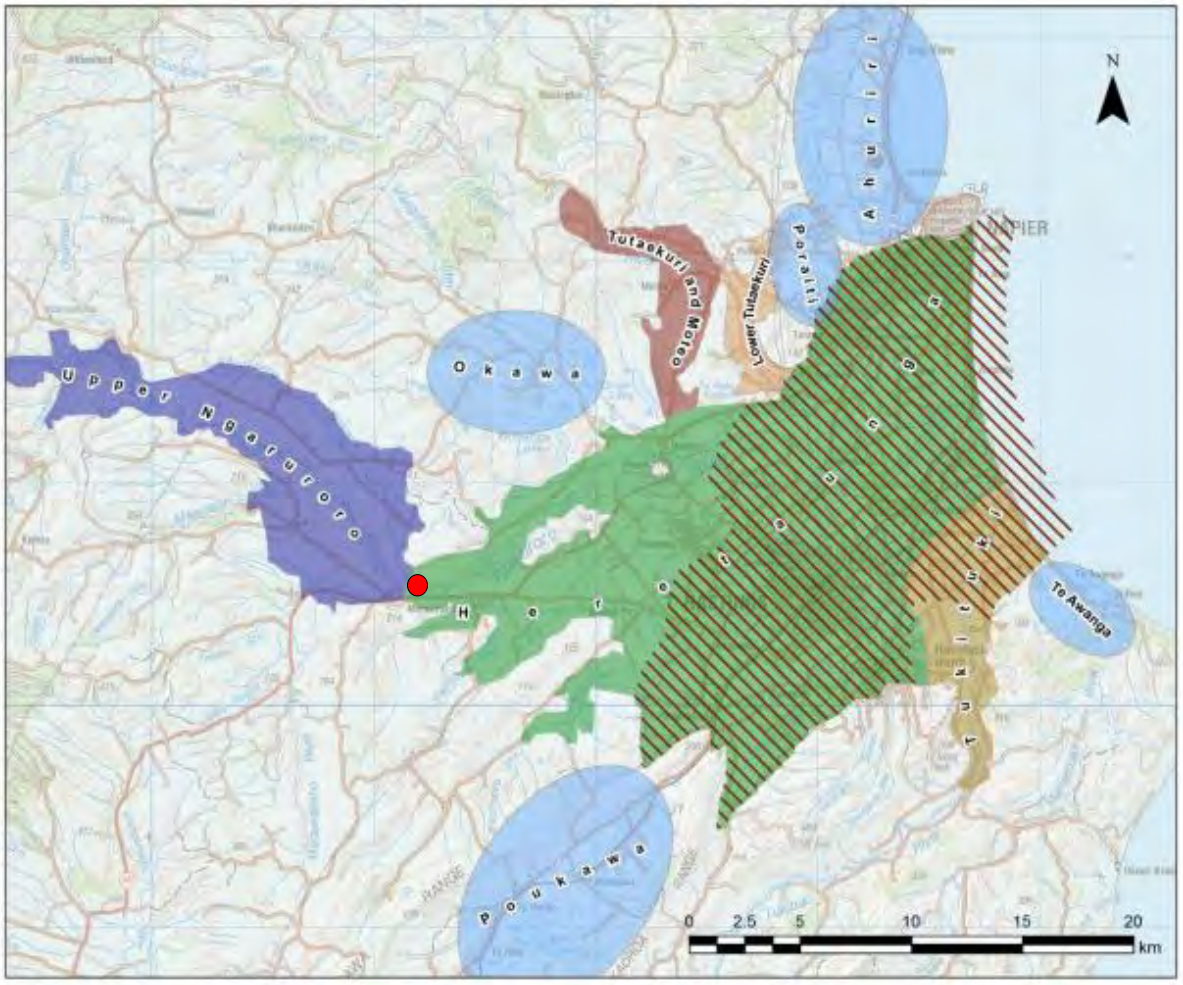

Figure 2.1: Heretaunga Aquifer System. The confined area of the aquifer system is indicated by the brown hatched lines (HBRC, 2018). The location of the existing and proposed quarry is indicated by the red dot.

3 Well Details in the Vicinity

To provide an understanding of the aquifer lithology well logs in the vicinity of the site (within a 1 km radius) have been reviewed with data sourced from the HBRC GIS database. Well logs provide information of the types of layers encountered while drilling and can be used to identify if semi-confining or confining layers are present (layers that may restrict water movement). Eleven wells within a 1 km radius were identified, including well 17214 drilled recently onsite. Wells 3173, 3262 and 4457 are close to site (see Figure 3.1). We have reviewed the available data for each of these 11 wells, sourced from the HBRC database. Well details are summarised in Table 3.1.

Well 17214 although screened[1] from 3.75 to 10.75 was drilled to a total depth of 30 m. The log describes a tightly layered gravel with clay at a depth of 12-19 m, which may provide some degree of confinement, that is, the lower sediments are confined and the upper sediments are unconfined.

Wells 3173 is screened from approximately 12 to 13 m, and shows no indication of confining layers to a depth of 13 m. However, it is listed as confined on HBRC database. It is possible that either this has been incorrectly entered into the database or there is further information (unavailable on the GIS), that suggests a confining aquifer.

If there is a confining layer present, then there may be a risk that if this layer is penetrated then upwelling of water may occur.

[1] The well screen (slotted) provides an opening to allow for the water to enter the well from the aquifer, while preventing coarse material also entering the well.

Wells 3262 and 4457, to the south east of the proposed site, are screened from approximately 16 to 23 m. The log for well 3262 indicates the presence of some clay at the base of the well, but the thickness of this layer is unknown as the well was not drilled any further. Well 4457 is listed as unconfined on the HBRC database. However, according to the available information, the groundwater level is higher than the depth where water was struck, which may suggest the aquifer is semi-confined. The log also suggests evidence of layers that may provide some degree of confinement.

The limited groundwater level data for these wells suggests groundwater levels may range from 2.2 to 7.3 m bgl. This would suggest that much of the proposed quarrying will be occurring within groundwater, possibly below a depth as shallow as 2.2 m bgl. Note that these are one off groundwater levels measurements and do not reflect possible seasonal fluctuations and variability across the site.

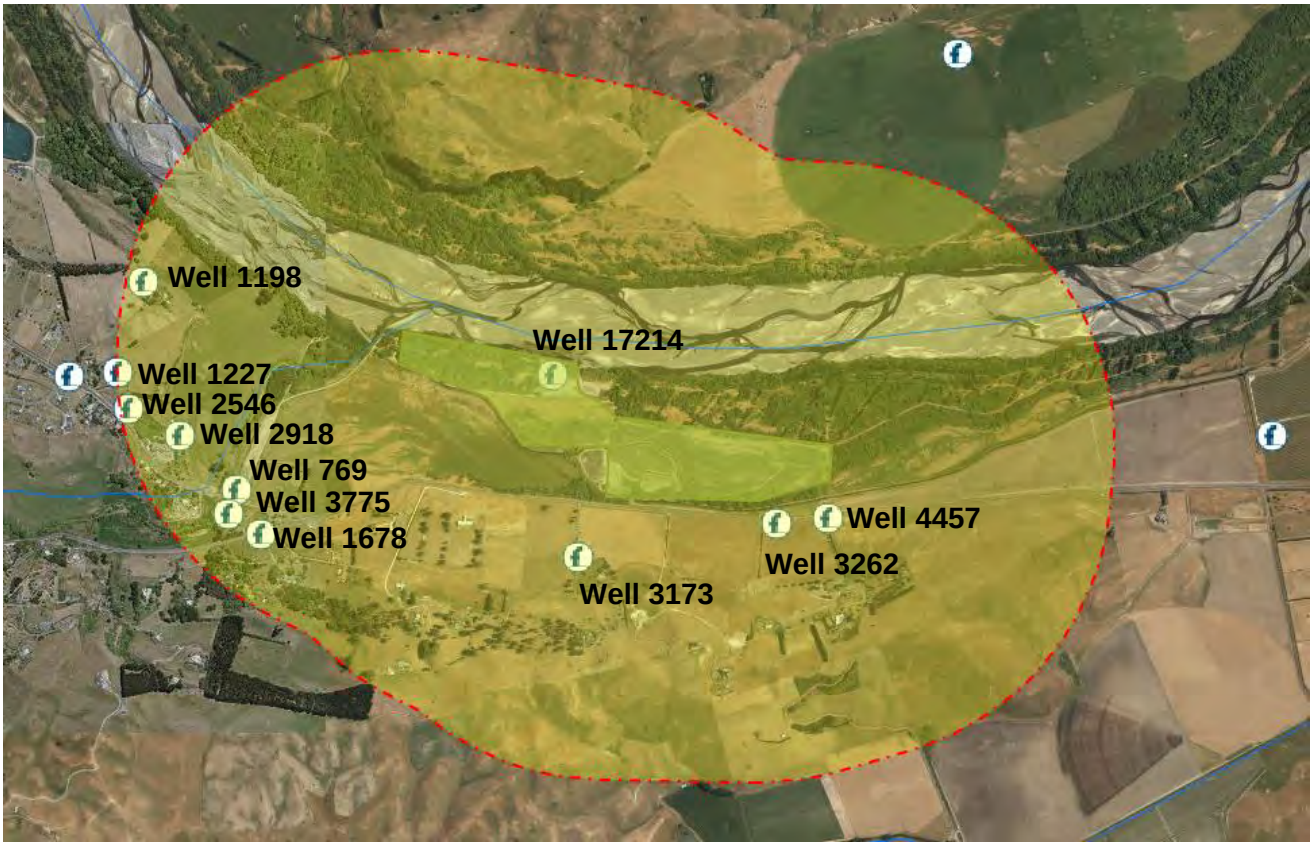

Figure 3.1: Location of on-site well 17214, and wells located within 1 km

Table 3.1: Details of wells 17214, 3173, 3262, 4457 (data sourced from HBRC GIS)

Well	17214	3173	3262	4457
Date Drilled	12/10/2021	25/11/1992	16/02/1993	5/10/2000
Initial Water Level (m)	-2.15	-6.4	-7.3	-6.4
Depth (m)	30.0	12.8	22.5	22.57
Diameter (mm)	500	250	100	250
Screen (m)	3.75-10.75	11.58-12.8	16.5-22.5	16.77-22.57
Test pumped flow (l/s)	36	3.1	-	6.5
Drawdown (m)	0.2	1.8	-	5.15
Specific capacity (l/s/m)	15.3	1.7	-	1.3
Use	Quarry washdown	Unknown	Unknown	Unknown
Aquifer Condition	Unknown	Confined	Unknown	Unconfined
Well log	0-1.5 m Fill / silt / brown gravel	0-1m red TOPSOIL with gravel	0-1m TOPSOIL	0-0m TOPSOIL
	1.5-2.1 m Brown gravel – loose	1-2m brown SANDSTONE (soft)	1-16m brown GRAVEL	0-10m coarse brown GRAVEL with clay/silt
	2.1-4 m Silty gravel & Vegetation	2-4m red GRAVEL		
	4.0-5.1 m Brown gravel – medium	4-10m blue/red GRAVEL		
	5.1-7.0 m Brown gravel with clay – large & tight			
	7.0-12 m Brown gravel with clay – medium & free	10-13m blue GRAVEL		10-13m coarse blue GRAVEL with clay/silt (water yielding)
	12-19 m Tightly layered gravel with clay			13-15m brown GRAVEL with clay (claybound)
			16-21m blue GRAVEL	15-23m brown GRAVEL (free, water yielding)
	19-21.2 m Brown gravel		21-22m blue SAND with gravel	
	21.2-30 m Brown gravel – tight		22-22m blue SAND with clay/gravel	

Table 3.2 summarises the well details for the remaining wells located within 1 km of the site. These wells are located within the Upper Ngaruroro aquifer. Table 3.2 shows that there are four wells, 1198, 1227, 1678 and 2546, which are listed as artesian wells (flowing confined). These wells are located at the Maraekakaho terrace, which is approximately 20 m higher than the Russell Aggregates proposed extraction site. This would suggest that the bottom of these wells is likely to be a similar height as to the ground level / groundwater level at the quarry site. The hydraulic connection between the aquifer at the terrace and that at the quarry site is not well understood.

Table 3.2: Details of remaining wells within 1 km

Well	769	1198	1227	1678	2546	2918	3775
Date Drilled	27/06/1978	2/02/1982	14/04/1982	3/07/1984	17/05/1989	24/04/1991	1/02/1996
Initial Water Level (m)	-0.5	9	7.9	6	9	-8	-3.2
Depth (m)	11.71	16.46	13.6	23.4	19.66	24.84	16.5
Diameter	100	150	150	150	150	150	150
Screen (m)	-	14.5-16.5	?-13.6	17.3-23.4	16.6-19.7	5.7-19.2	14.5-16.5
Test pumped flow (l/s)	-	Free flow 7.6 Tested at 1.7	Free flow 3.1 Tested at 3.2	2.3	2.5	-	-
Drawdown (m)	-	1.0	1.2	0	1.4	-	-
Specific Capacity (l/s/m)	-	1.7	2.65		1.8	-	-
Use	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Aquifer Condition	-	Flowing confined	Flowing confined	Flowing confined	Flowing confined	-	-
Well log	0-12m blue GRAVEL with clay/silt	0-1m TOPSOIL	0-0m TOPSOIL	0-0m TOPSOIL with gravel	0-0m TOPSOIL	0-0m TOPSOIL	0-1m TOPSOIL
		1-12m brown GRAVEL	0-7m brown GRAVEL with clay	0-3m coarse GRAVEL (tight)	0-12m coarse red GRAVEL	0-1m brown CLAY	1-2m brown GRAVEL
				3-5m blue/grey CLAY		1-1m brown CLAY with sand (hard, light)	2-3m GRAVEL with clay (claybound)
				5-8m brown GRAVEL with limestone/shell		1-10m coarse blue GRAVEL	3-7m blue CLAY
			7-16m brown GRAVEL	8-9m brown CLAY with sand (light)		10-10m brown CLAY	7-10m brown CLAY
		12-13m CLAY with sand		9-17m blue CLAY with shell	12-19m blue GRAVEL	10-14m blue GRAVEL	10-10m blue CLAY with shell
		13-14m brown GRAVEL				14-23m blue/red GRAVEL	10-14m blue CLAY
		14-16m blue GRAVEL					14-15m CLAY with gravel
							15-16m blue GRAVEL
				17-23m blue GRAVEL with shell	19-20m red GRAVEL (tight)	23-25m blue GRAVEL	

The specific capacity (l/s/m) (refer to Table 3.1 and Table 3.2), provides an indication of the performance of the wells. A high performing well would suggest that there is good flow into the well from the aquifer and may indicate highly permeable gravels., Conversely, a low performing well may indicate the presence of less permeable layers within the aquifer. Well 17214 (on site) is high performing with a specific capacity of 15 l/s/m. However, the specific capacity of the other nearby wells is low, ranging from 1.7 to 2.7 l/s/m. 17214 suggests there are some highly permeable gravels present, and this needs to be accounted for when considering the operation of the quarry.

4 Geotechnical Trial Pits

LDE Ltd has completed a preliminary geotechnical investigation on-site for Russell Aggregates[2]. This investigation included characterising the engineering geology and assessing the groundwater level across the site.

As part of this investigation five machine excavated test pits were dug to depths ranging from 0.9 to 2.5 m bgl (see Figure 4.1). The maximum depth excavated depended on safety relating to side walls collapsing and the inflow of groundwater into the pits.

Figure 4.1: Location of Test Pit sites (Source: LDE, 2022)

The following information is available from these test pits:

- Depth excavated ranged from 0.9 to 2.5 m bgl.
- Groundwater was encountered at various depths: 0.9 m (TP04), 1.3 m (TP03), 2.3 m (TP01 and TP02).
- Generally, the logs showed silty sand (of varying depth – 0.1 to 1.5 m) overlying sandy gravel.

The depth of the gravel has not been determined.

LDE has recommended drilling several additional boreholes using a sonic rig down to at least 30 m depth to determine the thickness and consistency of the gravel source. We agree this would be a necessary approach to substantiate this desk top investigation to support the application for resource consent.

[2] LDE, 2022; Geotechnical Preliminary Assessment Report for Quarry Expansion. Kereru road / State Highway 50, Maraekakaho. Prepared for Russell Aggregates Ltd. Project Reference: 22392. 14 October 2022. Land Development & Engineering.

5 Summary of Desktop Assessment Outcomes

The desktop assessment completed in the vicinity of the Russell Aggregates proposed Quarry, has shown the following:

- It is difficult to draw conclusions on the presence or not of semi-confining / confining layers on-site based on the available well logs in the vicinity. However, our assessment shows that these wells may indicate the presence of a semi-confining layer at a depth of approximately 5 to 7 m, and 10 to 12 m, as follows:
    - On-site well 17214 although screened from 3.75 to 10.75 was drilled to a total depth of 30 m. The log describes gravel with clay at 5 to 7 m, gravel with clay and tightly layered gravel with clay at 12-19 m. These gravel layers with clay may provide some degree of confinement between a deeper aquifer (if present) and the shallow aquifer.
    - Well 3173 is screened from approximately 12 to 13 m and shows no indication of confining layers to a depth of 13 m, though it is listed as confined on HBRC database.
    - Wells 3262 and 4457 are screened from approximately 16 to 23 m. The log for well 3262 indicates the presence of some clay at the base of the well (thickness unknown). Well 4457 is listed as unconfined on the HBRC database. However, the groundwater level, at 6.4 m bgl, is higher than the depth where water was struck, at 15 m bgl, which may suggest some confinement. Also, the log has evidence of layers, from 0 to 15 m bgl, that may provide some degree of confinement.
- The groundwater levels for wells 17214, 3173, 3262 and 4457 range from 2.2 to 7.3 m bgl. Evidence from the geotechnical investigations suggest that groundwater may occur at even shallower depths than this (0.9 – 2.3m). This indicates that most of the quarrying will be occurring into the water table.
- There are flowing artesian wells located approximately 1 km east of the site at the Maraekakaho Terrace, which is approximately 20 m higher than the Russell Aggregates proposed Quarry site. These wells are obviously tapping a confined aquifer with high water pressure. It is possible that this aquifer may be connected with the sediments below the quarry site, meaning that works at this site may affect these artesian bores if there is loss of pressure in the artesian aquifer (see Section 6.1).
- Given the trial pits excavated for the geotechnical investigation and the available bore logs, it appears that there is no evidence of a very shallow confining layer, and the risk of puncturing a confining aquifer layer is considered low to a depth of approximately 5 m.

6 Assessment of Possible Risks of Quarrying

The three main risks identified to groundwater as a result of the proposed quarrying activity are as follows:

1. Risk of puncturing a semi-confining to confining aquifer layer, and resulting upwelling of groundwater;
2. High turbidity in groundwater as a result of quarrying works, with possible risk of extending both to the Ngaruroro River and the aquifer; and
3. Possible risk of contaminates entering river and groundwater as a result of quarrying activities (e.g. vehicle refuel spills / leaks).

6.1 Risk of Puncturing Aquifer while Quarrying

Our assessments suggest that quarrying to a depth of 30 m could potentially puncture a semi-confining or confining aquifer layer and cause upwelling of groundwater. If this occurred, it could affect pressure in the confined aquifer, and potentially affect other users of the aquifer. However, further information is required to confirm aquifer types beneath the site, including the depth of any semi-confining and confining layers, as well as testing to obtain aquifer properties. The results of testing would be useful to assess any likely impact of the quarry on other groundwater users, as well as provide information to the quarry operators about conditions likely to be encountered at the site.

Although there are some drillers' logs available, the drillers would not have been focussed on obtaining the level of detail needed to fully assess the existence of confining material or identify water strikes. Given the trial pits

excavated for the geotechnical investigation and the available bore logs, it appears that there is no evidence of a very shallow confining layer, and the risk of puncturing a confining aquifer layer is considered low to a depth of approximately 5 m.

In the event that a confined or semi-confined aquifer is punctured during the quarrying process, then upwelling of water from the aquifer could occur, i.e. loss of water from the semi-confined / confined aquifer. Once this aquifer is punctured (if present) it would be difficult to rectify. The effect of this may be for example that the currently flowing artesian bores located at the Maraekakaho terrace may no longer flow artesian.

Beyond a depth of 5 m, without further information, it is very difficult to quantify the risk of puncturing a confined / semi-confined aquifer. Without this information, it is considered prudent to assume that there is a higher risk of puncturing a semi-confined / confined aquifer below a depth of 5 m.

It will be important to locate the semi-confining / confining layers (if present) beneath the site and ensure that quarrying does not occur below this depth, including a suitable buffer distance above these layers.

6.2 High Turbidity Resulting from Quarrying

Turbidity is a measure of the number of particles suspended or dissolved in water. High turbidity can be problematic in drinking water supplies, as it can make it difficult to treat water for bacteria and other micro-organisms. Also, high turbidity in surface water creates both aesthetic problems and may affect aquatic life in the vicinity.

During gravel extraction, it was considered that turbidity may extend into the aquifer and to the Ngaruroro River. However, research (Thorpe, 1990) has shown that the smallest clay particles extend only 40 metres into the aquifer before filtration effects remove suspended sediment and colloids.

The closest well to the excavation site is 70 m from the site and the Ngaruroro River is approximately 130 m from the site. Thus, nearby wells and the Ngaruroro River are unlikely to be affected by turbidity resulting from the quarrying activity.

As the quarrying is occurring within the groundwater there will be minimal steps that can be undertaken to minimise turbidity within the ‘lake’ itself. To minimise the effects of turbidity on the Ngaruroro River, it will be important to ensure that there is no direct outflow from the lake into the river.

6.3 Machinery Use On-Site

There is a high risk to groundwater if there is a spill or fuel leak on-site associated with the machinery used for quarrying on-site. This risk can be mitigated with appropriate on-site management procedures and the risk mitigated appropriately.

7 End of life

At this stage, following the completion of the aggregate extraction on the site, it is intended to prepare and implement an end of life plan across the site. The end of life plan at a high level is intended to comprise two lakes (or water bodies), which will be planted with riparian and/or wetland planting and will potentially include stepped terraces. Final detailed design and features will be confirmed in the resource consent application.

From a hydrological perspective, we consider the key considerations with this proposal include:

- Groundwater levels - Further investigation will be required to determine the long-term effects on groundwater levels and this will be informed by the outcomes from further investigative drilling on the site as recommended in this report, and possibly groundwater/surface water modelling.
- Water quality – the primary concern is the potential for increased numbers of wildfowl becoming established and contributing microbial contamination that could affect groundwater. This will be assessed through an investigation of the changes in habitat and whether there are likely to be any changes in species or numbers on flat water as opposed to the flowing river. It has been shown that microbes travel less than 2.5 km through aquifer systems, so if there was considered to be additional risks from the lake as opposed to the flowing river, an assessment would be carried to determine any vulnerable groundwater drinking water sources downgradient.

- Ngaruroro River – It is our view that adverse effects on the Ngaruroro River as a result of the end of life plan features are unlikely. Modelling will assist in exploring this issue further.

8 Conclusions and Recommendations

Based on our desktop assessment, it is our view that:

- There is no evidence of a very shallow confining layer, and the risk of puncturing a semi-confining / confining aquifer layer is considered low to a depth of approximately 5 m. Beyond a depth of 5 m, it is difficult to quantify the risk, based on existing information. Thus, until further investigation is completed, it is considered prudent to assume a higher risk below a depth of 5 m. Further investigation is required to locate these layers (if present) beneath the site and ensure that quarrying does not occur below this depth, including a suitable buffer distance above these layers.
- There is a high risk to groundwater if there is a spill or fuel leak on-site associated with the machinery used for quarrying on-site. This risk can be mitigated with appropriate on-site management procedures and the risk mitigated appropriately.
- Nearby wells and the Ngaruroro River are unlikely to be affected by turbidity resulting from the quarrying activity. To minimise the effects of turbidity on the Ngaruroro River, it will be important to ensure that there is no direct outflow from the lake into the river.

To support a substantive application to an expert consenting panel for resource consent for this project and to further address the potential risks identified to the groundwater as a result of the proposed quarrying it is recommended that:

- Two exploratory wells be drilled (minimum) (see Figure 8.1), to a depth of 30-40 m, to assess the lithology of the site, and to confirm (or not) the presence of confining layers. Sonic drilling would enable the best logs to be obtained. The logging during this drilling is to include the following:
    - Log, in detail, the lithology of each layer encountered.
    - Log any water strikes.
    - Log any changes in groundwater level that result due to drilling through a confining layer (if encountered).
- Commence monitoring water quality and groundwater levels in the nearest well (3262) and the on-site well 17214, and the Ngaruroro River on a regular basis to establish baseline groundwater and, surface water quality, and groundwater levels, prior to starting any excavation at the site.
- Prepare a management plan to mitigate the risk of possible fuel spills / leaks due to the usage of machinery on-site.

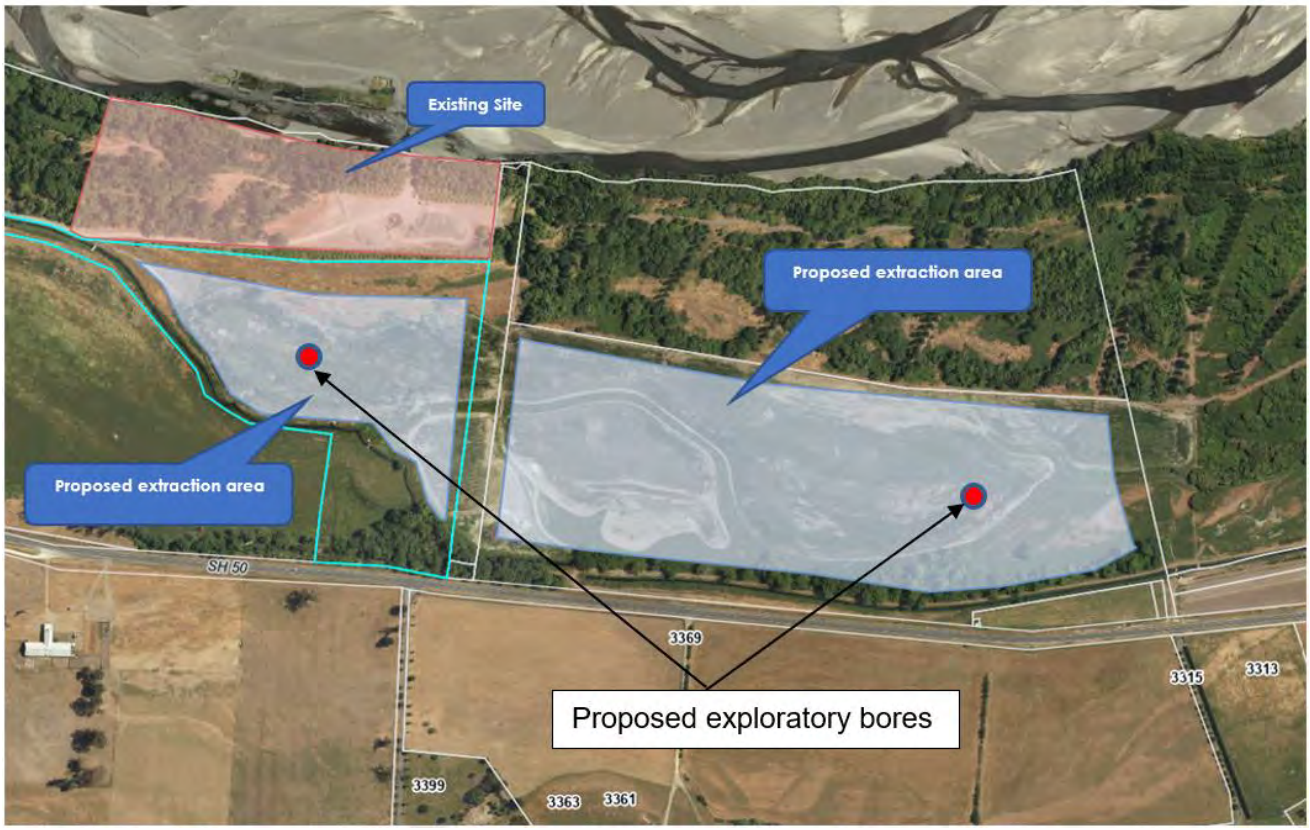

Figure 8.1: Location of proposed exploratory wells

9 References

Bal, A., A., 1996, *Valley fills and coastal cliffs buried beneath an alluvial plain: evidence from variation of permeabilities in gravel aquifers, Canterbury Plains, New Zealand*: Wellington North, Journal of Hydrology, vol. 35, no. 1, p. 1-27.

Dravid, D., & Brown, L. J. (1997). *Heretaunga Plains Groundwater Study: Executive Summary.* Hawkes Bay Regional Council.

HBRC. (2018). *Heretaunga Aquifer Groundwater Model Development Report. HBRC Report No. RM18-14 - 4997.* Hawkes Bay Regional Council.

LDE, (2022). Geotechnical Preliminary Assessment Report for Quarry Expansion. Kereru road / State Highway 50, Maraekakaho. Prepared for Russell Aggregates Ltd. Project Reference: 22392. 14 October 2022. Land Development & Engineering.

Thorpe, H. R. & New Zealand. Geophysics Division. (1990). *Movement of fine sediment through a natural alluvial gravel*. Wellington, N.Z : Geophysics Division, Dept. of Scientifc and Industrial Research.