Sensitivity: General

Takapau Wastewater Treatment Plant – Hydrogeological Assessment

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Prepared for Central Hawke's Bay District Council
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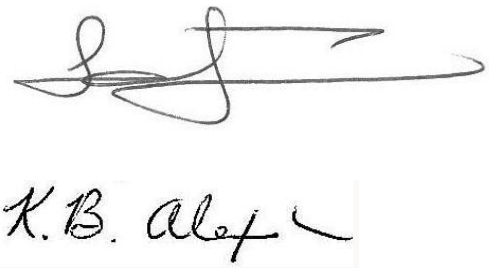
Reviewed by	Keg Alexander and Sian France		23/04/2021
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Contents

Executive Summary 1
1 Introduction 2
2 Site Description 2
2.1 WWTP Location and Operation 2
2.2 Geology 3
2.3 Soil types 4
2.4 Hydraulic Conductivity 6
2.5 Hydrogeology 6
2.6 Hydrology 8
3 Conceptual hydrogeological model 11
3.1 Model set-up 11
3.2 Groundwater Levels and Direction of Flow 12
3.3 Connection between groundwater and surface water 12
3.4 Hydraulic gradient and travel time assessment 14
3.5 Limitations and uncertainties 16
4 Subsurface nutrient attenuation potential 17
4.1 Nitrogen 17
4.2 Phosphorus 18
5 Conclusion and recommendations 18
6 Applicability Statement 18
7 References 18

Appendices

Appendix A – Bores used in the hydrogeological conceptual model
Appendix B – Bores within 2 km of the Takapau WWTP
Appendix C – HBRC log for Takapau public supply bore

Executive Summary

As part of the consent renewal for wastewater discharge at the Takapau Wastewater Treatment Plant (WWTP), a revised system comprised of spray irrigation of treated wastewater at the surface is proposed. A hydrogeological assessment was conducted to describe the groundwater system at and around the site, and to assess the potential movement of treated wastewater once it has infiltrated into the groundwater system.

A conceptual model showing the interpreted water table elevation around the WWTP has been developed. The model indicates that groundwater flow around the Takapau WWTP is from west to east generally parallel to the Makaretu River.

Near the WWTP, the Makaretu River is interpreted to be a losing stream, i.e. subsurface flow is from the river to groundwater, based on regional and local groundwater levels.

The two most significant potential receptors, identified as being the Makaretu River and the Source Protection Zone (SPZ) around the Takapau public supply bore, are both upgradient of the site, suggesting that infiltrated wastewater from the WWTP site will not travel towards these locations.

There are 27 existing groundwater bores known to be located within 2 km of the WWTP but none are considered to be directly downgradient and most are located upgradient, or on the other side of significant surface water bodies, hence infiltrated wastewater is not expected to travel towards these receptors.

1 Introduction

As part of the consent renewal for wastewater discharge at the Takapau Wastewater Treatment Plant (WWTP), a hydrogeological assessment was conducted to describe the groundwater characteristics at and around the site, and to assess the potential movement of treated wastewater once it has infiltrated into the groundwater system.

The scope of this report is as per Deliverable Scoping Document T:B.14, dated 26/03/2021.

The scope of this report does not include design of the proposed disposal system (drainage calculations etc), which has been undertaken by others.

2 Site Description

2.1 WWTP Location and Operation

The Takapau Wastewater Treatment Plant (WWTP) is located on Burnside Road adjacent to the Makaretu River Bridge in Central Hawke's Bay, approximately 2 km northeast of the town of Takapau (Figure 1).

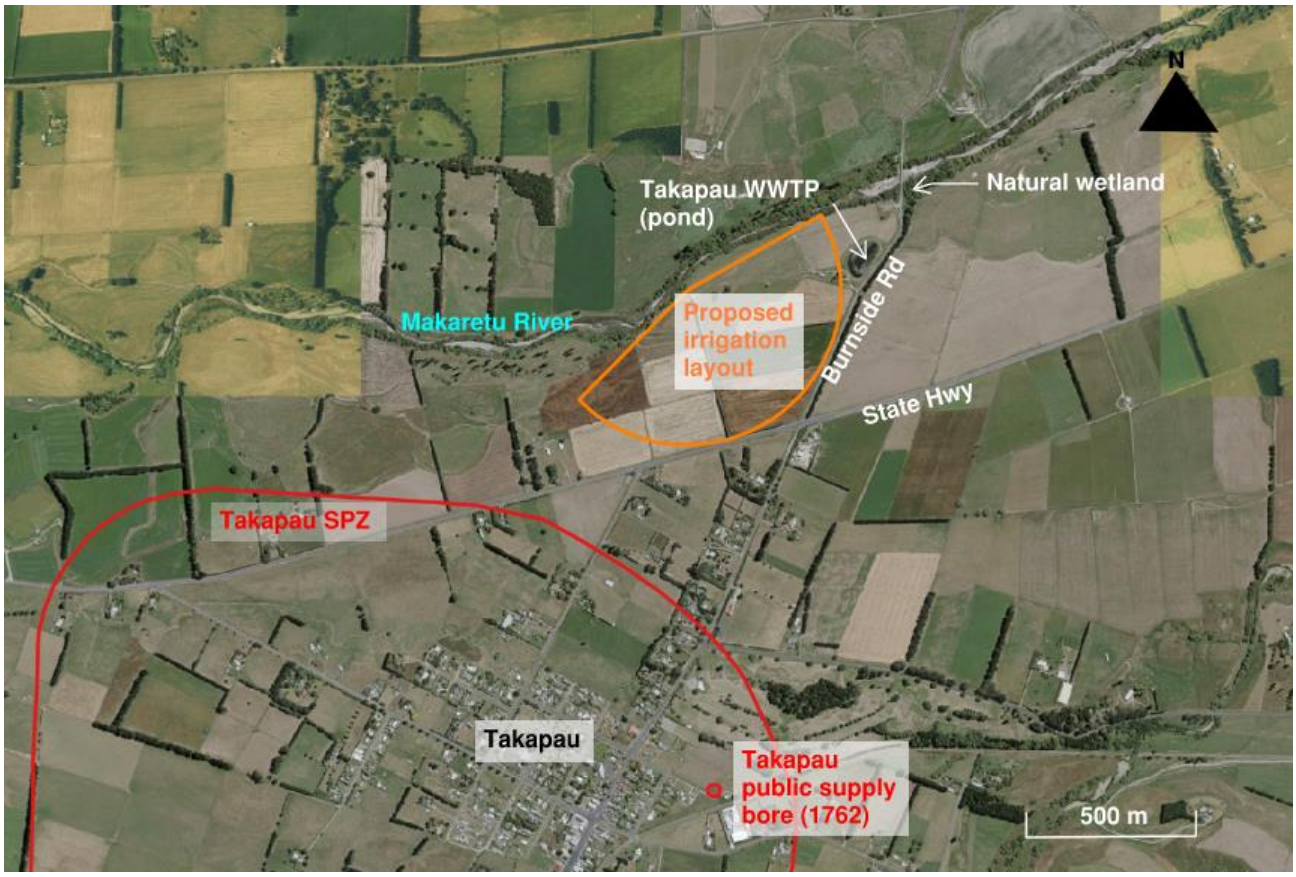

Figure 1: Location of Takapau WWTP. Proposed irrigation plan layout provided by LEI (2021a).

Wastewater from the small rural community is currently pumped to the Takapau WWTP, which consists of one clay-lined stabilisation pond of approximately 0.6 ha. Treated effluent is discharged to a drainage system in a natural wetland located approximately 120 m to the northeast adjacent to the southern bank of the Makaretu River.

The current discharge consent expires on 31 October 2021. For the consent renewal, it has been proposed to avoid discharging from the pond to the wetland, except during low river flow conditions, and to discharge directly to nearby farmland (Drummond Farm) as irrigation.

For this proposed discharge scheme, two key potential receptors are identified as follows:

- The Makaretu River, located 150 m north of the WWTP
- The Takapau Source Protection Zone (SPZ) around the public supply bore 1762. The edge of the SPZ is located approximately 1.1 km southwest of the WWTP.

A search of the Hawke's Bay Regional Council bores database was undertaken, and whilst there are 27 existing bores known to be located within a 2 km radius, there are none considered to be directly down-gradient of the WWTP.

2.2 Geology

The area is situated in the southern Ruataniwha Plains, in the area between Ruahine and Raukawa Ranges. The WWTP is situated between 220 and 222 m above mean sea level (MSL), in the alluvial terrace of the Makaretu River.

The general physical geography of the area is characterised by plains of alluvial origins. Intermediate river terraces composed of Pleistocene-aged alluvium (Q2a) are present across the wider Ruataniwha Plains, while the low terraces are composed of Holocene-aged alluvium (Q1a) generally follow the course of the Makaretu River (Lee et al, 2011). Figure 2 presents the distribution of the stratigraphic units around the WWTP and Table 1 provides the summary of these units.

According to Lee et al (2011), there are three major active faults close to the site, all with reverse movement: Ruataniwha, Oruawharo, and Takapau Faults, located respectively 2.9 km west, 3.0 km east, and 1.5 km southwest of the WWTP. The author also mentions the inactive Waikopiro Fault, situated just 100 m east to the WWTP (Figure 2) although active fault locations are often concealed beneath the alluvium.

Table 1: Stratigraphic formations at Takapau (Lee et al, 2011).

Unit	Typical Lithology	Thickness
Q1a – Holocene river deposits	Poorly consolidated alluvial gravel, sand, and mud	Approximately 40 m
Q2a – Late Pleistocene river deposits	Poorly to moderately sorted gravel with minor sand and silt underlying terraces.	Up to 250 m

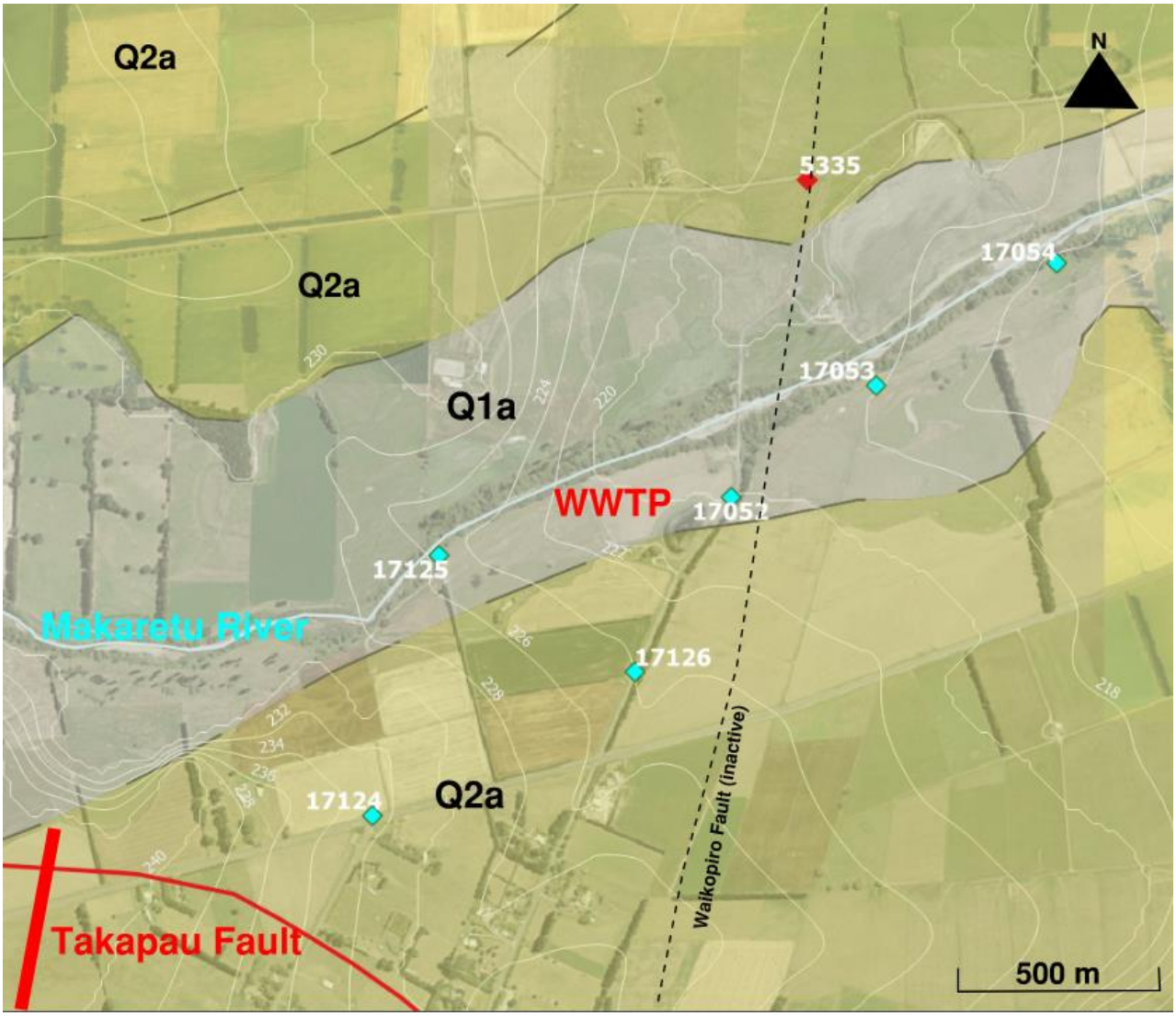

Figure 2: Geology of Takapau area (Lee et al, 2011). Blue point indicate the location of the six piezometers installed in 2020 around the WWTP. Red diamond is a HBRC groundwater level monitoring bore. Contours indicate the ground elevation in m MSL.

2.3 Soil types

A site investigation performed by LEI (2020) identified six different types of soil in the area (Figure 3):

- Lower terrace:
  - Ashburton Silt Loam: silty to sandy loam with gravels, occupying most of the lower terrace
- Upper terrace:
  - Ruataniwha Silt Loam: silty topsoil texture, with some gravels and poorly drained
  - Takapau Silt Loam: silty allophanic soils with no gravels, well drained
  - Tikokino Silt Loam: silty topsoil texture, moderately to well drained
  - Tikokino Shallow and Stony Loam: similar to Tikokino Silt Loam, but with up to 10 cm gravels in the topsoil
- Transition from lower to upper terrace:
  - Oronoko Silt Loam: silty loam with no gravels, moderately well drained, located in the transition from the lower to the upper terrace.

Figure 3: Soils distribution around Takapau WWTP. Source: LEI (2020).

2.4 Hydraulic Conductivity

No site-specific testing of hydraulic conductivity[1] is available; however, some inferences can be made from the soil descriptions and infiltration rates as detailed below.

In 2020, six shallow piezometers (up to 5.8 m deep) were installed around the WWTP to monitor groundwater quality and levels. Their locations are indicated by the blue points in Figure 2 and their details are further presented in Section 3.1. According to LEI (2021b), the soils encountered during installation of piezometers 17124 and 17126, in the Q2a unit, had high clay contents and the piezometers were slow to recharge after purging. A similar behaviour was observed in 17052, located in Q1a but close to the boundary with Q2a. The remaining piezometers, all located in Q1a, had fast recoveries after purging. This is discussed in Section 3.4.

LEI (2020) also performed infiltration tests in four different sites across the WWTP, as shown in Figure 3. These infiltration tests provide a measure of the rate of downward movement of water through the upper meter or so of soil. The results are summarised in Table 2 and indicate that, in general, the soil in the lower terrace Q1a (Site 1) appears to have a higher infiltration rate than the soils in the upper terrace Q2a (Sites 2, 3, 4). This is consistent with the observations of recovery times in the site-specific piezometers described above.

Table 2: Infiltration test results at Takapau WWTP. Source: LEI (2020)

Location	Unsaturated soil infiltration rate (mm/h)
Site 1	119 ± 55
Site 2	65 ± 48
Site 3	26 ± 29
Site 4	50 ± 33

Based on the bore log descriptions and the response of the piezometers to purging, the estimated saturated hydraulic conductivity values of the shallow aquifer in the lower terrace are likely higher than the shallow aquifer in the upper terrace, which has a higher content of fine material (clay and silt).

The estimated upper bound saturated hydraulic conductivity for the shallow alluvial sand and gravel aquifer in the lower terrace could be as high as $4x10^{-4}$ to $4x10^{-3}$ m/s (Geotechdata.info, 2013); the estimated range of saturated hydraulic conductivity values for the shallow aquifer in the upper terrace could be 1-2 orders of magnitude lower depending on fines content.

2.5 Hydrogeology

According to Bay Geological Services Ltd (2019), most aquifers in the southern Ruataniwha Plains are typically thick intermittent gravel lenses of variable permeability. These materials are grouped into two main Quaternary geological units. The older one, the Salisbury Gravels (Q2a - Lower Quaternary), can be up to 250 m thick. This unit is overlain by Young Gravels (Q1a - Upper Quaternary), which is approximately 40 m thick and comprise mostly unconfined aquifers composed of gravels with sandy, clayey, or silty matrix.

Recharge of the aquifer system occurs mainly by precipitation in the Ruahine Range to the west, especially during winter, and from losing rivers across the plains.

Hawke's Bay Regional Council (HBRC) has an extensive groundwater monitoring network. Table 3 provides a summary of the bores that are shallower than 30 m that are within 15 km of the WWTP.

[1] A measure of how easily groundwater water can pass through saturated soil or rock.

Table 3: HBRC monitoring bores within 15 km of the WWTP

Bore ID	NZTM Coordinates (m)	Elevation (m MSL)[1]	Distance from WWTP (km)	Screened Interval[1]	Total depth[1]	Maximum water level	Minimum water level	Average water level
5335	E: 1886887 N: 5566276	221.06	0.8	28.8 – 29.8 m BGL 192.3 – 191.3 m MSL	29.8 m BGL 191.3 m MSL	3.52 m BGL 217.54 m MSL	5.24 m BGL 215.82 m MSL	4.00 m BGL 217.05 m MSL
16507	E: 1892932 N: 5563970	180	6.5	27.6 – 28.8 m BGL 152.4 – 151.2 m MSL	28.8 m BGL 151.2 m MSL	9.62 m BGL 170.38 m MSL	9.95 m BGL 170.05 m MSL	9.71 m BGL 170.29 m MSL
16095	E: 1886853 N: 5569343	222.68	3.8	25.1 – 26.1 m BGL 197.6 – 196.6 m MSL	26.1 m BGL 201.6 m MSL	3.77 m BGL 218.91 m MSL	7.01 m BGL 215.67 m MSL	5.21 m BGL 217.47 m MSL
1376	E: 1896318 N: 5568312	154.96	10.1	20.1 – 25.2 m BGL 134.9 – 129.8 m MSL	24.2 m BGL 130.8 m MSL	0.52 m BGL 154.44 m MSL	0.93 m BGL 154.03 m MSL	0.72 m BGL 154.24 m MSL
16252	E: 1884059 N: 5569026	251.65	4.3	22.3 – 23.5 m BGL 229.4 – 228.2 m MSL	23.5 m BGL 228.2 m MSL	10.70 m BGL 240.95 m MSL	10.97 m BGL 240.68 m MSL	10.84 m BGL 240.81 m MSL
16247	E: 1890384 N: 5571135	194.75	6.7	12.5 – 14.0 m BGL 182.3 – 180.8 m MSL	14.0 m BGL 180.8 m MSL	1.84 m BGL 192.91 m MSL	4.84 m BGL 189.90 m MSL	2.87 m BGL 191.88 m MSL
16479	E: 1883704 N: 5566042	254.28	3.0	10.7 – 11.5 m BGL 243.6 – 242.8 m MSL	12.0 m BGL 242.3 m MSL	3.63 m BGL 250.65 m MSL	4.32 m BGL 249.96 m MSL	3.94 m BGL 250.34 m MSL
16503	E: 1890973 N: 5563088	192.66	5.0	10.3 – 11.5 m BGL 182.4 – 181.2 m MSL	11.5 m BGL 181.2 m MSL	1.70 m BGL 190.96 m MSL	2.23 m BGL 190.44 m MSL	1.94 m BGL 190.72 m MSL
16500	E: 1897758 N: 5570301	149.11	12.1	10.3 – 11.4 m BGL 138.8 – 137.7 m MSL	11.4 m BGL 137.7 m MSL	1.29 m BGL 147.82 m MSL	1.60 m BGL 147.51 m MSL	1.51 m BGL 147.60 m MSL
16491	E: 1894469 N: 5567402	163.3	8.1	4.4 – 5.6 m BGL 158.9 – 157.7 m MSL	5.6 m BGL 157.7 m MSL	2.34 m BGL 160.96 m MSL	3.34 m BGL 159.96 m MSL	2.75 m BGL 160.55 m MSL

[1]Elevations in m MSL estimated from an 8-m resolution Digital Elevation Model downloaded from Land Information New Zealand (LINZ).

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Table 3 also presents the maximum, minimum, and average water levels recorded between July 2020 and February 2021.

As further discussed in Section 3, these bores indicate a general groundwater flow from west to east, approximately parallel to the Makaretu River.

Of the ten HBRC monitoring bores used in our assessment, five are shallower than 15 m BGL, while the remaining five are deeper than 20 m BGL. There are no nested piezometers, or pairs of piezometers (at the same location but screened at different depths) with which to assess vertical gradients.

Seasonal ranges (the difference between maximum winter and minimum summer levels) at individual bores vary from as little as 0.27 m (bore 16252) to 3.24 m (in bore 16095, Table 3). There is no clear correlation between seasonal range and depth, and the maximum and minimum water levels at individual bores can occur at different periods in the year (i.e. the summer low level across all bores does not occur consistently in the same month). The lack of clear depth, spatial or temporal correlation suggests that the seasonal ranges may reflect localised conditions, variability in screened unit etc.

2.6 Hydrology

The site is located in the Makaretu River sub-catchment, which is contained within the wider Tukituki catchment. The Makaretu River sub-catchment is approximately 80 km^2 and is located in the south-western, inland area of the Hawke's Bay Region (Figure 4). The sub-catchment is a linear feature draining from the southwest in the foothills of the Ruahine Ranges (at approximately 400 m MSL) onto the Ruataniwha Plains (Forbes et al, 2011).

The Makaretu River sub-catchment is bordered to the north and south by similarly defined, linear subcatchments – Tukipo and Porangahau respectively – all of which are contained within the wider Tukituki catchment management zone.

The Makaretu River, along with the Tukipo River and Porangahau Stream (via the Maharakeke River), converge with the Tukituki River approximately 5 km upstream of Waipukurau.

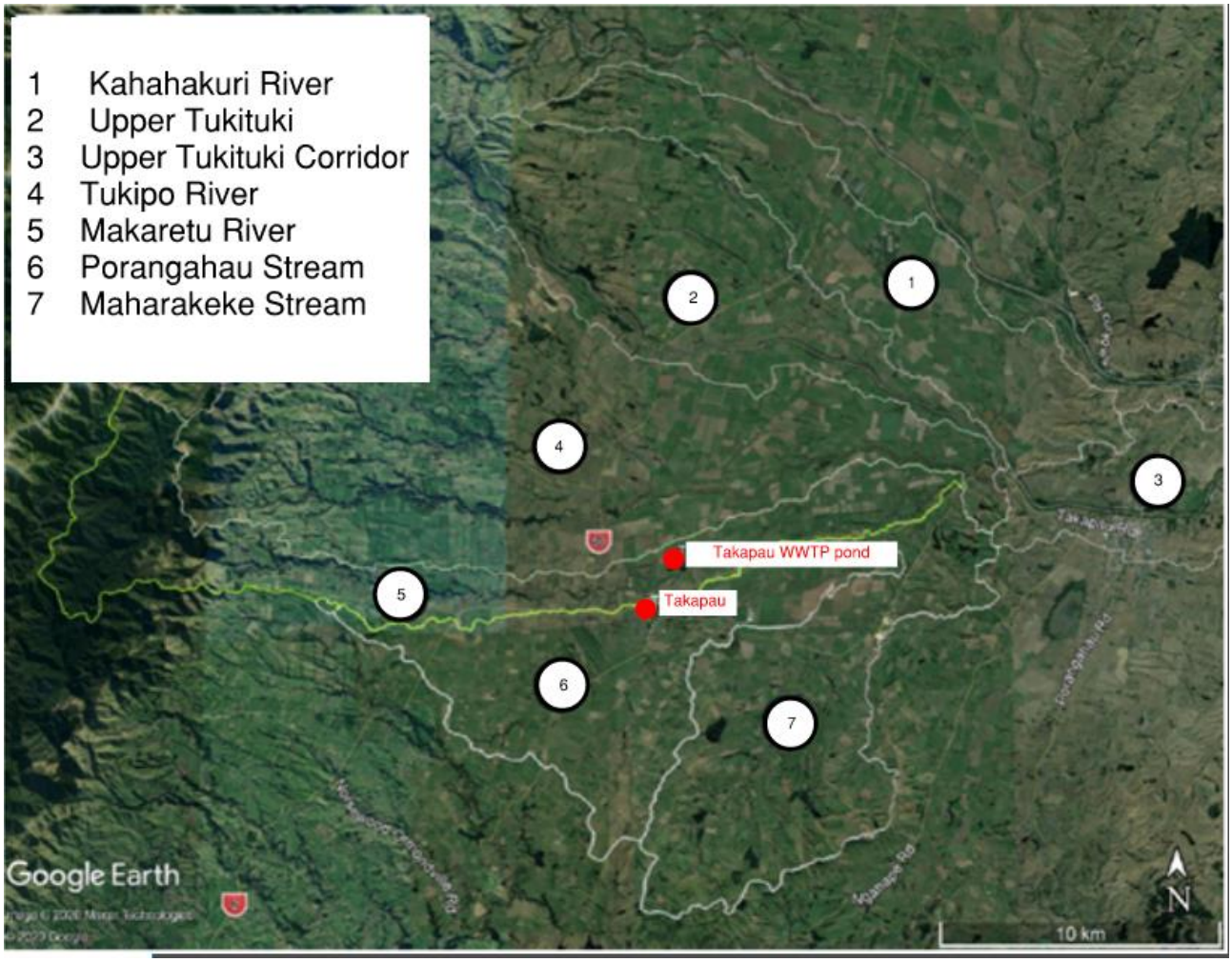

Figure 4: Southern sub-catchments of the Tukituki River catchment.

The relationship between these rivers and groundwater is discussed in Johnson (2011, as cited in Wilding & Waldron, 2012). According to this study, the rivers originating in the Ruahine Ranges tend to be conservative upstream (neither gaining nor losing water to groundwater), and then become losing streams in their middle reaches as the river water infiltrates the permeable alluvium material. Downstream, these rivers tend to gain flow from groundwater, as they intercept spring-fed tributaries at lower elevation areas, where the groundwater tends to be shallower.

Figure 5 shows the stream reaches in the Tukituki catchment and their classification as gaining, losing, or conservative reaches (Johnson, 2011). A further discussion based on our hydrogeological conceptual model is provided in Section 3.3.

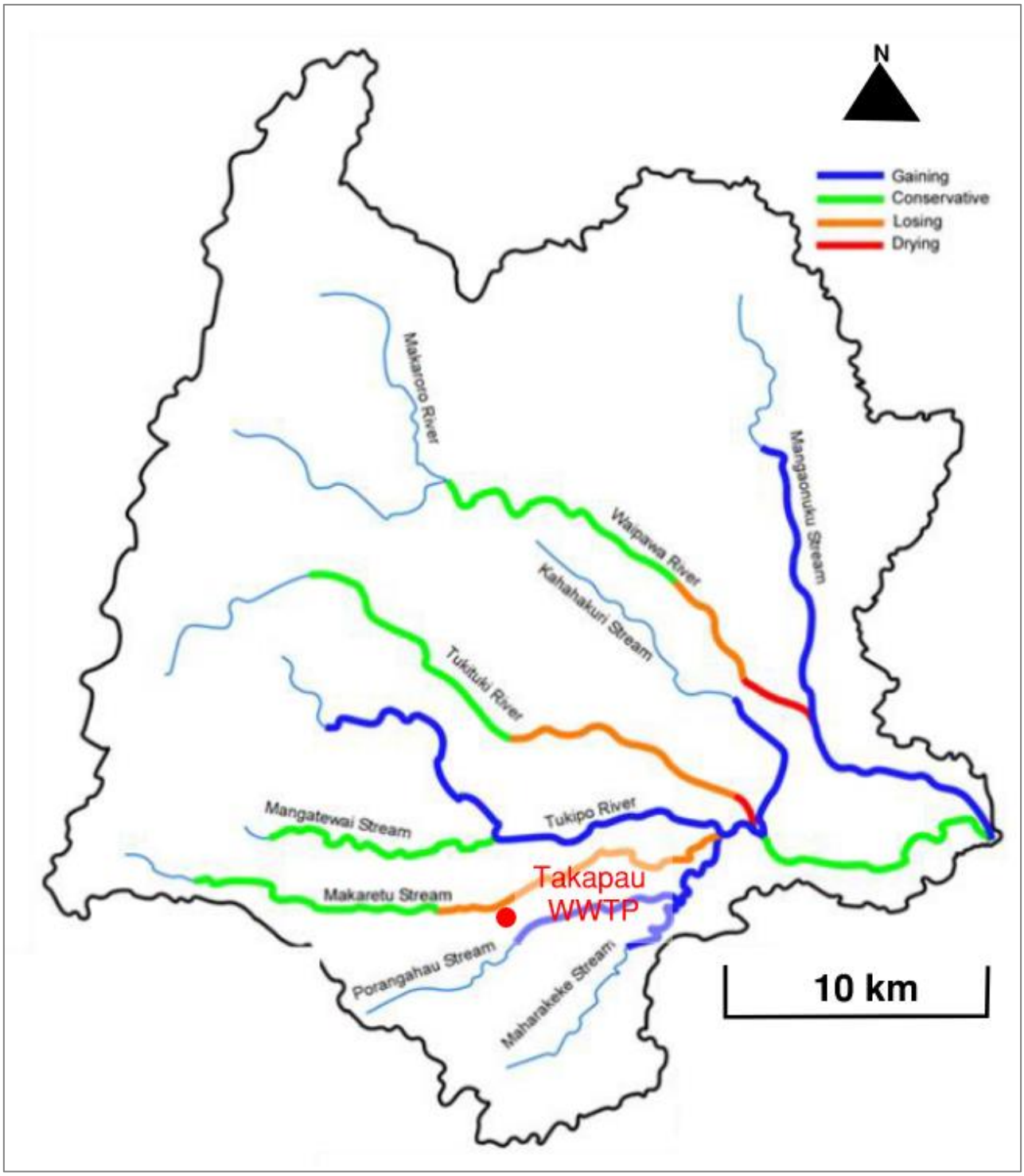

Figure 5: Conservative, losing and gaining stream reaches in the Tukituki Catchment. Source: Johnson (2011, as cited in Wilding & Waldron, 2012).

3 Conceptual hydrogeological model

3.1 Model set-up

A conceptual hydrogeological model was created using Golden Software Inc's Surfer 11 software using the following inputs:

- Groundwater level measurements obtained on 18 February 2021 from 6 shallow piezometers (no deeper than 5.8 m BGL) installed around the WWTP. Information about these piezometers was provided by LEI (2021b).
- Groundwater level measurements obtained on 23 February 2021 from 10 bores located within 15 km of the WWTP that are part of the groundwater monitoring network of HBRC. These data were obtained from HBRC Maps and GIS database.
- Approximately 850 elevation points located along Tukipo River, Makaretu River, Porangahau Stream and Maharakeke Stream. The groundwater elevation at these points was assumed to be equal to the surface water at these locations. Elevation data were estimated using an 8-m resolution Digital Elevation Model (DEM) obtained from LiDAR data downloaded from Land Information New Zealand (LINZ).

The location of the bores used in the model are presented in Figure 6 and their details are summarised in Appendix A.

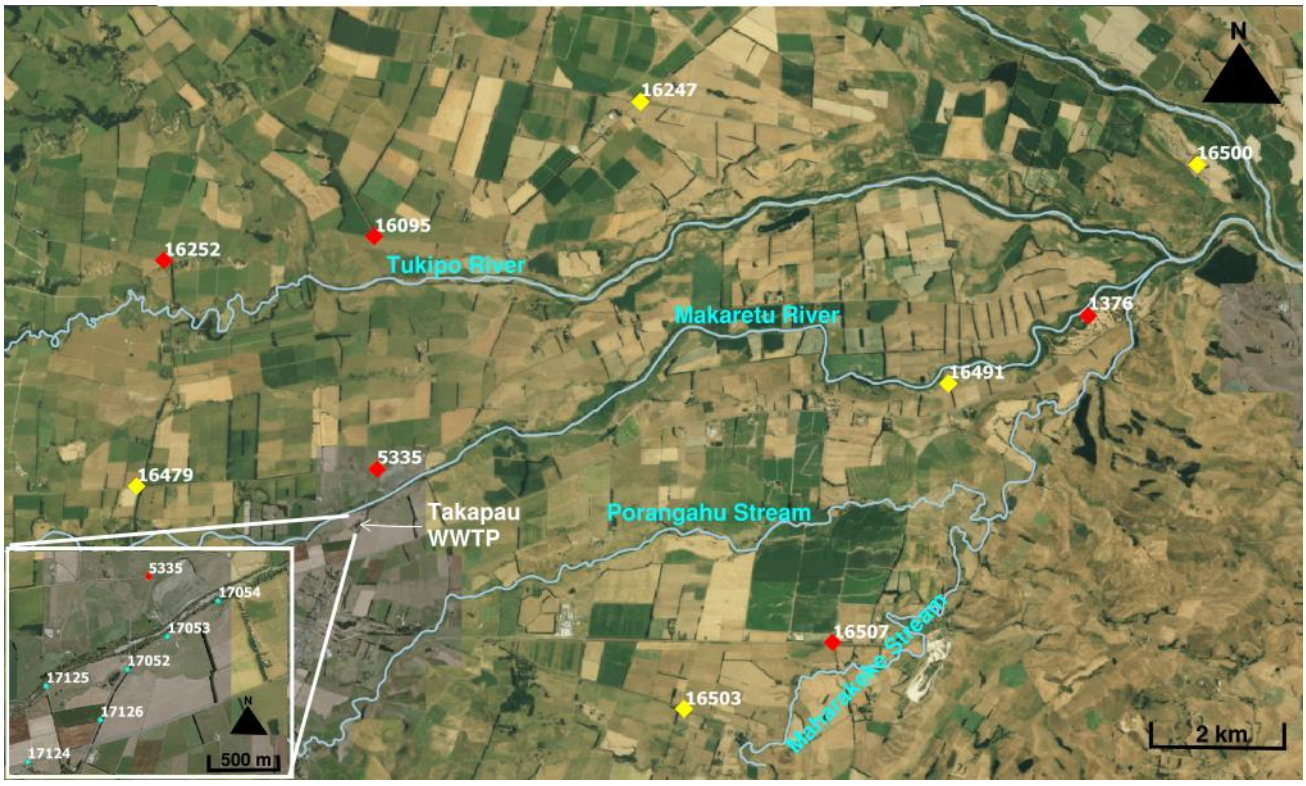

Figure 6: Regional bore locations used for hydrogeological conceptual model. Bores denoted by red dots are screened between 20 and 30 m and bore denoted by yellow dots are screened between 4 and 14 m. Blue dots indicate the location of the six piezometers around the WWTP.

We make the following observations:

- Water levels measured in the regional bores in February 2021 (dry season) were compared with water levels measured in August 2020 during the wet season. No significant seasonal differences in the interpreted groundwater flow direction were observed.

- There is only one set of groundwater level measurements (February 2021) from the 6 piezometers at the WWTP. No assessment of seasonal variation is available for these bores.
- The elevations in m MSL presented in this document are approximately 10 m lower than elevations presented in Table 1 of LEI (2021b). The LEI report notes that elevations are based on LiDAR data collected in 2006, while this report uses LiDAR data obtained in 2012, which we assumed to be more precise and whose levels are matching other sources (e.g. Google Earth). All levels provided by LEI were converted to levels given by the 2012 LiDAR data.
- Of the ten bores from HBRC monitoring network, five are screened below 20 m BGL (red dots in Figure 6), while the other five bores are screened at depths of less than 15 m (yellow dots in Figure 6). Three different conceptual models were developed, one using data from just the shallow bores, another using data from just the deeper bores, and a third using data from all 10 bores. No significant differences were observed between the three models indicating that there does not appear to be a significant hydraulic separation.

3.2 Groundwater Levels and Direction of Flow

The conceptual hydrogeological model shown in Figure 7 presents the water table elevation in m MSL and interpreted shallow groundwater flow direction in the vicinity of the WWTP site on a regional scale, whilst Figure 8 shows this on a local scale.

The groundwater at the site flows from west to east at a gradient of approximately 0.005 (1 m drop over a horizontal distance of 200 m), as can be inferred from Figure 8.

3.3 Connection between groundwater and surface water

The relationship between groundwater and the Tukipo River, Makaretu River, Porangahau Stream and Maharakeke Stream can be seen on the 3D blocks shown in Figure 7 and Figure 8. These figures illustrate that the reaches of these rivers closest to the WWTP are either conservative (neither gaining nor losing water) or losing water to groundwater.

In agreement with Johnson (2011), our conceptual model indicates that immediately adjacent to the Takapau WWTP, the Makaretu River is slightly more elevated than the surrounding water table, suggesting that the river is losing water to groundwater in this area.

Downstream, below the junction with the Tukipo River, the groundwater table becomes higher and the river starts to gain flow (Figure 5).

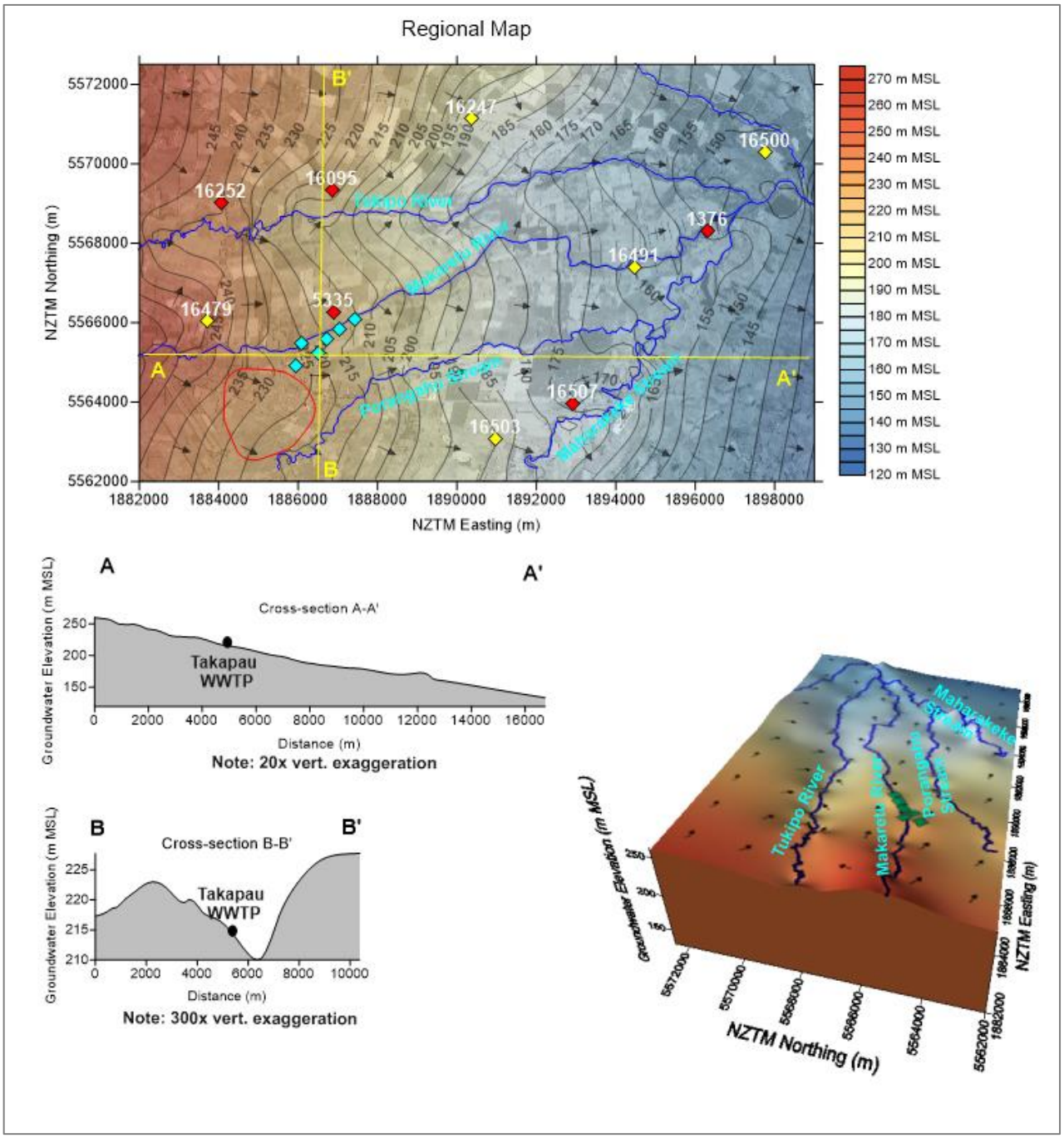

Figure 7: Regional conceptual hydrogeological model. The WWTP is located at the intersection of the cross-section lines. Red circle to SW is the Source Protection Zone for the Takapau water supply bore. Regional bores shown as red and yellow diamonds and local piezometers shown by blue diamonds. Contours indicate the water table elevation in m MSL and arrows indicate the interpreted groundwater flow direction.

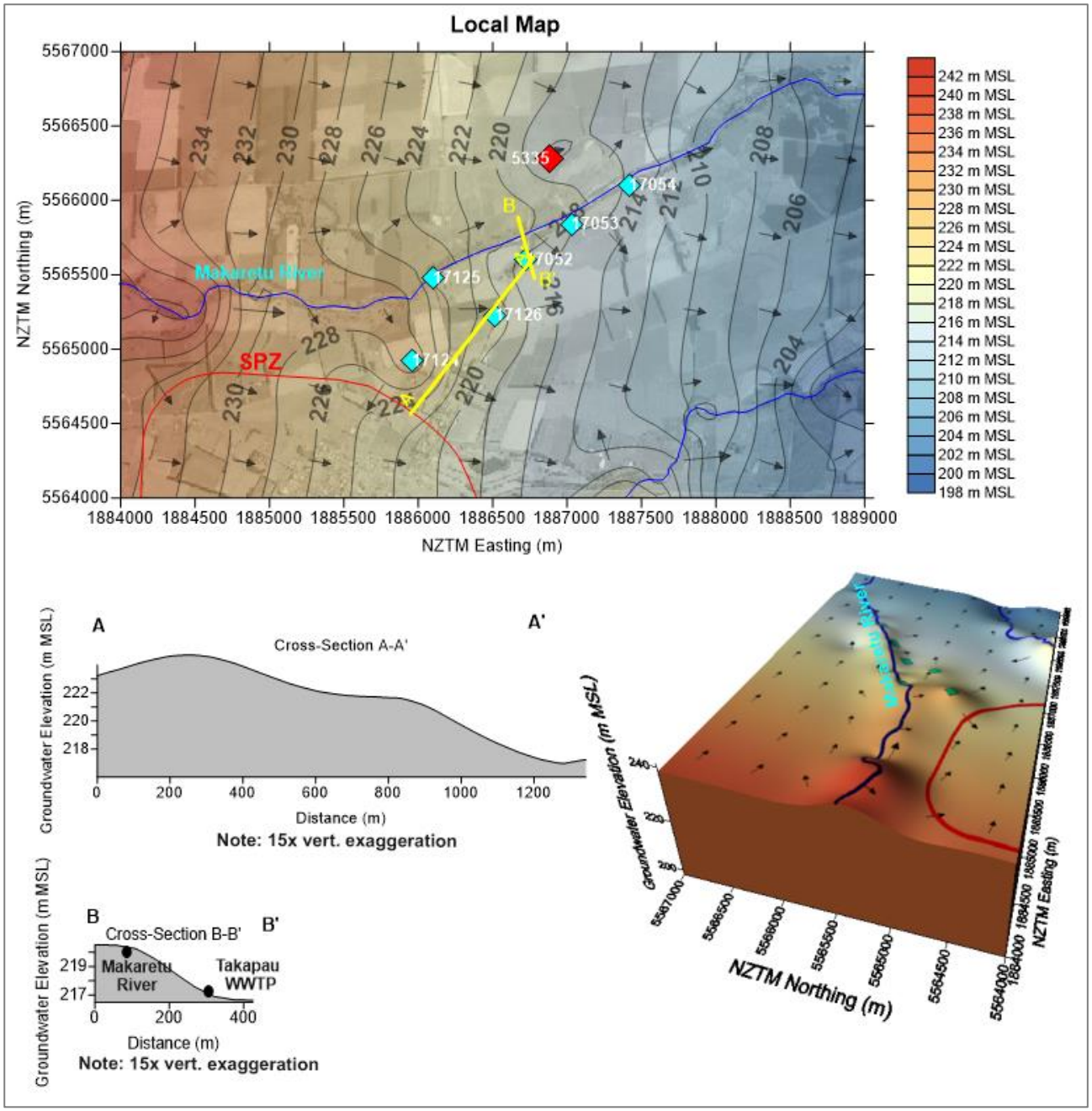

Figure 8: Local conceptual hydrogeological model. Regional bore 5335 shown as red diamond and local piezometers shown by blue diamonds. Contours indicate the water table elevation in m MSL and arrows indicate the interpreted groundwater flow direction.

3.4 Hydraulic gradient and travel time assessment

Figure 7 indicates the regional hydraulic gradient is predominantly from west to east (Cross-section A-A' in that same figure).

Cross-section A-A' in Figure 8 shows the hydraulic gradient over the shortest path between the Takapau SPZ and the WWTP site. Likewise, Cross-section B-B' in Figure 8 shows the hydraulic gradient over the shortest path between the Makaretu River and the WWTP site. Both cross-sections indicate that the potential receptors (the SPZ and the Makaretu River) are ***upgradient*** of the WWTP and thus, shallow groundwater flow and infiltrated wastewater from the WWTP would not be expected to flow towards these potential receptors and so travel time has not been assessed.

There are also private groundwater bores located within 2 km of the WWTP; these are shown in Figure 9 and their details are included in Appendix B. The yellow dots show bores deeper than 30 m, while the blue dots show the bores shallower than 30 m. There is only one bore that is directly downgradient of the WWTP, bore 4838, which is screened below 80 m BGL, and hence is considered unlikely to have any connection with the shallow groundwater.

Bores 1384 and 4254, which are shallower than 30 m BGL and are possibly downgradient of the WWTP, but are located 1.7 km and 1.9 km away, respectively, and on the other side of the Porangahau Stream, and, therefore, are unlikely to be impacted by any infiltrated wastewater from the WWTP.

Bore 1381 is along gradient and all other bores located between the Makaretu River and the Porangahau Stream are considered to be upgradient of the WWTP.

There is the possibility of upgradient bores reversing the hydraulic gradient when pumping, in which case the capture zone of the pumped bore could cause nearby shallow groundwater to flow toward the pumping bore. It is not possible to fully quantify this without details of well operation and performance (pumping rate and durations, drawdown etc) however qualitatively we would note:

- There are only three water take consents within 2 km of the WWTP, all of them relate to bores deeper than 30 m and based on bore 1762 described below, there is likely to be some hydraulic separation between shallow groundwater and the deeper aquifer screened in these bores.
- All other unconsented takes and shallower bores are likely to have lower pumping rates and, therefore, are unlikely to reverse the hydraulic gradient over large distances.
- The water take consent associated with bore 1762 is the Takapau community supply. According to its HBRC log (Appendix C), this bore is screened from 31.0 to 33.5 m BGL and there is approximately 22 m of lower permeability units (comprised of multiple clay layers) above the screened interval. These units are likely to provide some hydraulic separation between the pumped aquifer and the shallow groundwater. Further the SPZ is presumably based on an assessed extent of drawdown and suggests that this does not extent a significant distance downgradient.

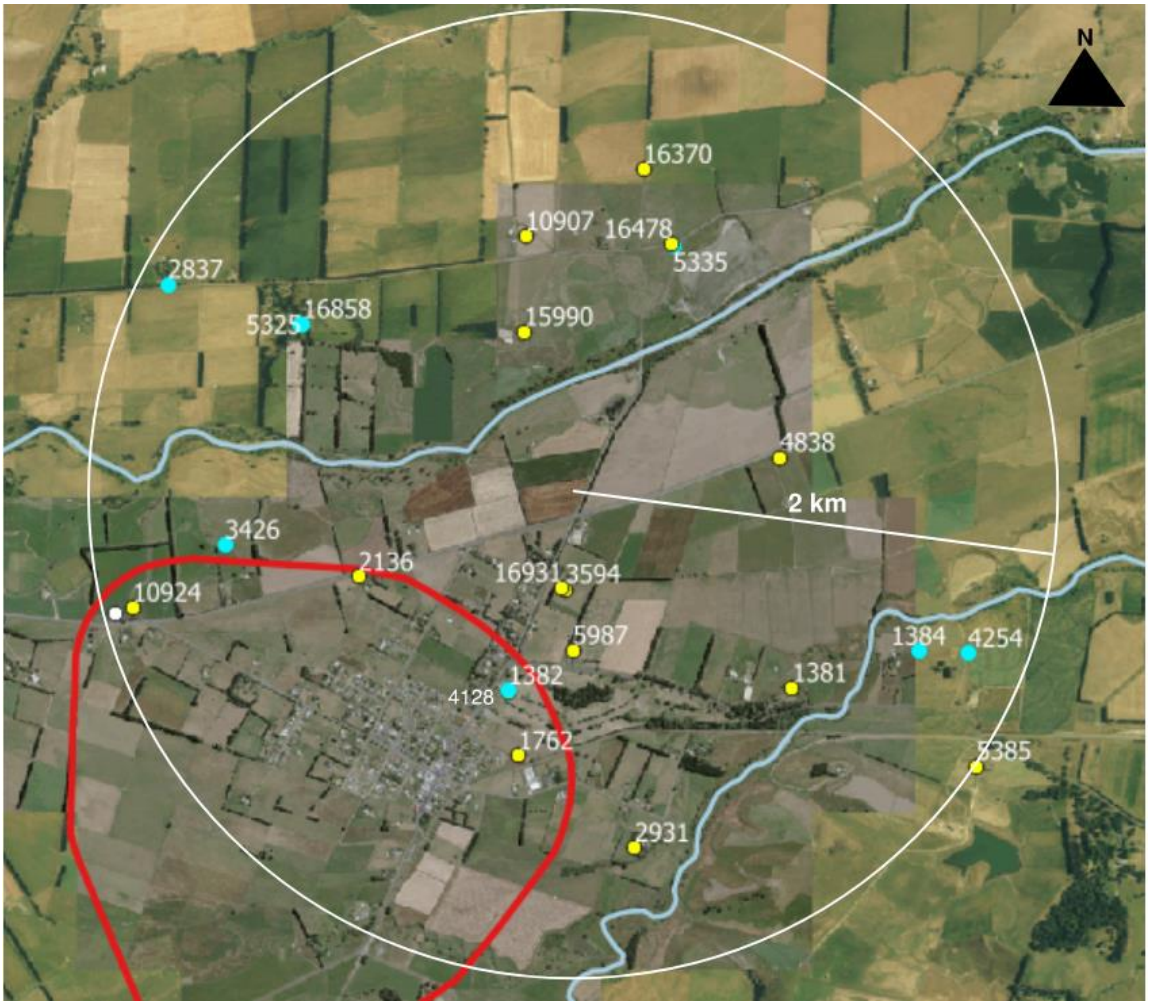

Figure 9: Bores within 2 km of the WWTP. Red line is SPZ surrounding the Takapau water supply bore 1762. The yellow dots show bores deeper than 30 m, while the blue dots show the bores shallower than 30 m.

3.5 Limitations and uncertainties

Table 4 outlines the key limitations to the hydrogeological assessment.

Table 4: Conceptual model and assessment limitations

Element	Comment
Ground elevation	• Limited resolution of LiDAR data and multiple LiDAR data sets • No ground elevation reported on HBRC logs
Water levels	• Limited information about river levels close to Takapau, these have been obtained from LiDAR • No monitoring of Makaretu River level available
Seasonal variations	• Groundwater levels for the six site specific piezometers around the WWTP have only been measured once (in February 2021)
Gradients	• In general, the flow of groundwater is such that there are no directly down-gradient receptors. It is possible that pumping from bores could locally reverse gradients thought the effect of this is likely to be limited to immediately around the bores and would not materially change the assessment presented above.

4 Subsurface nutrient attenuation potential

As described above, the Takapau Source Protection Zone (SPZ) and the Makaretu River are the two most significant potential receptors for this groundwater assessment. Any groundwater interaction between the SPZ and the Makaretu River adjacent to Drummond Farm is likely to be negligible due to the interpreted groundwater flow direction and the indication that the Makaretu River is generally losing water to groundwater along this reach.

There are no receptors (e.g. registered groundwater users, surface water bodies, source protection zones, etc) identified as directly down-gradient but regardless this section assesses the potential for nutrient (nitrogen and phosphorus) transmission through the soil and groundwater should there be unknown receptors down-gradient of the site.

4.1 Nitrogen

As nitrate moves from land to receiving waters there is potential for subsurface denitrification and hence the attenuation of nitrate flux to receiving surface waters. Attenuation potential is dependent on a number of variables including land-use type, soil type, organic carbon content, and permeability (drainage) (Table 5).

Table 5: Nitrogen attenuation factors by soil type (Singh et al, 2019).

Nitrogen attenuation factor		Soil types (soil texture, drainage and carbon classes)*	Rock types (geology)
Low	0.10 – 0.30	Stony sandy loam, and sand & stony gravel; soil carbon class 5; and soil drainage classes 4 and 5, and artificial drainage	e.g. Gravels
Medium	0.35 – 0.65	Sandy and silt loams; soil carbon classes 3 and 4; and soil drainage class 3	e.g. Sandstone, limestone, and siltstone
High	0.70 – 0.95	Heavy silt loam, clay loam and peaty loam; soil carbon classes 1 and 2; and soil drainage classes 1 and 2	e.g. Mudstone and peat

*According to the FSL, soil carbon is classified into 5 classes where soil carbon class 1 is very high soil total carbon content (>20%) and soil carbon class 5 is very low soil total carbon content (2%). Soil drainage classes (1 to 5) where soil drainage class 1 is assigned to very poorly drained soil and soil drainage class 5 to well drained soils.

The Drummond Farm area designated for treated wastewater irrigation is comprised of varying stages of silty loam (Figure 3), underlain by Quaternary river gravels. This is indicative of an environment with a low to medium attenuation factor (AFn) due to the high permeability of the gravels, although the silt and organic carbon content in the near surface soil could contribute to a higher attenuation factor and reduce the total discharge to the sensitive receptors.

Overseer farm nitrogen losses, modelled by LEI, indicate a nitrogen loss of 2,097 kg/yr as a result of the WWTP irrigation combined with existing farm irrigation and fertiliser regimes. Due to the assumed low to medium attenuation factor in the soils, limited attenuation by the soils may occur which would reduce the actual nitrogen loss to groundwater compared with the modelled Overseer value. Once leached from the agricultural soils, nitrogen, in the form of nitrate-nitrogen (NO_3-N), may be further attenuated through a process of denitrification if favourable conditions exist in the groundwater system (Collins et al, 2017).

Based on the interpreted groundwater contours, nitrogen in groundwater would need to travel several km downgradient before it is expected to enter any surface water body (if at all). As such, it is considered that attenuation of nitrogen, initially by soils and subsequently by groundwater, may contribute to reducing the modelled farm-loss mass-load of nitrogen (2,097 kg/yr) to surface water bodies in the Tukituki Catchment.

4.2 Phosphorus

Phosphorus is predominantly lost by erosion and entrainment in the form of overland flow. It binds readily with soil, rather than water, through adsorption with respect to ionic strength, higher clay content and acidic soils (Carpenter et al, 1998). As such, the loss of phosphorus by groundwater leachate is considered to be a minor by-product in the phosphorus cycle. It is considered likely that limited phosphorus would be leached from the site through groundwater.

5 Conclusion and recommendations

The conceptual hydrogeological model indicates the groundwater flow around Takapau WWTP is from west to east generally parallel to the Makaretu River. Near the WWTP, the Makaretu River is interpreted to be a losing stream (subsurface flow is from the river to groundwater) based on regional and local groundwater levels.

The two most significant potential receptors, being the Makaretu River and the Source Protection Zone (SPZ) around the Takapau public supply bore, are both upgradient of the site, suggesting that any infiltrated wastewater from the WWTP site will not travel towards these locations. There are no directly down-gradient receptors identified.

It is recommended that groundwater levels in the six new piezometers near the WWTP should be measured quarterly. The local conceptual hydrogeological model presented in this report should be re-evaluated with additional water level to confirm the assumption here that there is no material change to groundwater flow direction or groundwater-surface water interaction with the Makaretu River seasonally.

6 Applicability Statement

This report has been prepared by Beca on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

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A

Appendix A – Bores used in the hydrogeological conceptual model

Bore ID	NZTM Coordinates (m)	Ground elevation (m MSL)[1]	Screened Interval[1]	Total depth[1]	Water level - Feb 2021[1]
5335	E: 1886887 N: 5566276	221.1	28.8 – 29.8 m BGL 192.3 – 191.3 m MSL	29.8 m BGL 191.3 m MSL	5.24 m BGL 215.9 m MSL
16507	E: 1892932 N: 5563970	180.0	27.6 – 28.8 m BGL 152.4 – 151.2 m MSL	28.8 m BGL 151.2 m MSL	9.95 m BGL 170.0 m MSL
16095	E: 1886853 N: 5569343	222.7	25.1 – 26.1 m BGL 197.6 – 196.6 m MSL	26.1 m BGL 201.6 m MSL	5.52 m BGL 217.2 m MSL
1376	E: 1896318 N: 5568312	155.0	20.1 – 25.2 m BGL 134.9 – 129.8 m MSL	24.2 m BGL 130.8 m MSL	0.93 m BGL 154.1 m MSL
16252	E: 1884059 N: 5569026	251.7	22.3 – 23.5 m BGL 229.4 – 228.2 m MSL	23.5 m BGL 228.2 m MSL	10.97 m BGL 240.7 m MSL
16247	E: 1890384 N: 5571135	194.8	12.5 – 14.0 m BGL 182.3 – 180.8 m MSL	14.0 m BGL 180.8 m MSL	4.85 m BGL 190.0 m MSL
16479	E: 1883704 N: 5566042	254.3	10.7 – 11.5 m BGL 243.6 – 242.8 m MSL	12.0 m BGL 242.3 m MSL	4.32 m BGL 250.0 m MSL
16503	E: 1890973 N: 5563088	192.7	10.3 – 11.5 m BGL 182.4 – 181.2 m MSL	11.5 m BGL 181.2 m MSL	2.23 m BGL 190.5 m MSL
16500	E: 1897758 N: 5570301	149.1	10.3 – 11.4 m BGL 138.8 – 137.7 m MSL	11.4 m BGL 137.7 m MSL	1.60 m BGL 147.5 m MSL
16491	E: 1894469 N: 5567402	163.3	4.4 – 5.6 m BGL 158.9 – 157.7 m MSL	5.6 m BGL 157.7 m MSL	3.34 m BGL 160.0 m MSL
17125	E: 1886103 N: 5565475	225.6	Unknown	5.8 m BGL 219.8 m MSL	2.00 m BGL 223.6 m MSL

Bore ID	NZTM Coordinates (m)	Ground elevation (m MSL)[1]	Screened Interval[1]	Total depth[1]	Water level - Feb 2021[1]
17053	E: 1887033 N: 5565838	218.2	Unknown	4.5 m BGL 213.7 m MSL	1.78 m BGL 216.4 m MSL
17054	E: 1887420 N: 5566099	215.6	Unknown	4.3 m BGL 211.3 m MSL	0.90 m BGL 214.7 m MSL
17052	E: 1886724 N: 5565599	220.0	Unknown	4.2 m BGL 215.8 m MSL	2.89 m BGL 217.1 m MSL
17124	E: 1885961 N: 5564921	232.6	Unknown	4.2 m BGL 228.4 m MSL	3.38 m BGL 229.2 m MSL
17126	E: 1886519 N: 5565227	224.2	Unknown	4.2 m BGL 220.0m MSL	2.92 m BGL 221.3 m MSL

[1]Elevations in m MSL estimated from an 8-m resolution Digital Elevation Model downloaded from Land Information New Zealand (LINZ).

B

Appendix B – Bores within 2 km of the Takapau WWTP

Sensitivity: General

Bore ID	Easting	Northing	Well Number	Well Depth	Well Diameter	Drill Date	Driller Name	Top Screen	Bottom Screen	Bore No	Open Hole Top	Open Hole Bottom	Aquifer Lithology	Aquifer Condition	Initial Water Level Date	Initial Water Level	Bore Depth	Water Level Access	Location Method	Casing Diameter	Address
1381	1,887,435.25	5,564,251.27	1381	58.36	200	10/02/1982	Hill Well Drillers Ltd	39.36	43	1,381				Confined		-2.2		Unknown	Differential GPS	200	ORUAWHARA RD, TAKAPAU (L/C)
1382	1,886,134.44	5,564,239.07	1382	31.4	150	6/07/1982	N. WEBB	25.45	26.21	1,382				Confined		-5.33		Unknown	Differential GPS	150	CHARLOTTE/RUAWHARA ST, TAKAPAU (L/C)
1384	1,888,013.59	5,564,419.47	1384	19.53	150	1/03/1982	Hill Well Drillers Ltd	16.53	19.53	1,384				Confined				Unknown		150	ORUAWHARA RD, TAKAPAU (L/C)
1717	1,886,232.11	5,566,808.71	1717							1,717			Unknown	Unknown		0		Unknown	Map estimate		
1762	1,886,179.51	5,563,939.89	1762	48.9	150	19/02/1985	N. WEBB	31.08	33.48	1,762				Confined		-4.7		Unknown	Hand-held GPS	150	META ST, TAKAPAU (L/C)
2136	1,885,446.94	5,564,759.29	2136	63.5	200	22/08/1986	Hill Well Drillers Ltd	51.5	63.5	2,136			Gravels	Confined		-15		Yes	Hand-held GPS	200	S.H.2 / TAKAPAU (L/C)
2322	1,884,337.28	5,564,592.01	2322	5.5	1,000.00	3/11/1987	T J DRUMMOND			2,322			Unknown	Unknown		-1.2		Unknown	Differential GPS	1,000.00	S H 2 TAKAPAU
2837	1,884,573.19	5,566,099.99	2837	29.85	100	31/10/1990	Honnor Drilling Limited	17.53	18.96	2,837			Gravels	Confined		-7.31		Unknown	Differential GPS	100	PAGET ROAD, TAKAPAU
2931	1,886,712.91	5,563,518.70	2931	44.2	150	13/06/1991	Honnor Drilling Limited	23.16	40.84	2,931				Confined		-12		Unknown		150	SYDNEY TERRACE, TAKAPAU PH (06) 8558033
3426	1,884,834.53	5,564,906.29	3426	19	100	5/05/1994	Honnor Drilling Limited	15.15	17	3,426			Gravels	Confined		-1.2		Unknown		100	4292 S.H. 2, TAKAPAU
3594	1,886,395.53	5,564,703.40	3594	57.6	150	24/04/1995	Baylis Brothers Limited	51.6	57.6	3,594			Gravels	Confined		-10.5		Unknown	Hand-held GPS	150	4 CHARLOTTE STREET TAKAPAU
4128	1,886,138.44	5,564,233.07	4128	49.6	150	15/06/1998	N. WEBB			4,128			Unknown	Unknown				Unknown	Hand-held GPS	150	CHARLOTTE STREET, TAKAPAU
4254	1,888,240.74	5,564,409.50	4254	22.06	50	12/03/1999	Hill Well Drillers Ltd	14.73	20.45	4,254			Gravels	Confined		-2		Unknown	Differential GPS	50	478 ORUAWHARA ROAD, TAKAPAU
4838	1,887,379.06	5,565,306.94	4838	99.3	200	25/07/2002	Baylis Brothers Limited	80.39	99.3	4,838				Unknown		-17.96		Unknown	Differential GPS	200	SH 2, TAKAPAU
5325	1,885,183.59	5,565,917.97	5325	27.4	100	23/12/2004	Honnor Drilling Limited	25.6	27.4	5,325			Gravels	Flowing confined	12/23/2004, 1:00 PM	4	31	No	Hand-held GPS	100	189 NELSON RD, TAKAPAU
5335	1,886,887.60	5,566,276.47	5335	29.8	150	29/09/2005	Baylis Brothers Limited	28.76	29.76	5,335			Gravels	Confined	9/28/2005, 12:00 PM	-3.1	30.2	Unknown	Differential GPS	150	CNR BURNSIDE & NELSON RDS, TAKAPAU
5385	1,888,279.84	5,563,893.17	5385	117.6	100	15/08/2005	Honnor Drilling Limited	96.85	117.61	5,385			Sand	Confined	8/15/2005, 12:00 PM	-7.11	121	No	Hand-held GPS	100	184 ORUAWHARO RD, RD1, TAKAPAU
5987	1,886,429.60	5,564,423.23	5987	36.4	100	5/01/2009	Honnor Drilling Limited	34.5	36.4	5,987			Gravels	Confined	1/5/2009, 1:00 PM	-16.3	42	Unknown	Hand-held GPS	100	656 ORUAWHARO ROAD, TAKAPAU
10907	1,886,212.17	5,566,320.39	10907	44.1	100	18/02/1998	Honnor Drilling Limited	36.24	38.14	10,907				Unconfined		-3.9		Unknown		100	NELSONS ROAD, TAKAPAU
10923	1,884,511.38	5,564,619.06	10923		200					10,923			Unknown	Unknown				Unknown		200	CNR SH 2 AND SYDNEY ST, TAKAPAU
10924	1,884,411.32	5,564,619.04	10924	34.1	200	23/12/1981	N. WEBB	19.4	34.1	10,924				Unconfined		-5.5		Unknown		200	CNR SH2 & SYDNEY STREET, TAKAPAU
15636	1,888,518.73	5,565,630.32	15636							15,636								Unknown	Map estimate		TAKAPAU
15990	1,886,207.24	5,565,883.12	15990	65.2	150	17/07/2012	Honnor Drilling Limited	63.5	65.2	15,990			Other	Confined	7/17/2012, 12:00 PM	-12.5	81.5	Unknown	Hand-held GPS	150	Cnr Nelson & Burnside Rds, Takapau
16370	1,886,752.46	5,566,627.68	16370	34.75	150	19/05/2015	Honnor Drilling Limited	32.75	34.75	16,370					5/19/2015, 12:00 PM	-5.1	35	Unknown	Hand-held GPS	150	363 Burnside Road, Takapau
16478	1,886,886.60	5,566,285.48	16478	58	100	19/05/2016	Honnor Drilling Limited	56.75	58	16,478					5/19/2016, 12:00 PM	-7.63	96	Unknown	Hand-held GPS	100	Nelson Road, Central Hawke's Bay
16858	1,885,191.60	5,565,917.97	16858	26.2	100	14/03/2019	Honnor Drilling Limited	23.3	26.2	16,858				Flowing confined	3/14/2019, 1:00 PM	2	30	Unknown	Hand-held GPS	100	189 Nelsons Rd, Takapau
16931	1,886,381.52	5,564,710.40	16931	58.4	200	30/08/2019	Baylis Brothers Limited	52.4	58.4	16,931	58.4	59.95			8/30/2019, 12:00 PM	-11.8	59.95	Unknown	Hand-held GPS	200	4 Charlotte Street Takapau

C

Appendix C – HBRC log for Takapau public supply bore

Well 1762

IDENTIFICATION

WQ Site:	
Easting:	1886179.512
Northing:	5563939.889
Method:	Hand-held GPS
Address:	META ST, TAKAPAU (L/C)

WELL INFORMATION

Drill date:	19/02/1985
Driller:	N. WEBB
Casing Diameter (mm):	150
Bore Depth (m)	
Well Depth (m):	48.9
Screen top (m):	31.08
Screen bottom (m):	33.48
Open hole top (m):	
Open hole bottom (m):	
Water level access:	Unknown

Bore Consents

Consent Id	WP140534T
Consent Type	Ground-water consent
Use One	Public Water Supply
Use Two	Potable Supply

Aquifer Information

Inital Water Level	-5
Aquifer Condition	Confined
Aquifer Lithology	

Aquifer Test

Test Reliability	Unreliable
Specific Capacity	
Hydralic Conductivity	
Storativity	
Transmissivity	
Aquifer Thickness	
Number Of Pumping Steps	
Duration	
Maximum Draw Down	
Maximum Pumping Rate	
Report Number	
Bore No	1762

Bore Log (m)

Lithology	TOPSOIL with gravel

From Depth 0
To Depth 1

Lithology brown CLAY with gravel
From Depth 1
To Depth 13

Lithology grey CLAY with gravel (basaltic)
From Depth 13
To Depth 16

Lithology blue CLAY
From Depth 16
To Depth 17

Lithology grey CLAY with gravel
From Depth 17
To Depth 17

Lithology blue/grey GRAVEL (basaltic)
From Depth 17
To Depth 18

Lithology grey CLAY with gravel
From Depth 18
To Depth 19

Lithology brown/grey GRAVEL (basaltic)
From Depth 19
To Depth 25

Lithology brown/grey GRAVEL (welded, basaltic)
From Depth 25
To Depth 26

Lithology brown CLAY with gravel
From Depth 26
To Depth 27

Lithology blue CLAY
From Depth 27
To Depth 30

Lithology blue GRAVEL (basaltic)
From Depth 30
To Depth 30

Lithology blue GRAVEL (cemented, basaltic)
From Depth 30
To Depth 31

Lithology brown GRAVEL (basaltic)
From Depth 31
To Depth 33

Lithology brown GRAVEL (cemented, basaltic)
From Depth 33
To Depth 34

Lithology blue/brown CLAY
From Depth 34
To Depth 35

Lithology brown GRAVEL (basaltic)
From Depth 35
To Depth 35

Lithology fine brown GRAVEL (basaltic)
From Depth 35
To Depth 36

Lithology brown CLAY with gravel
From Depth 36
To Depth 37

Lithology brown GRAVEL (basaltic)
From Depth 37
To Depth 40

Lithology brown CLAY with gravel (basaltic)
From Depth 40
To Depth 43

Lithology GRAVEL with clay (cemented,clayey/claybound, basaltic)
From Depth 43
To Depth 45

Lithology blue/brown GRAVEL (basaltic)
From Depth 45
To Depth 46

Lithology blue CLAY
From Depth 46
To Depth 46

Lithology blue GRAVEL (basaltic)
From Depth 46
To Depth 46

Lithology fine blue GRAVEL (basaltic)
From Depth 46
To Depth 48

Lithology	blue CLAY with gravel
From Depth	48
To Depth	49

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