Bay Geological Services Ltd.

HYDROGEOLOGICAL ASSESSSMENT OF PRODUCTION WELL NOS. 15986 AND 15989 FOR RESOURCE CONSENT NO. AUTH-116104-03 REPLACEMENT APPLICATION RAVENSDOWN LIMITED, 200 WAITANGI ROAD, AWATOTO, NAPIER

for
Ravensdown
Private Bag 6012
Napier 4142

November, 2021
Project No. BGS305_01
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EXECUTIVE SUMMARY

Ravensdown Limited (the Applicant) hold Water Permit Consent AUTH-116104-03 for use in manufacturing of sulphuric acid and fertilisers at 200 Waitangi Road, Awatoto, Napier. The consent grants a maximum volume of 21,000 m^3 /7-days and 1,092,000 m^3/year to be abstracted from two 150 mm diam. Well Nos. 15986 and 15989 at a combined rate not to exceed 80 l/s. The resource consent was granted on 1 June, 2007 and expires on 31 May, 2027; however, an Application is being made to replace the Water Permit.

Potential effects

The plant operates on a 24-7 basis, with an operational methodology based on the most efficient use of groundwater resources, which is critical to the operation and must be available to underpin year-round production. A water discharge strategy for the site resulted after a review the method of treatment and the receiving environment. It is proposed to manage water discharges from the site through improved source control and specific treatment processes for various contaminants. Part of the process will involve discharging the treated water to land via spray irrigation and growing drought relief crops. Alternatively, the treated water will be discharged to the Waitangi Estuary at high tide through a constructed wetland when the proposed irrigation application is unavailable due to ground conditions.

It is proposed that the water take is maintained for use on site at a weekly volume of 12,840 m^3. An additional water take of 637 m^3/week will be required to maintain the ecosystem and water level at the constructed wetland proposed within the Waitangi Regional Park. The proposed combined take totals 13,477 m^3/week with an annual volume of 666,455 m^3.

A review of historic water use indicates that groundwater is pumped year-round with a mean annual volume of 240,716.40 m^3 over the years January 2007 to December 2011, which is 21.96% of the consented annual volume of 1,092,000 m^3. The records from January 2014 to January 2021 reveal a mean annual volume of 343,778 m^3 calculated using pumping records, which is 31.5 % of the consented annual volume.

Assessments undertaken

Deep groundwater bores near the coast and the Awatoto area typically exhibit flowing artesian conditions. About 85 bores are recorded within approximately 2 km of the Production Wells, used for industrial, irrigation, domestic and stockwater, exploratory and environmental purposes, which range in depth from 2.40 to 64.90 m below ground level (bgl), with the majority screened across the confined gravel aquifer greater than 40 m depth. The closest municipal water supply wells are located approximately 2.4 and 2.5 km NNW from the Production Wells and are screened across the confined gravel aquifer.

The Production Well Nos. 15986 and 15989 are screened across a confined brown gravel aquifer from 55.90 to 63.90 m and 48.21 to 57.43 m bgl, respectively with a static water level (SWL) of + 6 to 7 m above ground level (agl). HBRC data indicates that the confined aquifer displays high to very high transmissivity values. The test results for the nearby pump tested Well No.1722 determined a very high transmissivity value of 25,000 m^2/day, which is considered appropriate for the confined aquifer conditions and setting. Predicted long-term well interference at an average flow rate of 34.63 l/s over 365 days in surrounding bores screened over the confined gravel aquifer is considered negligible due to the very high adopted transmissivity value.

The Production Wells exhibit flowing artesian aquifer conditions with SWL's of +6 and +7 m agl which demonstrates hydraulic separation from nearby surface water features and negligible stream depletion effects. The closest State of the Environment (SOE) Well No.222 SWL shows a seasonal variation of approximately 1.94 m over the past 10 years.

Results of assessments

In reviewing the available information, it is considered that the Applicant's proposed groundwater take is not likely to adversely affect the ability of nearby users and consent holders to take groundwater from the confined aquifer, due to the flowing artesian conditions and very highly transmissive aquifer. Furthermore, it is understood that the current Water AUTH-116104-03 is utilised efficiently within the plant. Therefore, the proposed water take is considered to have negligible impact on neighbouring takes, and a *less than minor effect* on the surrounding environment.

Suggested Approach for Effects Identified

It is recommended that Ravensdown continue to maintain a record of the water take and use at the site.

1. INTRODUCTION

The Water Permit Consent AUTH-116104-03 (WP060639Tb) was initially granted to Ravensdown Limited (the Applicant) on 1 June, 2007 for the use in the manufacture of sulphuric acid and fertilisers at the plant located at 200 Waitangi Road, Awatoto, Napier. The groundwater is abstracted from the 150 mm diam. Well Nos. 15986 and 15989 at a combined rate not to exceed 80 l/s, for a maximum volume not to exceed 21,000 m^3 in any 7-day period and 1,092,000 m^3/year. The resource consent expires on 31 May, 2027; however, an Application is being made to Replace the Water Permit to support the Applicants Napier Works Air and Water Discharge Improvement Project.

The Applicant has operated with efficient water use since the consent was granted, which has provided increased production capacity over this time. The plant operates on a 24-7 basis, with an operational methodology based on the most efficient use of groundwater resources, which is a critical part of the operation that must be available to underpin year-round production. It is proposed that a weekly groundwater volume of 12,840 m^3 is required for use at the Plant. An additional 637 m^3/week will be required to maintain the ecosystem and water level at the constructed wetland proposed within the Waitangi Regional Park. The proposed combined take totals 13,477 m^3/week and an annual volume of 666,455 m^3.

2. SITE DESCRIPTION

The Ravensdown Awatoto, Napier plant is located adjacent to the Hawkes Bay coastline approximately 6 km south of Napier City as shown in Figure 1. The property is located at 200 Waitangi Road, Awatoto and lies between Waitangi Road to the north and State Highway 51 (SH51) to the east.

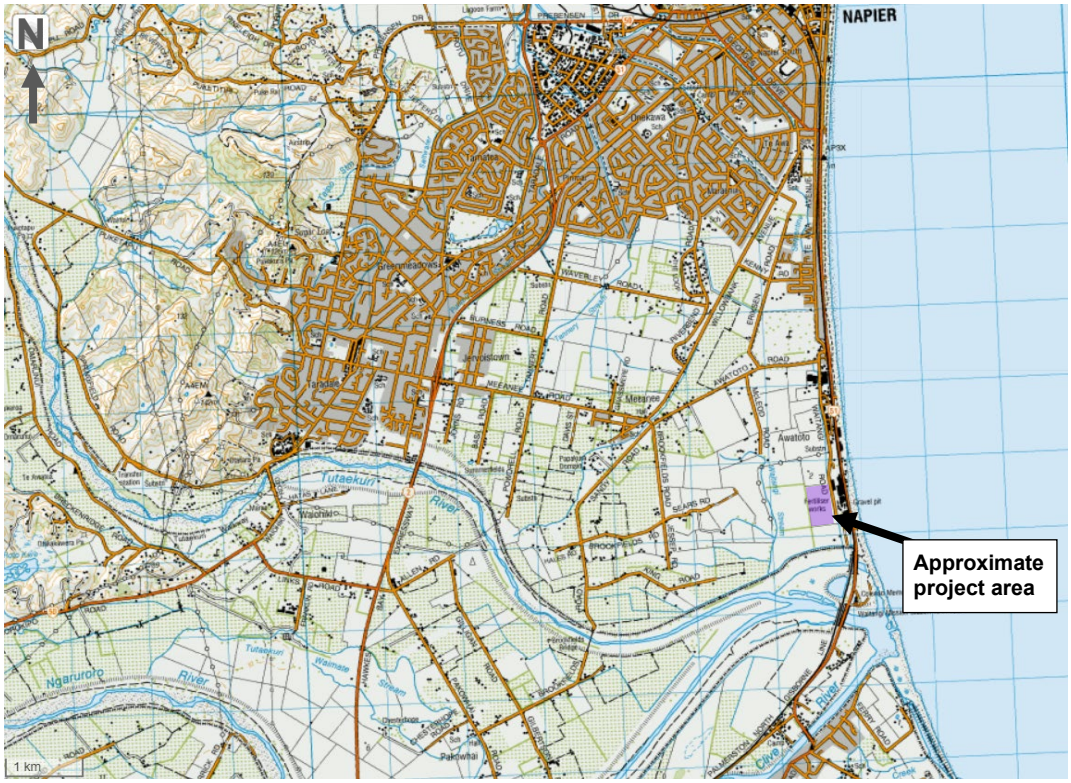

Figure 1. Topographic map showing the project area south of Napier City (NZ Topomap)

The site is located approximately 100 m west of the mean high-water springs (MHWS) and 475 m north of the blind arm of the Tutaekuri River, which is also known as the Waitangi Estuary.

The Legal Description of the project site is as follows:

- Site of take: Pt Sec 32 Blk 1 Clive SD
- Site of use: Pt Sec 32 Blk 1 Clive SD

3. WATER PERMIT CONSENT AUTH-116104-03

The Water Permit AUTH-116104-03 granted a maximum of 21,000 m^3 in any 7-day period and 1,092,000 m^3/year within the 12-month period, 1 July to 30 June in consecutive calendar years. from the 150 mm diam. Well Nos. 15986 and 15989 at a combined rate not to exceed 80 l/s. The consent was initially granted on 1 June, 2007 and expires on 31 May, 2027. As required by Hawkes Bay Regional Council (HBRC) consent conditions, both wells have headworks telemetry installed.

The map reference for the Production Wells are as follows:

- Well 15986: V21 2846951 6175828
- Well 15989: V21 2846957 6175810

4. PROPOSED STORMWATER AND PROCESS WATER DISCHARGE

The Applicant undertook a complete review of the water discharges from the site to review both the method of treatment and the receiving environment. The result of this review process is detailed in the water discharge strategy for the site[1].

The proposal is to manage water discharges from the site through improved source control and specific treatment processes for various contaminants implemented in a staged approach. As outlined in the water discharge strategy, it is understood that these measures "*are expected to have an immediate and significant impact on quality of the water being discharged from the site".* It is proposed that the treated water will then be discharged to land via spray irrigation to grow drought relief crops. At times when spray irrigation is unable to occur (e.g., when ground conditions are unacceptable or during large storm events), the treated water will be discharged to the Waitangi Estuary at high tide via a constructed wetland.

The Applicant currently takes water as authorised by their existing water take permit for the existing onsite processes (as detailed in Section 3). It is proposed that the water take is maintained for use at the plant at a total weekly volume of 12,840 m^3.

A further water take of 637m^3 per week will be required to maintain the ecosystem and water level at the constructed wetland being proposed within the Waitangi Regional Park. It is proposed that the groundwater will be abstracted from the existing Production Wells.

[1] Ravensdown Napier Works, Resource Consent Renewal Project. Water Discharge Strategy 2021 - Draft, September 2021.

5. SITE GEOLOGY AND HYDROGEOLOGY

5.1 Local Geology

The Heretaunga Plains area is mapped as a relatively deep, fault-controlled, mid-Pleistocene sedimentary basin, downthrown to the southeast, bound by limestone-capped siltstone, sandstone and mudstone hillslopes to the north, south and west (Lee et al, 2011). The generally southwest-northeast oriented basin is approximately 900 m deep, infilled with Quaternary marine sediments and alluvium deposited by the meandering Ngaruroro, Tukituki and Tutaekuri rivers which flow eastward to the coast.

Published geological maps indicate the presence of faulting and folding across the plains, near the foot of the western Taradale hills, and north and south of the Awatoto area (Lee et al, 2011). Furthermore, the online GNS Active Fault Database indicate the presence of the active Awanui Fault which is mapped through Pakowhai and Meeanee, tracking approximately 2 km northwest of the project area (gns.cri.nz/af).

5.2 Hydrogeology of the Heretaunga Plains and Awatoto Area

The Heretaunga Plains area is mapped as a relatively deep, fault-controlled, mid-Pleistocene sedimentary basin, downthrown to the southeast, bound by limestone-capped siltstone, sandstone and mudstone hillslopes to the north, south and west (Lee et al, 2011). The generally southwest-northeast oriented basin is approximately 900 m deep, infilled with Quaternary marine sediments and alluvium deposited by the Ngaruroro, Tukituki and Tutaekuri rivers which flow eastward to the coast. Subsurface conditions across the Heretaunga Plains comprise sequences of fluvial deposits, alluvial sands and silts, and marine clays as a result of fluctuating sea levels during glacial and interglacial periods. This formed a complex system of multilayered, interconnected aquifer systems as a result of ancient braided rivers depositing significant gravel loads across the plains and out into Hawke Bay during glaciations over the past 250,000 years. The overlying marine/marginal marine and overbank flood sediments reflect post-glacial and interglacial sequences that act as confining aquicludes and cap the deeper gravel intervals.

The main aquifer system is generally unconfined in the west and becomes increasingly confined to the east (as shown in Figure 2), with confinement as a result of successive sequences of marine transgressional and subsequent fluvial progradational deposition (Dravid and Brown 1997; Rakowski and Knowling 2018). The confining layers are comprised of thick, laterally continuous marine silts and clays, while the aquifer units are variably sandy gravel channel deposits of the Tukituki, Tutaekuri and Ngaruroro rivers, along with beach gravel and sand (Dravid and Brown, 1997). The boundary between the unconfined and confined zones of the Heretaunga Aquifer is displayed in Figure 3, with the latter represented by brown hatching.

The confined portion of the basin extends east of the green line to beyond the coastline, where the most recent marine transgressive sequence formed a wedge of fine-grained sediments, capping the deep gravel aquifers. Contour maps produced by Dravid and Brown (1997) indicate that the thickness of confining strata within the project area is about 40 m. There is no evidence of springs or discharging groundwater within the vicinity of the project area or Waitangi Estuary, inferring that the confining layer is likely intact.

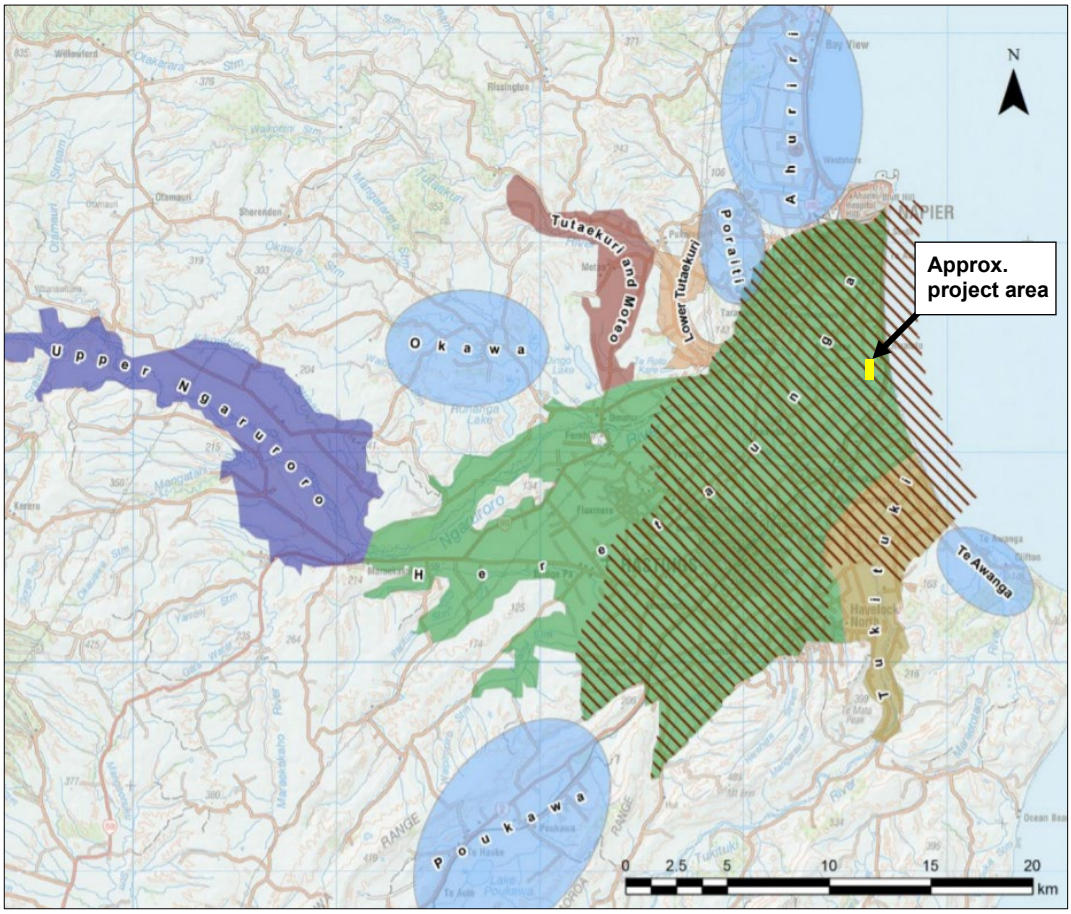

Figure 2. HBRC map showing extent of the Heretaunga Aquifer System, with the confined portion shown as brown hatch. Blue circles show other aquifer systems (from Rakowski and Knowling, 2018).

Deep groundwater bores near the coast and the Awatoto area typically exhibit flowing artesian conditions suggesting upward flow of groundwater from the confined aquifers (Dravid and Brown 1997; Lee et al 2014), although this is coupled with seasonal variations and tidal effects. Seasonal fluctuations occur within bores across the Heretaunga Plains in response to rainfall recharge and groundwater abstractions.

A PDP (2014) study on transmissivity and storativity values across the Heretaunga Basin, concluded that the Awatoto area lies within a zone of very high transmissivity values, where wells screened between 35 and 60 m depth exhibit transmissivities >10,000 m^2/day (refer Figure 3). Furthermore, an earlier study by Dravid and Brown (1997) indicates that transmissivities of >20,000 m^2/day are to be expected within a zone extending from Clive, north toward Meeanee and west to Omahu.

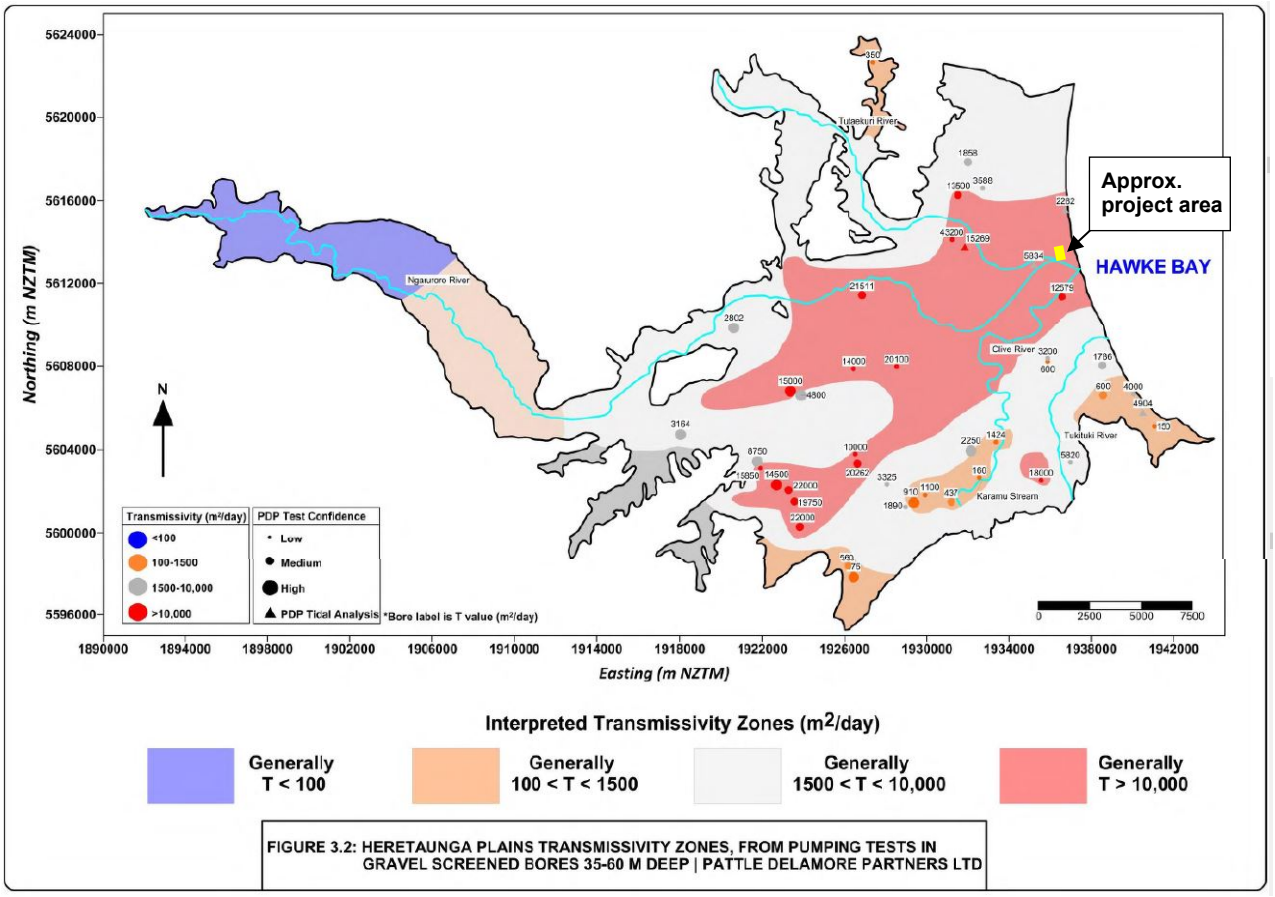

Figure 3. Map of transmissivity zones across Heretaunga Plains (PDP, 2014)

Data provided by HBRC for nearby pump tested wells indicates that the confined aquifer displays high to very high transmissivity values. The test results for two pump tested Well Nos.1722 and 1151 are classified as 'unreliable' by HBRC; however, the very high transmissivity value of 25,000 m^2/day calculated for Well No. 1722 is deemed appropriate for the hydraulic setting for a flowing confined gravel aquifer near the eastern periphery of the onshore alluvial basin. The bore log indicates that the well is screened from 67 to 75 m bgl across a gravel aquifer, with a storativity of 0.00034 reflecting confined aquifer conditions.

6. DETAILS FOR PRODUCTION WELL NOS. 15986 AND 15989

6.1 Production Well No.15986

The 150 mm diameter production Well No. 15986 was drilled by Honnor Drilling Ltd. in 2012, boring to 65.40 m depth bgl, with the well installed to 63.90 m bgl. The bore encountered 2 m of near-surface sand, overlying blue gravel to 9 m bgl, and blue gravelly sand to 13 m bgl. Below this, a 25 m thick blue clay with peat/wood/organics was encountered to 38 m depth, above fine blue gravel to 45 m bgl. Underlying this, brown gravel extended to at least the base of the 65.40 m-deep bore as detailed overleaf:

Depth (m bgl)	Lithology
0.00 - 1.00	TOPSOIL (Driveway Seal)
1.00 - 2.00	SAND
2.00 - 9.00	blue GRAVEL
9.00 - 13.00	blue SAND with gravel
13.00 - 38.00	blue CLAY with peat/veg/wood
38.00 - 44.00	fine blue GRAVEL
44.00 - 45.00	fine blue GRAVEL
45.00 - 65.40	brown GRAVEL

The well was subsequently screened over an 8 m interval from 55.90 to 63.90 m bgl across a 20 m-thick brown gravel zone logged from 45 to 65 m bgl as detailed in the bore log included in Appendix A. The flowing confined SWL is recorded as +7.00 m agl. The bore consent records primary use in the Manufacturing/Chemical Industry, and details a 2-hour pump test at a flow rate of 75 l/s, which is classified 'unreliable' by HBRC.

6.2 Production Well No.15989

The 150 mm diameter production Well No. 15986 was drilled to 68.00 m depth by Honnor Drilling Ltd. in 2012, with the well backfilled to 57.43 m bgl. The bore encountered 2.00 m of near-surface sand, overlying blue gravel to 9.00 m bgl, and blue gravelly sand to 13.00 m bgl. Below this, a 25.00 m-thick blue clay with peat/wood/organics was encountered to 38.00 m bgl, above fine blue gravel to 45.00 m depth. Underlying this, brown gravel extended to at least the base of the 68.00 m-deep bore as detailed below:

Depth (m bgl)	Lithology
0.00 - 1.00	TOPSOIL (Driveway Seal)
1.00 - 2.00	SAND
2.00 - 9.00	blue GRAVEL
9.00 - 13.00	blue SAND with gravel
13.00 - 38.00	blue CLAY with peat/veg/wood
38.00 - 45.00	fine blue GRAVEL
45.00 - 68.00	brown GRAVEL

The well is screened over a 9.22 m interval from 48.21 to 57.43 m bgl across a 23.00 m-thick brown gravel zone logged from 45.00 to 68.00 m bgl as detailed in the bore log included in Appendix A. The flowing confined SWL is recorded as +6.00 m agl. The bore consent states primary use in the Manufacturing/Chemical Industry, with an 'unreliable' pump test classified as 'unreliable' by HBRC completed for 2 hours, flowing at 85 l/s.

The locations of the two Production Wells at the plant, immediately west of SH51 are shown in the HBRC wells map presented as Figure 4, with bore logs included in Appendix A.

Figure 4. HBRC Wells map showing locations of the Applicant's Well Nos. 15986 and 15989.

7. HISTORIC WATER USE

The Applicant provided historic water use data from 2007 to Feb 2012 which are recorded from former Production Well Nos. 15348, 15349, 15350, 15351, 15352, and presented in Table 1. The highest weekly use in the 10 years prior to 17 August 2017 was 11,287 m^3 as recorded in May 2008.

Table 1. Historic Water use data 2007 to 2012

Monthly totals	2007 to 2012			Welll Nos. 15348, 15349, 15350, 15351, 15352 (All 100 mm)									
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2007	15,450.0	34,968.0	28,566.0	24,511.0	37,156.0	20,097.0	6,252.0	28,783.0	16,175.0	23,448.0	34,041.0	37,551.0	**306,998.0**
2008	18,119.0	7,977.0	32,067.0	27,312.0	18,061.0	33,228.0	5,821.0	2,075.0	3,745.0	19,098.0	24,215.0	25,101.0	**216,819.0**
2009	5,761.0	3,717.0	13,371.0	23,349.0	22,474.0	15,317.0	2,450.0	15,989.0	14,550.0	17,461.0	18,680.0	18,778.0	**171,897.0**
2010	4,671.0	7,380.0	33,064.0	23,655.0	26,956.0	15,457.0	2,672.0	18,705.0	26,896.0	29,837.0	33,620.0	21,635.0	**244,548.0**
2011	27,869.0	23,532.0	7,485.0	29,399.0	33,295.0	16,975.0	2,359.0	2,798.0	15,162.0	36,244.0	32,615.0	35,587.0	**263,320.0**
2012	36,958.0	21,844.0											**58,802.0**
Min.	4,671.0	3,717.0	7,485.0	23,349.0	18,061.0	15,317.0	2,359.0	2,075.0	3,745.0	17,461.0	18,680.0	18,778.0	**135,698.0**
Mean	14,374.0	15,514.8	22,910.6	25,645.2	27,588.4	20,214.8	3,910.8	13,670.0	15,305.6	25,217.6	28,634.2	27,730.4	**240,716.4**
Max.	27,869.0	34,968.0	33,064.0	29,399.0	37,156.0	33,228.0	6,252.0	28,783.0	26,896.0	36,244.0	34,041.0	37,551.0	**365,451.0**
Note: the Min Mean and Max of Annual values are for complete years only.													

The data indicate that groundwater was pumped year-round with annual volumes ranging from 171,897 to 306,998 m^3. A mean annual volume of 240,716.40 m^3 is calculated using pumped volumes over the years that provide full records, from January 2007 to December 2011. This is 21.96% of the consented annual volume of 1,092,000 m^3.

Following this period, the new Production Well Nos. 15986 and 15989 were drilled to replace the older bores, with telemetry installed to record volumes abstracted. A request to HBRC was made for water use records from Water Meter at 060639M6 which are presented as Table 2 and cover the period 3 December, 2012 to 1 January 2020.

In addition, water use data provided by the Applicant includes groundwater use from January 2020 to December 2020 which are also presented in Table 2. The highest weekly use in the 10 years prior to 2 May 2020 was recorded in January 2019 as 11,883m^3.

Table 2. Historic Water use data (Water Meter at 060639M6) for Well Nos. 15986 and 15989

Monthly totals	2013 to 2020	Water Meter(m3) at Site 060639M6											
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2013	30,132.8	242.5	808.4	48,506.5	50,123.4	48,506.5	50,123.4	50,123.4	?	13,960.6	25,025.9	28,828.0	**346,381.4?**
2014	32,849.9	26,272.9	25,938.6	22,923.4	24,804.9	16,216.9	7,460.1	13,948.2	34,074.6	27,876.0	30,891.9	33,444.9	**296,702.2**
2015	34,233.1	29,976.9	32,904.2	37,323.8	40,846.1	9,199.5	19,174.8	32,197.3	29,960.4	32,130.4	31,686.3	33,291.1	**362,923.9**
2016	32,004.1	30,685.5	31,413.1	30,026.3	31,024.2	7,234.0	6,657.6	7,600.1	22,130.4	38,144.6	33,897.6	39,394.1	**310,211.5**
2017	43,365.0	32,214.7	35,384.8	30,347.2	32,300.7	6,858.8	6,179.2	6,998.0	15,141.0	34,823.5	37,878.6	39,951.4	**321,442.7**
2018	38,087.2	35,891.6	35,693.8	26,172.5	37,501.4	10,792.4	6,672.0	13,261.0	43,627.6	42,439.9	44,568.0	47,096.9	**381,804.4**
2019	47,928.5	42,051.4	46,210.1	35,113.8	18,100.4	11,315.2	14,540.3	31,514.9	36,315.8	36,597.1	39,825.2	23,978.9	**383,491.5**
2020	24,269.4	41,226.3	45,636.0	32,294.1	30,804.6	19,401.8	10,925.3	15,359.2	40,773.2	32,441.5	34,685.9	22,050.7	**383,491.5**
Min.	24,269.4	242.5	808.4	22,923.4	18,100.4	6,858.8	6,179.2	6,998.0	15,141.0	13,960.6	25,025.9	22,050.7	**296,702.2**
Mean	36,105.3	34,045.6	36,168.7	30,600.2	30,768.9	11,574.1	10,229.9	17,268.4	31,717.6	34,921.9	36,204.8	34,172.6	**348,581.1**
Max.	47,928.5	42,051.4	46,210.1	48,506.5	50,123.4	48,506.5	50,123.4	50,123.4	43,627.6	42,439.9	44,568.0	47,096.9	**383,491.5**
Note: the Min Mean and Max of Annual values are for complete years only.													

The data indicate that the groundwater take is used year-round with annual volumes ranging from 296,707 to 383,492 m^3. A mean of 343,778 m^3/year is calculated using pumped volumes over the years that provide full records, from January 2014 to January 2021, which is 31.5% of the consented annual volume of 1,092,000 m^3.

8. SURROUNDING BORES AND GROUNDWATER TAKES

8.1 Details of Nearby Wells

A review of the HBRC website revealed about 85 bores within approximately 2 km of the Production Wells as displayed in Figure 5. The bores range in depth from 2.40 to 64.90 m bgl and are utilised for industrial, irrigation, domestic and stockwater, exploratory and environmental purposes. The majority of the wells are screened across the confined gravel aquifer greater than 40 m depth, and record flowing confined conditions, with SWL's ranging from -15.60 m bgl to +7.00 m agl.

Eight shallow wells either drilled to or screened above 18.00 m depth across the unconfined sand and gravel aquifer, are described as environmental/exploration bores and not installed for groundwater abstraction.

The HBRC online bore logs record near-surface sands and gravels east of Waitangi Road, as evidenced by lithology logs for the Production Well Nos. 15986 and 15989. The majority of the nearby wells indicate near-surface sand and gravels extend to depths between 10.00 and 16.00 m bgl. Beneath the shallow sand and gravel zone is a relatively thick clay interval to approximately 40.00 m depth bgl. Underlying the clay is the confined, brown gravel zone, across which the majority of bores are screened.

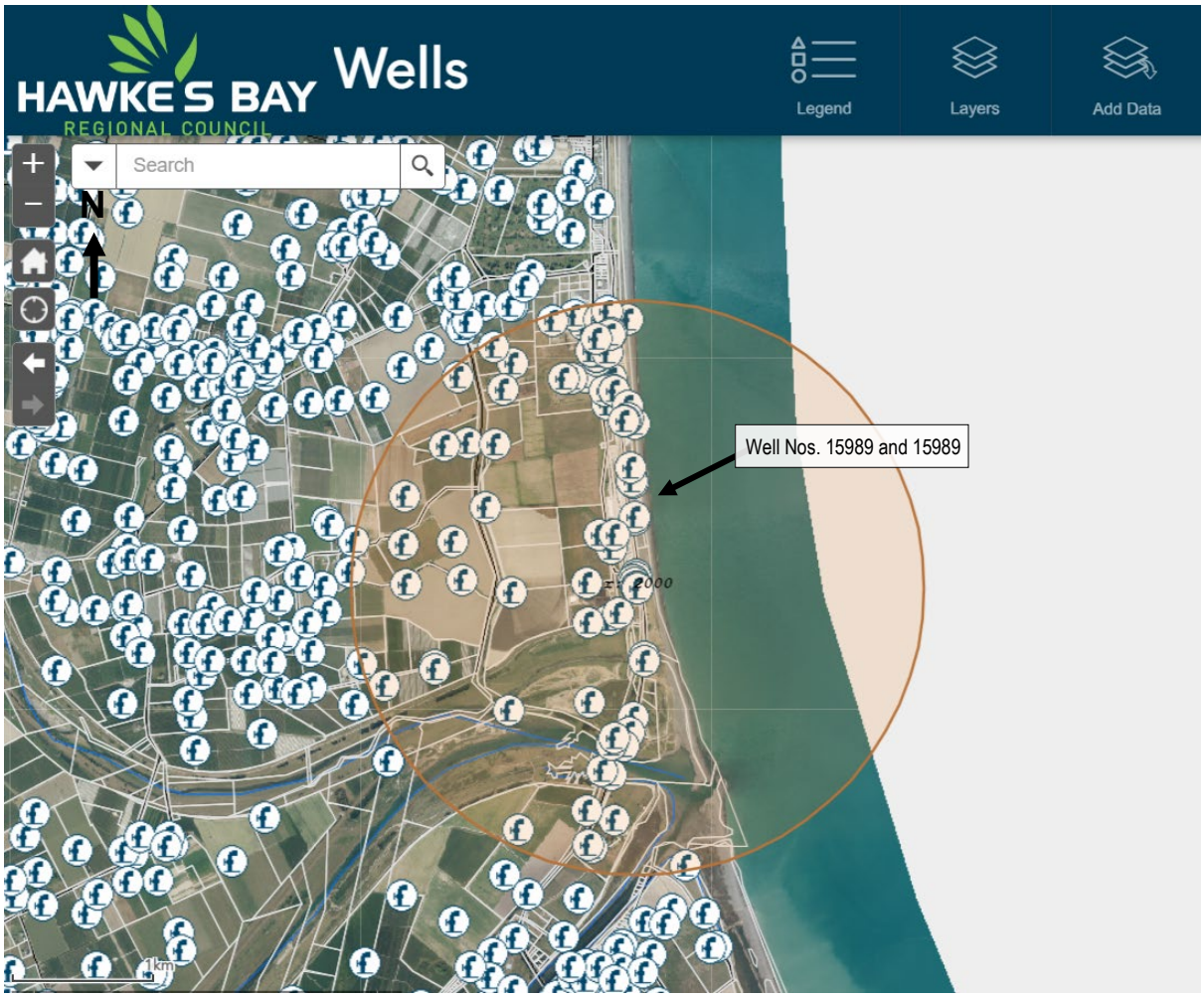

Figure 5. Map showing bores within 2 km radius of production Well Nos. 15986 and 15989 (HBRC)

The surrounding bores to the west of Waitangi Road predominantly log near-surface soils comprising silts and clays with some sand layers to depths between 4.00 and 30.00 m bgl. Sand and clay intervals are typically described to 40.00 m depth, underlain by a confined gravel aquifer. The details for surrounding bores are included in Appendix B.

8.2 Nearby Public Supply Wells

A search of the HBRC online wells database revealed two Government bores, being NCC Well Nos. 5913 and 16352, the former utilised for a public potable supply. The NCC bores are located approximately 2.4 and 2.5 km NNW from the Production Wells and are screened across the confined gravel aquifer. The details for the wells are outlined in Table 3.

Table 3. Details of nearby municipal supply wells

Well No.	Distance (m)	Depth (bore)(m)	Diam. (mm)	Screen Details (m)	Aquifer	SWL (m toc)	USE
5913	2365	90.00	300	74.00-76.00	brown Gravel (flowing confined)	+6.00	Public potable supply
16352	2500	133.25	300	110.97-120.66	coarse brown Gravel	+6.00	Govt. water

8.3 Surrounding Groundwater Takes

A search of the HBRC website consents map showed approximately fifty consented groundwater water wells within about 2 km of the Applicant's Production Wells. The bores are consented for various purposes including quarry works, agriculture cropping, agriculture pastoral farming, concrete/cement industries, water/beverage bottling, orchard irrigation, government, rendering, industrial subdivision, wool processing, sporting/recreational, and public water supplies as discussed in Section 6.2. The HBRC online resource consents database indicates that four wells hold current consents for water bottling as outlined in Table 4. The data available for three of the bores indicate that the wells are screened across the deep confined gravel aquifer.

Table 4. Details of nearby resource consents for potable supply wells

Well No. (diam)	Consent No.	Screen Details (m)	Aquifer	SWL (m toc)	USE
16341 (200 mm)	AUTH-120235-02	60.64-62.00	blue/brown Gravel	+3.00	Water Supply – Potable - Bottling
15391 (200 mm)	AUTH-120793-01	*no data*			Water Supply – Potable - Bottling
595 (100 mm)	AUTH-115985-03	53.34-56.39	- (flowing confined)	-	Water Supply – Potable - Bottling
2577 (150 mm)	AUTH-109680-02	51.82-53.34	coarse blue Gravel	-	Government - Water Supply - Potable

It is considered that the Applicant's proposed groundwater take will not adversely affect the ability of other users and consent holders to take groundwater from the confined aquifer, due to the flowing artesian conditions and very high transmissivity of the confined aquifer as discussed in Section 5.

9. LONG-TERM WELL INTERFERENCE ASSESSMENT

The Applicant requires an instantaneous combined pumping rate of 80 l/s (6,912 m^3/day) from both wells and an annual volume of 1,092,000 m^3 for use in the processing plant. The average pumping rate over the year is 34.63 l/s. An estimate of well interference effects within neighbouring bores as a result of pumping the Applicant's Well Nos.15986 and 15989 at 34.63 l/s is based on 365 days, as the plant operates year-round.

A review of technical publications and nearby wells revealed a relevant transmissivity value of 25,000 m^2/day from Well No.1722 which is used in the long-term well interference analysis, along with an adopted storativity value of 0.00034 determined from the same well which is deemed appropriate for confined aquifers.

The aquifer parameters are applied to the Aqtesolv (Duffield, 2007) Forward Solution using the Theis (1935) solution for confined aquifers as displayed in Figure 6, which provides a conservative estimate of well interference effects. It is noted that the majority of the surrounding bores in the area are screened across the confined gravel aquifer.

The solution and Aqtesolv forward modeling provide conservative Displacement (drawdown) v. Radial distance (m) well interference estimates within bores screened across the confined gravel aquifer, as a result of pumping the Production Wells continuously on a 24/7 basis. As shown in Figure 6, when using the Theis (1935) solution, the Aqtesolv Forward Solution predicts about 0.128 m well interference within a 300 m radius of the Production Wells. The full Aqtesolv graph is presented in Appendix C.

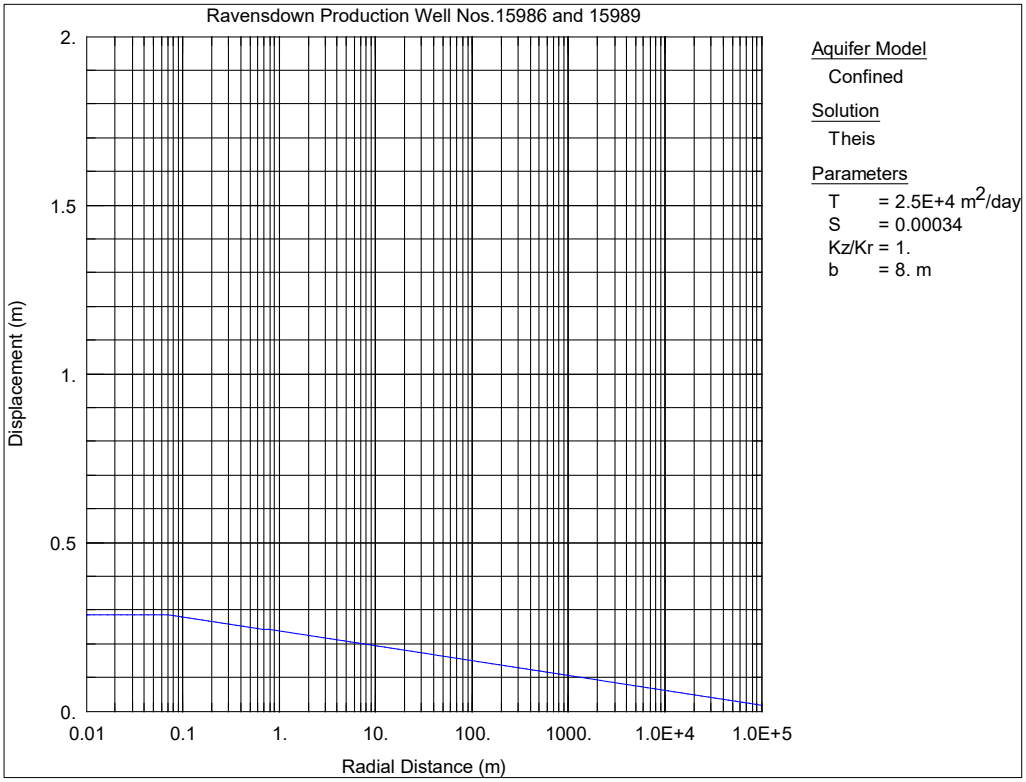

Figure 6. Prod Well Nos. 15986 & 15989 Aqtesolv Forward Solution graph at 34.63 l/s for 365 days (Theis, 1935)

At distances of 500 m, 750 m and 1 km from the Production Wells, the long-term well interference effects are predicted to be 0.118, 0.110 and 0.105 m, respectively. The predicted well interference effects in bores screened across the same deep gravel aquifer is detailed in Table 5.

Table 5. Predicted well interference as a result of pumping Prod WellNos.15986, 15989 over 365 days

Predicted Long-Term Well Interference as a result of pumping Prod Wells (T = 25,000 m²/day, s = 0.00034)					
Pumping Rate	**Duration (days)**	**300 m radius**	**500 m radius**	**750 m radius**	**1 km radius**
34.63 l/s	365	0.128	0.118	0.110	0.105

In addition, the Drawdown.xls program using the Theis (1935) solution (created by D Scott, Environment Canterbury (2001) as presented in Appendix C, details predicted long-term well interference effects at selected radii. The well interference assessment is deemed conservative as it models pumping being undertaken 24-hours per day, rather than factoring in times of intermittent or no pumping when groundwater use is not required.

It must be noted that periods of no- or periodic pumping allows for recharge of groundwater levels, which would be very rapid within the confined gravel aquifer, due to the very high transmissivity value. Furthermore, the depth of the gravel aquifer and flowing artesian conditions provide a greater total water column within bores screened across the same unit, therefore, potential well interference estimates are considered negligible.

10. STREAM DEPLETION EFFECTS

The Production Well Nos.15986 and 15989 are located approximately 475 m north of the blind arm of the Tutaekuri River, which is also known as the Waitangi Estuary. No springs were observed across the site and are not expected due to the thickness of confining layers provided by marine clays as recorded on bore logs.

The Production Wells exhibit flowing artesian aquifer conditions with SWL's of +6 and +7 m agl which indicates hydraulic separation from nearby surface water features.

11. AQUIFER SUSTAINABILITY

The magnitude of seasonal fluctuation across the Heretaunga basin varies dependent upon the depth of screened aquifers, number of surrounding wells, well proximity and groundwater use. The groundwater levels are typically higher in the winter and decline in summer months due to reduced rainfall recharge and increased groundwater use, the degree of which is often climate-dependent.

HBRC monitor SOE bores across the basin to determine how seasonal fluctuations are potentially impacting aquifer sustainability. The SOE SWL data is available on the HBRC online database, which identified three SOE bores within 2.5 km of the Production Wells, being Well Nos. 222, 1417 and 15022. Two of the bores are screened > 50 m depth across the confined gravel aquifer, and Well No. 15022 is recorded as 40 m depth bgl.

The closest SOE monitoring Well No. 222 is located off SH51, approximately 1.5 km north of the Production Wells. The 75 mm diam. bore is recorded as 59.13 m deep, screened from 57.30 to 59.13 m across undocumented lithology that is likely to be a confined gravel aquifer, similar to nearby wells including Well No. 3114.

The Well No. 222 was installed in 1972 and provides an extended record of SWL and seasonal variations. The graph for the SOE Well No.222 exhibits generally consistent seasonal variation, with recovery following summer irrigation periods, punctuated by dry summers and wet winters (refer Figure 7).

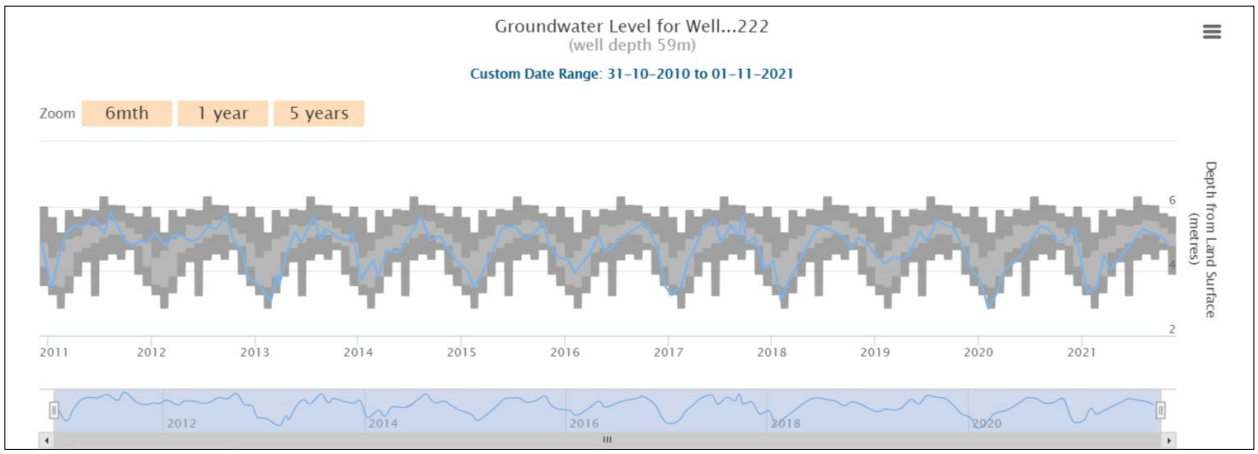

Figure 7. HBRC SOE Well No.222 online SWL data 2011 to 2021 (source HBRC)

A review of SWL's over the past 10 years show summer declines ranging from +2.84 to +5.10 m agl and winter recharge levels from +5.29 to +5.73 m agl. The seasonal variation is approximately 1.94 m over the past 10 years which reflects groundwater fluctuations within the confined gravel aquifer. The most recent 2020-21 summer SWL is recorded as +3.32 m agl, followed by a winter recharge SWL of +5.29 m agl (1.97 m seasonal variation).

12. SUMMARY AND CONCLUSIONS

The Water Permit AUTH-116104-03 was initially granted to the Applicant on 1 June, 2007 for use in manufacturing of sulphuric acid and fertilisers at the plant located at 200 Waitangi Road, Awatoto, Napier. The two 150 mm diam. Well Nos. 15986 and 15989 pump groundwater at a combined rate not to exceed 80 l/s, up to a maximum volume of 21,000 m^3 /7-days and 1,092,000 m^3/year. The plant operates on a 24-7 basis, with an operational methodology based on the most efficient use of groundwater resources, which is critical to the operation and must be available to underpin year-round production. The resource consent expires on 31 May, 2027; however, an Application is being made to replace the Water Permit for a proposed weekly volume of 12,840 m^3 to be used at the Plant, and 637 m^3/week required to maintain the ecosystem and water level at the constructed wetland proposed within the Waitangi Regional Park. The proposed combined take totals 13,477 m^3/week with an annual volume of 666,455 m^3.

To summarise:

- The Applicant holds the current Water Permit AUTH-116104-03 which grants groundwater volumes of 21,000 m^3 in any 7-day period and 1,092,000 m^3/year from the 150 mm diam. Well Nos. 15986 and 15989 at a combined rate not to exceed 80 l/s;
- A proposed weekly volume of 12,840 m^3 is to be used at the plant, with an additional 637 m^3/week required to maintain the ecosystem and water level at the proposed wetland within the Waitangi Regional Park;
- The proposed combined take totals 13,477 m^3/week with an annual volume of 666,455 m^3;
- Established groundwater take infrastructure is in place, and as required by the consent, both wells have headworks telemetry installed;
- The resource consent was granted on 1 June 2007 and expires on 31 May, 2027;
- A Replacement for Water Permit AUTH-116104-03 is being applied for;
- Well Nos. 15986 and 15989 are both screened across a confined brown gravel aquifer from 55.90 to 63.90 m and 48.21 to 57.43 m bgl, respectively;
- A review of historic water use indicates that groundwater is pumped year-round with a mean annual volume of 240,716.40 m^3 over the years January 2007 to December 2011, which is 21.96% of the consented annual volume of 1,092,000 m^3. A mean annual volume of 343,778 m^3 is calculated using pumping records from Jan 2014 to Jan 2021, which is 31.5 % of the consented annual volume;
- HBRC data indicates that the confined aquifer displays high to very high transmissivity values. The test results for two pump tested Well Nos.1722 and 1151 are classified as 'unreliable' by HBRC; however, the very high transmissivity value of 25,000 m^2/day;
- About 85 bores are recorded within approximately 2 km of the Production Wells, used for industrial, irrigation, domestic and stockwater, exploratory and environmental purposes;
- The bores range in depth from 2.40 to 64.90 m bgl, with the majority screened across the confined gravel aquifer greater than 40 m depth and recording flowing confined conditions;
- The closest NCC public supply wells are located approximately 2.4 and 2.5 km NNW from the Production Wells and are screened across the confined gravel aquifer;
- Predicted long-term well interference at an average rate of 34.63 l/s over 365 days in surrounding bores screened over the confined gravel aquifer is considered negligible due to the very high adopted transmissivity value;

- The Production Wells also exhibit flowing artesian aquifer conditions with SWL's of +6 and +7 m agl which demonstrates hydraulic separation from nearby surface water features and negligible stream depletion effects;
- A review of nearby SOE Well No.222 SWL over the past 10 years show summer declines ranging from +2.84 to +5.10 m agl and winter recharge levels from +5.29 to +5.73 m agl, with a seasonal variation of approximately 1.94 m.

In reviewing the available information, it is considered that the Applicant's proposed groundwater take is not likely to adversely affect the ability of nearby users and consent holders to take groundwater from the confined aquifer, due to the flowing artesian conditions and very highly transmissive aquifer. Furthermore, it is understood that the current Water AUTH-116104-03 is utilised efficiently within the plant. Therefore, the proposed water take is considered to have negligible impact on neighbouring takes, and a *less than minor effect* on the surrounding environment.

13. REFERENCES

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Hawkes Bay Regional Council website (www.hbrc.govt.nz).

NZ Topo Map: www.topomap.co.nz

PDP, 2014: Heretaunga Plains Transmissivity and Storativity Maps. Client Report for Hawkes Bay Regional Council. Pattle Delamore Partners Ltd Christchurch, New Zealand.

Scott, D., 2001: Drawdown worksheet (.xls). Environment Canterbury, Christchurch, New Zealand.

Theis, C. V., 1935: The relation between the lowering of the piezometric surface and the rate of duration of discharge of a well using ground-water storage. American Geophysical Union Transactions v16, 519-524.

Report Limitations

This letter report is written based on conditions as they existed at the time of the desktop study, and there is no interpretation made on potential changes that may occur across the site. Subsurface conditions may exist across the site that are not able to be detected or revealed by the investigation within the scope of the project, and are therefore not taken into account.

APPENDICES

APPENDIX A

Production Well Bore Logs

(HBRC)

APPENDIX A1: Production Well No. 15986

HAWKE'S BAY REGIONAL COUNCIL

Well 15986

IDENTIFICATION

WQ Site:	
Easting:	1937005.757
Northing:	5614108.411
Method:	Hand-held GPS
Address:	808 Waitangi Rd, Awatoto

WELL INFORMATION

Drill date:	31/07/2012
Driller:	Honnor Drilling Limited
Casing Diameter (mm):	150
Bore Depth (m)	65.4
Well Depth (m):	63.9
Screen top (m):	55.8
Screen bottom (m):	63.9
Open hole top (m):	
Open hole bottom (m):	
Water level access:	Unknown

Bore Consents

Consent Id	LU120144B
Consent Type	Bore consent
Use One	Manufacturing/Chemical Industry
Use Two	Water

Consent Id	WP060639Tb
Consent Type	Ground-water consent
Use One	Miscellaneous Industry
Use Two	Water

Aquifer Information

Inital Water Level	7
Aquifer Condition	
Aquifer Lithology	Gravels

Aquifer Test

Test Reliability	Unreliable
Specific Capacity	
Hydralic Conductivity	
Storativity	
Transmissivity	
Aquifer Thickness	
Number Of Pumping Steps	
Duration	2
Maximum Draw Down	
Maximum Pumping Rate	75
Report Number	
Bore No	15986

APPENDIX A2: Production Well No. 15986 (cont.)

Bore Log (m)

Lithology	TOPSOIL (driveway Seal)
From Depth	0
To Depth	1
Lithology	SAND
From Depth	1
To Depth	2
Lithology	blue GRAVEL
From Depth	2
To Depth	9
Lithology	blue SAND with gravel
From Depth	9
To Depth	13
Lithology	blue CLAY with peat/veg/wood
From Depth	13
To Depth	38
Lithology	fine blue GRAVEL
From Depth	38
To Depth	44
Lithology	fine blue GRAVEL
From Depth	44
To Depth	45
Lithology	brown GRAVEL
From Depth	45
To Depth	65

APPENDIX A3: Production Well No. 15989

HAWKE'S BAY REGIONAL COUNCIL

Well 15989

IDENTIFICATION

WQ Site:	
Easting:	1937006.761
Northing:	5614099.402
Method:	Hand-held GPS
Address:	808 Waitangi Rd, Awatoto

WELL INFORMATION

Drill date:	30/08/2012
Driller:	Honnor Drilling Limited
Casing Diameter (mm):	150
Bore Depth (m)	68
Well Depth (m):	57.43
Screen top (m):	48.21
Screen bottom (m):	57.43
Open hole top (m):	
Open hole bottom (m):	
Water level access:	Unknown

Bore Consents

Consent Id	LU120155B
Consent Type	Bore consent
Use One	Manufacturing/Chemical Industry
Use Two	Water

Consent Id	WP060639Tb
Consent Type	Ground-water consent
Use One	Miscellaneous Industry
Use Two	Water

Aquifer Information

Inital Water Level	6
Aquifer Condition	
Aquifer Lithology	Gravels

Aquifer Test

Test Reliability	Unreliable
Specific Capacity	
Hydralic Conductivity	
Storativity	
Transmissivity	
Aquifer Thickness	
Number Of Pumping Steps	
Duration	2
Maximum Draw Down	
Maximum Pumping Rate	85
Report Number	
Bore No	15989

APPENDIX A4: Production Well No. 15989 (cont.)

Bore Log (m)

Lithology	TOPSOIL (Driveway Seal)
From Depth	0
To Depth	1
Lithology	SAND
From Depth	1
To Depth	2
Lithology	blue GRAVEL
From Depth	2
To Depth	9
Lithology	blue SAND with gravel
From Depth	9
To Depth	13
Lithology	blue CLAY with peat/veg/wood
From Depth	13
To Depth	38
Lithology	fine blue GRAVEL
From Depth	38
To Depth	45
Lithology	brown GRAVEL
From Depth	45
To Depth	68

APPENDIX B

Details for Surrounding Bores

(HBRC)

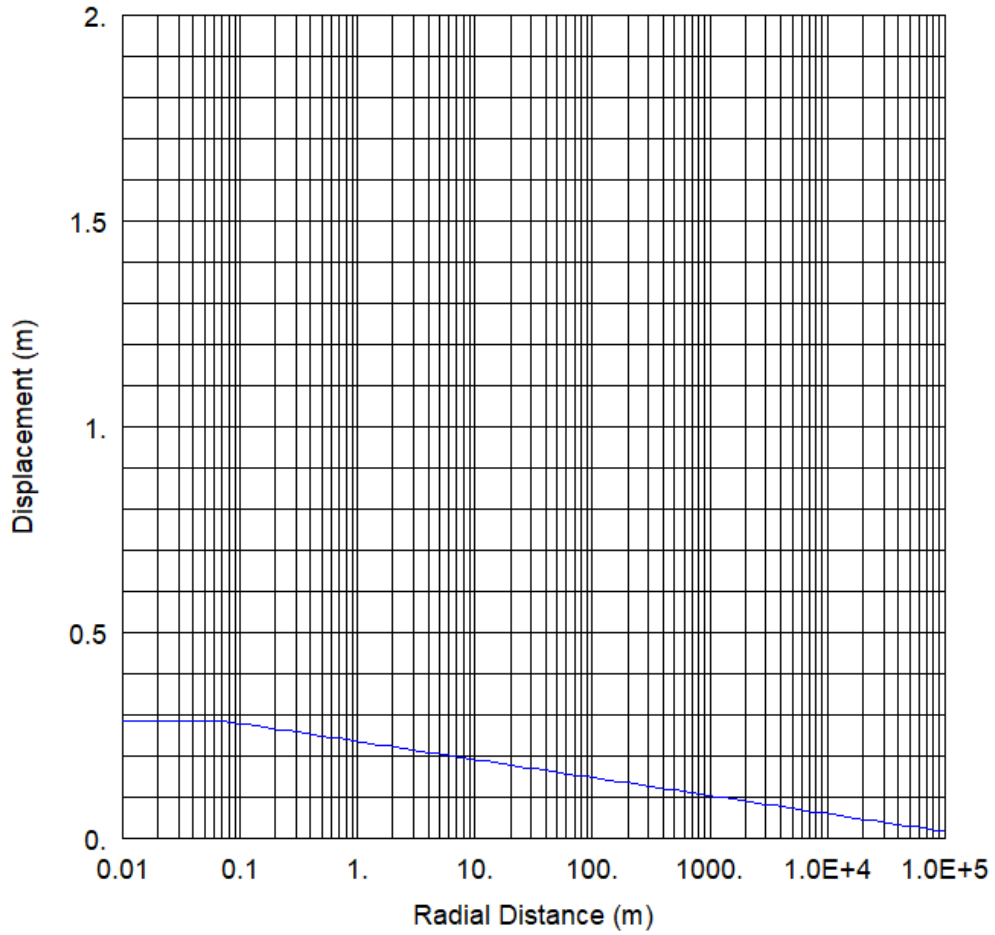
BoreNo	Owner (at time of drilling)	Distance	Bore Dept	Diameter	DrillDate	Use1ID	Use2ID	TopScreer	BtmScreer	InitialWat	NZTM_Easting	NZTM_Northing
7770	EAST COAST FERTILISER	155	48.10	100	3/08/1964	UNKN	UNKN	48.10	0.00	5.49	1936741	5614472
704	EAST COAST FERTILIZER C(	220	31.30	50	27/10/1977	UNKN	UNKN			6.40	1936829	5614380
10258	EAST COAST FERTILIZER C(	245	46.60	100	8/05/1964	INCO	UNKN	45.40	46.60	-5.20	1936841	5614472
5840	BIORICH LTD	259	5.95	50	25/06/2008					0.00	1936657	5614135
204	AWATOTO SHINGLE CO. L	423	41.40	100	3/08/1972	INCO	UNKN	40.18	41.40	6.10	1936990	5614577
15348	RAVENSDOWN	428		100							1936993	5614199
15350	RAVENSDOWN	430		100							1936974	5614160
4218	WINSTONE AGGREGATE	434	40.00	100	4/12/1998	INCO		38.30	40.00		1936991	5614598
15349	RAVENSDOWN	441		100							1936999	5614181
15351	RAVENSDOWN	458		100							1936991	5614135
15352	RAVENSDOWN	479		100							1936999	5614110
15986	Ravensdown Ltd	486	63.90	150	31/07/2012			55.80	63.90	6.66	1937006	5614108
15989	Ravensdown Ltd	492	57.43	150	30/08/2012			48.21	57.43	6.50	1937007	5614099
5841	BIORICH LTD	528	5.69	50	24/06/2008					-1.50	1936875	5613933
5839	BIORICH LTD	533	5.94	50	25/06/2008					-1.10	1936664	5613860
5672	MICHAEL GLAZEBROOK TR	543	45.60	100	31/05/2007	IRRI	INCO			6.00	1936805	5613883
15346	FIRTH INDUSTRIES LTD	579	24.40	75							1936965	5614847
3024	OHITI HARVESTING	581	51.20	100	16/10/1991	IRRI	UNKN	49.20	51.20	6.00	1936123	5614073
5796	FIRTH INDUSTRIES	581	48.00	100	29/01/2008	INCO		46.70	48.00		1936980	5614838
16714	Turu Pounamu Investment	655		75	9/10/2017						1936961	5614943
3025	OHITI HARVESTING	722	41.20	100	18/10/1991	IRRI	UNKN	39.20	41.20	5.00	1935944	5614669
16470	Apatu Farms Limited	858	50.80	100	7/06/2016			48.90	50.80		1935784	5614159
5901	OPUS INTERNATIONAL CO	887	27.00	100	19/12/2008			5.00	7.00		1937052	5613621
4738	ELGIN TRUST (TREVETTES	894	52.00	100	7/12/2001	IRRI		50.40	52.00		1935716	5614427
5902	OPUS INTERNATIONAL CO	913	27.00	100	22/12/2008			5.00	7.00		1937052	5613591
15737		929	63.00	200							1936919	5615267
16341	One Pure International Gr	930	60.64	200	27/02/2015					3.10	1936915	5615269
10057	GILBERDS	933	76.20	75	21/05/1980	UNKN	UNKN	0.00	0.00	-15.60	1936010	5615105
1955	LOUIS WOOD & SON	936	63.00	200	5/09/1985	UNKN	UNKN			-4.20	1936984	5615248
4821	TATTERSFIELD SECURITIES	941	27.50	100	26/06/2002	INCO		26.00	27.50	-5.50	1936934	5615274
15391	WAIPA INVESTMENTS LTD	950		200							1936937	5615282
2565	SUPER FISH LTD	1008	55.30	75	10/07/1989	IRRI	UNKN	53.30	55.30	3.00	1936795	5615381
10280	WOOD LOUIS & SONS	1037	59.10	100	29/05/1964	INCO	UNKN	57.00	59.10	4.60	1936941	5615373
328	MORI R P	1071		100	28/01/1972	UNKN	UNKN				1935821	5615115
5076	HAWKE'S BAY REGIONAL C	1084	40.60	100	30/04/2004	GRSA		39.30	40.60		1936675	5613308
3114	HARBOUR INN SEAFOODS	1102	55.47	100	9/06/1992	INCO	UNKN	53.95	55.47		1936774	5615480
10229	EAST COAST FERTILIZER	1107	46.90		26/06/1947	UNKN	UNKN	0.00	0.00	0.00	1936841	5615473
10068	TURNER P J	1107	55.50	50	24/11/1960	UNKN	UNKN	54.60	55.50	7.00	1936841	5615473
595	TOWNSEND & PAUL LTD	1120	56.39	100	8/06/1976	INCO	UNKN	53.35	56.39		1936817	5615491
5027	NAPIER CITY COUNCIL	1175	18.00	50	3/09/2003	EXWE		16.30	18.00		1936550	5615564
5028	NAPIER CITY COUNCIL	1179	40.20	100	27/04/2004	EXWE		38.90	40.20		1936495	5615564
2577	NAPIER CITY COUNCIL	1183	53.30	150	9/08/1989	DOWS	UNKN	51.82	53.34		1936641	5615573
5809	J M TICKNER	1186	52.10	100	10/01/2008	DOWS		50.17	52.10		1935657	5615096
222	NAPIER CITY COUNCIL - P/	1191	59.13	75	14/09/1972	INCO	GRSA	57.30	59.13		1936827	5615561
16140	Trevor Allen	1223	44.33	100	19/12/2013			44.33	45.63		1936075	5615489
2880	BEARSLEY D J (MCCLELLAN	1239	52.12	100	21/01/1991	STWA	IRRI	50.60	52.12		1935371	5614408
16720	Hawke's Bay Regional Cou	1241	51.00	125	20/11/2017			49.70	51.00	7.00	1936112	5613253
10858	MINISTRY OF WORKS	1246	48.70		18/08/1962	UNKN	UNKN	0.00	0.00	0.00	1936982	5613201
16469	Apatu Farms Limited	1247	53.94	100	31/05/2016			52.04	53.94	5.13	1935391	5614129
15392	SALIAN INVESTMENTS LTD	1271		150							1935387	5614737
3358	AGROW PRODUCTS LTD	1302	55.47	100	10/11/1993	DOWS	UNKN	53.95	55.47		1936724	5615687
15789	BROOKFIELDS FARM LTD	1311		75							1935589	5613568
16287	Mr Apple New Zealand Lim	1324	50.47	150	12/08/2014			47.47	50.47	6.01	1935594	5613541
3509	HAWKES BAY PROTEINS N	1330	56.42	300	12/09/1994	INCO	UNKN	54.72	56.42		1936719	5615716
5606	HAWKES BAY PROTEIN	1331	54.00	100	2/10/2006	DOWS		52.70	54.00		1936722	5615716
10859	MINISTRY OF WORKS	1334	30.40		18/08/1962	UNKN	UNKN	0.00	0.00	0.00	1936952	5613100
15342		1350	32.60			EXWE					1936842	5613060
10243	STODDART	1366	50.30		21/02/1955	UNKN	UNKN	0.00	0.00	6.70	1936140	5615673
15147		1371	2.40	105		GRSA					1936685	5615759
15148		1371	3.20	105		GRSA					1936793	5615749
15341		1396	32.30			EXWE					1936822	5613010
10860	MINISTRY OF WORKS	1422	30.00		15/08/1962	UNKN	UNKN	0.00	0.00	0.00	1936912	5613000
17080	Bradbury Partnership	1459	53.64	100	30/11/2020			52.44	53.64		1936717	5615845
5780	D & C SCHULTZE	1461	64.90	100	7/12/2007	STWA		63.64	64.94		1935751	5615571
16799	S B T Properties Limited	1492	58.28	100	26/06/2018			56.74	58.28		1936812	5615868
15413	ROBBIE BELL	1500		75							1936823	5615875
16306	Patrick Allison	1519	47.36	100	16/10/2014			45.76	47.36		1936006	5615784
1151	RUSSELL K P & C P	1549	65.12	100	4/05/1982	UNKN	UNKN	63.12	65.12	7.00	1936630	5615939
5294	HIGGINS BELSPRAY ASPHA	1559	57.20	100	8/11/2004			55.90	57.20		1936813	5615936
15340		1567	31.40			EXWE					1936762	5612830
3254	SOUTH PACIFIC BY PRODU	1570	61.40	80	10/02/1993	DOWS	UNKN	59.40	61.40	-5.00	1936761	5615953
615	WONG B & J	1585	51.80	100	15/09/1976	UNKN	UNKN			5.79	1935026	5614423
16749	Awatoto Development	1587	61.70	150	22/09/2020			58.87	61.77	7.50	1936416	5615965
8473	BELSPRAY ASPHALT	1589	58.10	75	20/06/1970	UNKN	UNKN	58.10	0.00	6.10	1936741	5615973
15339		1604	30.50			EXWE					1936822	5612800
1722	UEB INDUSTRIES LTD	1615	75.00	300	10/09/1984	UNKN	UNKN	67.00	75.00	7.50	1936565	5616004
16472	Mike Baylis	1617	49.60	100	11/04/2016			48.20	49.60		1935002	5614218
10049	STEINER F J	1617	65.50	100	10/12/1964	IRRI	UNKN	0.00	0.00	0.00	1936941	5615973
15387	CAVALIER SPINNERS	1649		200		INCO					1936795	5616028
783	MILLER G F	1677	47.24	100	28/04/1979	UNKN	UNKN			5.79	1935238	5613426
15376	BARBARA & COLIN SUE	1731		100		IRRI					1935083	5613575
2294	RICHARDSON C.K.	1731	62.18	100	29/10/1987	DOWS	STWA	59.78	62.17		1935780	5615909
3890	EARTH GARDENS	1737	46.95	100	7/10/1997	IRRI		44.65	46.95	0.00	1935554	5615770
88	NAPIER CITY COUNCIL	1747		150	28/09/1971	UNKN	UNKN				1936140	5616073
2473	DONAVAN T.P.	1751	61.00	100	1/02/1989	STWA	UNKN	59.40	61.00		1935820	5615953
16297	John Cornish	1753	43.31	100	8/10/2014			43.31	44.61		1936120	5616073
4484	NICHOLS S J	1755	61.50	100	10/08/2000	IRRI		58.50	61.50	8.00	1934861	5614543
3202	NAPIER CITY COUNCIL	1763	48.31	100	5/01/1993	IRRI	UNKN	46.78	48.31		1935362	5615635
541	MONTEITH B W & M A	1780		50	18/05/1975	UNKN	UNKN				1934839	5614571
5681	AB & DEWAR	1780	68.00	100	23/07/2007	IRRI		66.20	68.00	3.50	1935168	5615433
211	CAMPBELL A M	1806	46.30	50	6/09/1972	STWA	UNKN	45.38	46.30	6.40	1935740	5615973
87	NAPIER CITY COUNCIL	1811		150	28/09/1971	UNKN	UNKN				1935940	5616073
2869	NICHOLLS H S	1819	52.73	100	9/01/1991	STWA	IRRI	51.20	52.73	-3.66	1934813	5614114
16515	Selwyn Smith	1828	52.83	100	15/10/2016			50.93	52.83	7.40	1934839	5613939
3880	APATU FARMS LTD	1841	45.38	100	15/10/1996	IRRI	UNKN	42.38	45.38	0.00	1936657	5612550
16717	Ian Richardson	1853	47.00	100	8/12/2017			45.00	47.00	5.00	1936211	5616199
2178	HOHEPA HOMES TRUST B(	1919	45.50	100	15/01/1987	IRRI	UNKN	45.50	47.50	0.00	1936845	5612486
763	MILLER G F	1924	47.24	100	27/04/1979	UNKN	UNKN			5.48	1935030	5613292
5913	NAPIER CITY COUNCIL	1925	90.00	300	23/12/2008			74.00	76.00	6.50	1935752	5616113
4900	MARAENUI GOLF CLUB IN	1932	56.20	100	15/10/2002	IRRI		54.90	56.20		1936263	5616290
16619	Barry Wise	1970	53.00	100	19/02/2018			51.20	53.00	5.00	1934650	5614190
15506	Donovan T P	1974									1934921	5615412
16800	Barry David WISE and Pam	1977									1934643	5614186
4409	NICHOLLS J S & K M	1982	53.25	100	14/02/2000	DOWS	STWA	50.25	53.25		1934700	5613860

APPENDIX C

Aqtesolv Forward Solution
(Duffield, 2007)

Long Term Predicted Drawdown
(Scott, 2001)

APPENDIX C1. Ravensdown Prod Well Nos. 15986 and 15989 Aqtesolv Forward Solution using Theis (1935) 150-day, Displacement – Distance Graph at 34.63 l/s (T = 25,000 m^2/day)



RAVENSDOWN PRODUCTION WELL NOS.15986 AND 15989

Data Set: C:\...\Well Nos. F Sol 150 days 30 lps T =15000.aqt
Date: 11/19/21 Time: 07:13:46

PROJECT INFORMATION

Company: Bay Geological Services Ltd
Client: Ravensdown
Project: BGS305
Location: Waitangi Road, Awatoto
Test Well: Prod WellNos.15986 and 15989
Test Date: N/a

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Prod Well Nos.15986 &1598	1937006	5614108

Observation Wells

Well Name	X (m)	Y (m)
Prod Well Nos.15986 &159	1937006	5614108

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

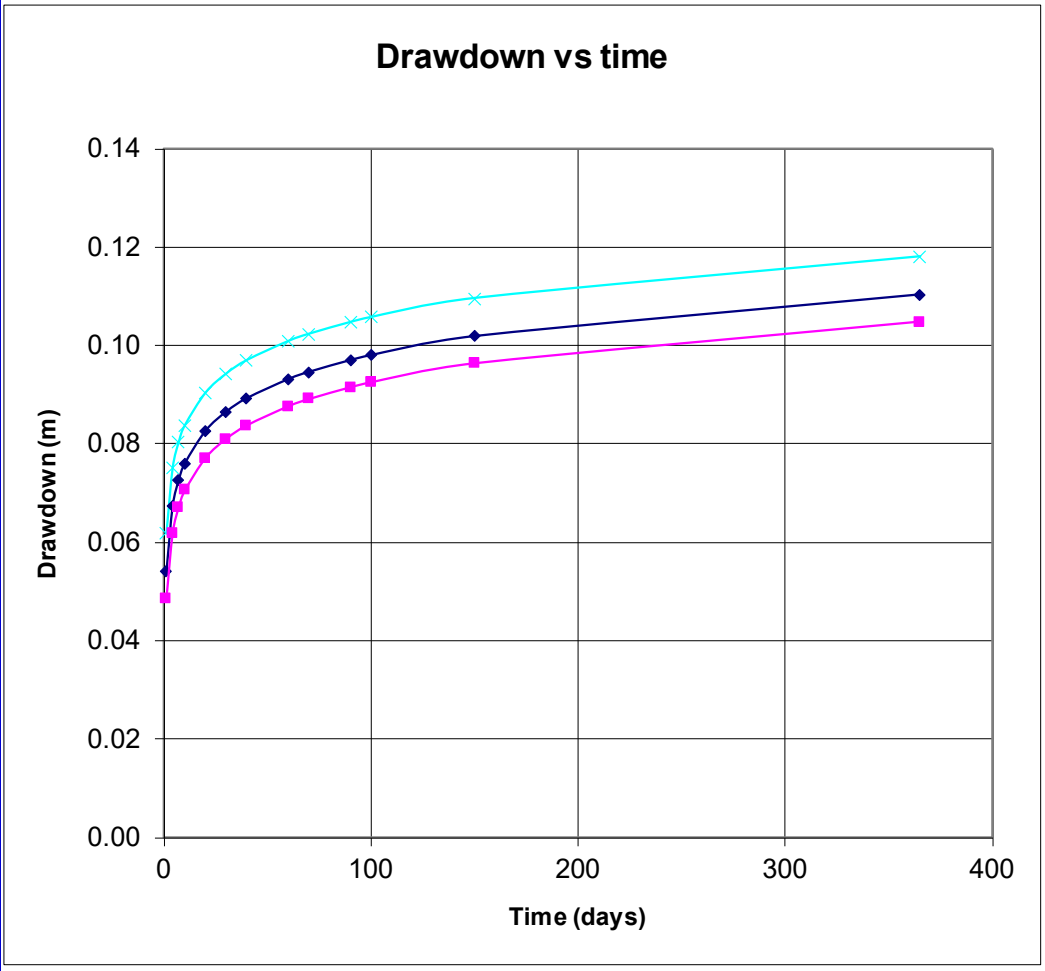
T = 2.5E+4 m^2/day
S = 0.00034
Kz/Kr = 1.
b = 8. m

APPENDIX C2. Scott (2001) Drawdown v Time Calculations using Theis (1935)

Time-drawdown calculations using Theis equation

Aquifer parameters		
T	25000	m2/d
S	0.00034	
B		
Pumping rate		
Q	34.63	l/s

Radius (m)	500	750	1000
Time (days)	Drawdown (m)	Drawdown (m)	Drawdown (m)
1	0.062	0.054	0.049
4	0.075	0.067	0.062
7	0.080	0.073	0.067
10	0.084	0.076	0.071
20	0.090	0.083	0.077
30	0.094	0.087	0.081
40	0.097	0.089	0.084
60	0.101	0.093	0.088
70	0.102	0.095	0.089
90	0.105	0.097	0.091
100	0.106	0.098	0.092
150	0.110	0.102	0.096
365	0.118	0.110	0.105



APPENDIX C3. Scott (2001) Drawdown v Distance calculations using Theis (1935).

Distance-drawdown calculations using Theis equation

Aquifer parameters		
T	25000	m2/d
S	0.00034	
B		

Pumping rate		
Q	34.63	l/s

Time (days)	1	30	365
Radius (m)	Drawdown (m)	Drawdown (m)	Drawdown (m)
1	0.180	0.213	0.236
10	0.136	0.169	0.193
20	0.123	0.156	0.179
50	0.106	0.138	0.162
100	0.092	0.125	0.149
200	0.079	0.112	0.135
350	0.069	0.101	0.125
500	0.062	0.094	0.118
800	0.053	0.085	0.109
1000	0.049	0.081	0.105
1500	0.041	0.073	0.097
1750	0.038	0.070	0.094
2000	0.036	0.068	0.092