APPENDIX G

Land Water People Groundwater Assessment

Wheatsheaf Quarry

Sullivan Block

Groundwater Assessment

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Prepared By:

Brydon Hughes

For any information regarding this report please contact:

Brydon Hughes

Phone: 021495229

Email: Brydon@landwaterpeople.co.nz

LWP Ltd
PO Box 70
Lyttelton 8841
New Zealand

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Executive Summary

Winstone Aggregates is seeking resource consent to enable expansion of existing quarrying activities at the Wheatsheaf Quarry into an approximately 4 Ha area referred to as the Sullivan Block. Proposed operations in this area comprise gravel extraction followed by site rehabilitation which may include the deposition of cleanfill.

Monitoring of groundwater levels at the Wheatsheaf Quarry site indicates a hydraulic gradient of the order of 0.0031 m/m, with groundwater flow according across the site in a south-easterly direction (approximate orientation 120 degrees). Groundwater quality monitoring indicates some minor effects on aesthetic water quality (slightly elevated Total Alkalinity, Hardness and Electrical Conductivity) resulting from historical quarrying operations toward the south-eastern end of the site. However, monitoring results do not appear to indicate any significant or ongoing adverse effects on groundwater quality from historical or ongoing activities on the Wheatsheaf Quarry site.

The potential for the proposed quarry expansion to adversely affect groundwater quality will be significantly mitigated by:

- Maintenance of a minimum separation of 1 metre between the base of the excavation and underlying groundwater.
- Placement of a 1-metre layer of VENM at the base of the excavation to increase separation between maximum groundwater levels and overlying fill.
- Use of cleanfill materials meeting the LWRP cleanfill definition (generally equivalent to Class 4 Controlled Fill under the Wasteminz 2023 guidelines).

With some minor amendments it is recommended that conditions similar to those specified in the previous Wheatsheaf Quarry expansion consents (CRC213142 and CRC213146) be established for the monitoring and reporting of groundwater levels and groundwater quality for the duration of quarrying and rehabilitation activities in the Sullivan Block. Given the nature of the proposed, these conditions will ensure effects on the environment resulting from the proposed quarry expansion will be less than minor.

1 Background

Winstone Aggregates purchased the Wheatsheaf Quarry from Selwyn Quarries Ltd (SQL) in 2016. In February 2022 Winstone Aggregates was granted consent to enable expansion of existing quarry operations into Blocks B and C, located along the northern and western sides of the existing (at that time) quarry site respectively.

The existing consented quarry area (including Blocks B and C) is nearly depleted of aggregate and Winstone Aggregates is seeking resource consents to expand the quarrying activities to include an area referred to as the Sullivan Block. Proposed operations in this area will comprise gravel extraction only and, once exhausted, it is proposed to rehabilitate the site back to ground level with cleanfill.

Figure 1 shows the layout of the Wheatsheaf Quarry site including current operating areas along with the extent of the proposed Sullivan Block expansion area.

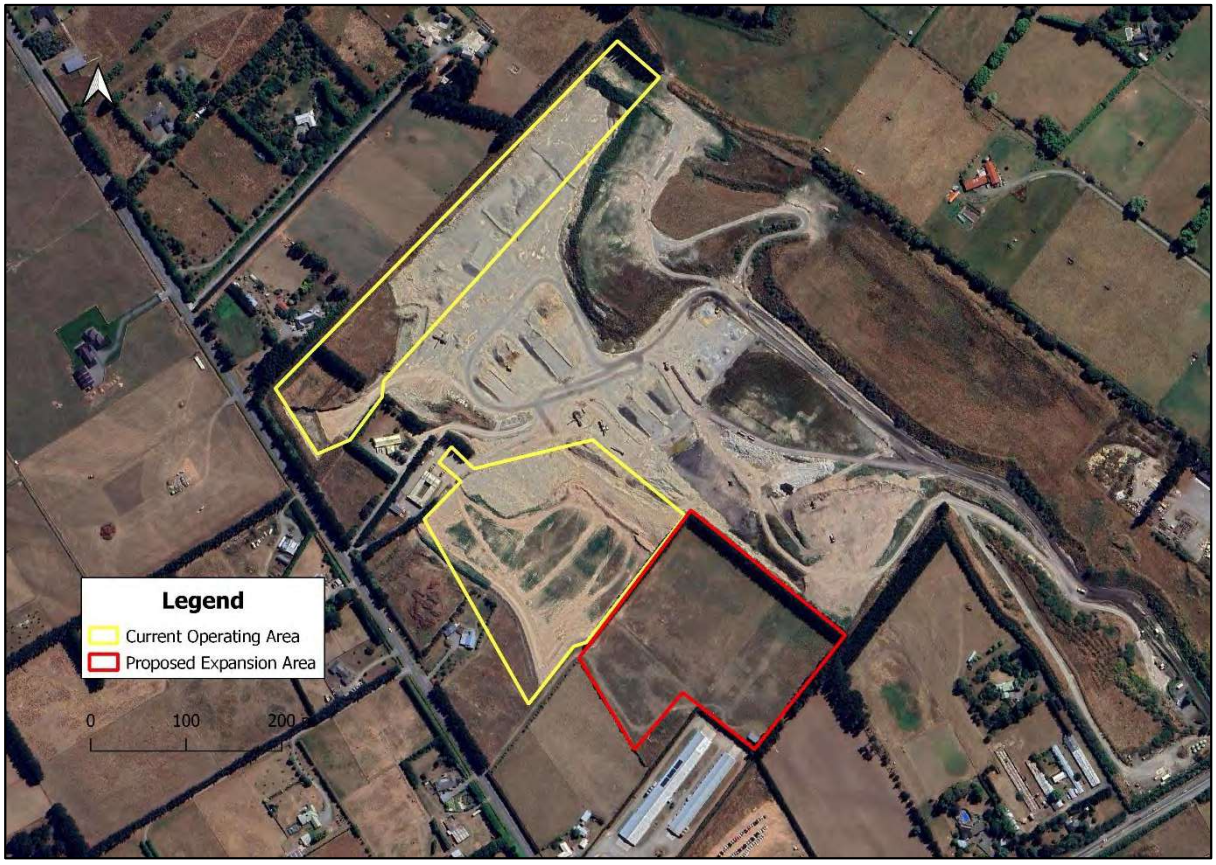

Figure 1. *Aerial view showing current and proposed extraction areas at the Wheatsheaf Quarry.*

LWP has been engaged by Winstone Aggregates to assess potential effects on groundwater associated with the proposed quarry expansion and associated site rehabilitation, which may include cleanfilling. This report details our assessment methodology and provides a summary of our findings. For background, LWP was involved in the assessment of groundwater effects and development of conditions for the current extraction area.

1.1 Project Overview

The Wheatsheaf Quarry has been operating at the site in its current form since the early 2000's and has expanded onto several adjoining blocks of land during that time. The site itself comprises the existing quarry area, a hazardous storage facility, quarried areas under rehabilitation and unquarried areas currently used for grazing.

The site is accessed from Selwyn Road, with an ancillary light vehicle access from Robinsons Road to serve the site offices, which are located in a former dwelling at 706 Robinsons Road. The site and surrounding area are all within the General Rural zone of the Partially Operative Selwyn District Plan – Appeals Version (POSDP).

Current quarrying operations occur in Blocks B and C along the northern and western boundaries of the site authorised under resource consents RC215749 and CRC213142. The existing consented quarry area is nearly depleted of aggregate, so the applicant (Winstone Aggregates) is seeking authorisation to further expand quarrying operations into an area adjoining the southern boundary of Block C, referred to as the Sullivan Block.

The Sullivan Block encompasses an area of approximately 4ha. The proposal includes an extension of the bund as approved by SDC consent RC215749 along the rear boundary of 692 Robinsons Road to 668 Robinsons Road and wrap around the boundary along the rear of properties on Selwyn Road. These will be constructed from the stripped overburden and grassed, prior to excavation of the aggregate.

Aggregate extraction involves standard quarry to strip the material, which will then be loaded into dumper trucks and taken back to the existing quarry for processing. At the completion of extraction, the floor of the extraction area will be covered by 1.0m of clay/silt VENM before placement of cleanfill. Areas where no cleanfill is deposited will be covered with a minimum of 300 mm of topsoil.

Activities within the proposed expansion area will be limited to the extraction and transport of aggregate, and subsequent cleanfilling. Processing operations will remain in their current location within the existing quarry area. Quarrying activities will not occur within 100 metres of any dwelling.

It is noted that a small area (approximately 1,800 m^2) along the southern boundary of the Sullivan Block (adjacent to the chicken sheds) is excluded from the proposed development. This area has been identified as containing a historical landfill so will remained undisturbed by the proposed quarrying activities.

2 Description of the Environment

Characterisation of the hydrogeological setting of the Wheatsheaf Quarry and potential effects of quarrying activities on groundwater was canvassed in detail during the 2022 applications for the current Winstone Aggregates consents (CRC223410 and RC215749). The following section summaries salient points of the information provided for that process, updated to reflect information from monitoring undertaken over the subsequent period following implementation of these consents.

2.1 Hydrogeological Setting

The Wheatsheaf Quarry is located within a sequence of alluvial gravels, sands, silts and clay that extend from the ground surface to a depth of several hundred metres. These highly

permeable alluvial sediments host a spatially extensive aquifer that contains a significant groundwater resource.

Groundwater is interpreted to primarily be recharged by a combination of infiltrating rainfall (land surface recharge) across the area west of the Wheatsheaf Quarry and flow losses from the Waimakariri River, with minor contributions from irrigation and seepage losses from streams, rivers, and water races. Groundwater discharge from the aquifer system occurs via spring-fed surface waterways on the lowland plains south-east of the quarry site, with an uncertain volume also discharged via off-shore seepage. Significant volumes of groundwater are taken from this aquifer system for consumptive use including domestic, municipal and irrigation water supply.

Water levels measurements show the aquifer in the vicinity of the Wheatsheaf Quarry is permanently saturated from a depth of between 15 to 17m below the natural ground surface. Above this depth, the groundwater table fluctuates over time by several metres. This temporal variation in water table depth reflects seasonal and inter-annual variations in the balance between variable groundwater recharge (particularly from rainfall) and relatively constant outflows to surface water and offshore.

2.1.1 Bores located on the Wheatsheaf Quarry site

Bores located within the Wheatsheaf Quarry site are shown on Figure 2 below and basic construction details outlined in Table 1. The bores listed include the water supply well for the quarry site (M36/20476), three existing monitoring wells (M36/20450, M36/20451 and BX23/0273) as well as five monitoring bores (Bores 1 to 5) installed subsequent to the granting of CRC223410, but exclude those bores decommissioned or removed during ongoing quarry operations.

Figure 2. *Existing wells on the Wheatsheaf Quarry site.*

Table 1. *Location and construction details of wells on the Wheatsheaf Quarry site.*

Well No	Date Drilled	Easting (NZTM)	Northing (NZTM)	Depth (m)	Use
M36/20450	22/2/2008	1557019	5173396	18	Monitoring
M36/20451	22/2/2008	1557205	5173094	15	Monitoring
BX23/0273	-	1556792	5173690	18	Monitoring
M36/20476	25/8/2010	1557215	5173081	52	Water Supply
Bore 1	22/9/2022	1556320	5173541	15	Monitoring
Bore 2	22/9/2022	1556598	5173247	15	Monitoring
Bore 3	22/9/2022	1556841	5173228	15	Monitoring
Bore 4	22/9/2022	1556593	5173822	15	Monitoring
Bore 5	22/9/2022	1556848	5173627	15	Monitoring

2.1.2 Downgradient private wells

The location of private wells down-gradient of the Wheatsheaf is shown on Figure 3 below. The bores identified include those located up to 1,000 metres down-gradient and 300 metres cross gradient from the Sullivan Block, based on the interpolated site groundwater flow direction[1] (Note: bores recorded as 'Not used' are excluded from the map). Table 3 summarises details of down-gradient these downgradient wells. The data indicate most of the bores identified are recorded as having screened intervals set at depths between 22.5 and 36.0 m bgl, with five being screened in deeper water bearing intervals. Drillers logs from the wells identified generally indicate the presence of clay horizons and/or layers of '*claybound gravel*' between 10m and 25m bgl, with static water levels ranging between 11m and 15m bgl.

The nearest bore located directly down-gradient of the Sullivan Block is M36/5310. This bore is located approximately 285 metres from the southern margin of the Sullivan Block and is recorded as being screened between 42.5 and 44.0 m bgl. Static water level at the time of drilling was recorded as 14.2 m below top of casing, approximately 28 metres above the top of the screened interval. The log from this bore records layers of '*claybound gravel*' from 18 to 34 and 36 to 40 m bgl. The next closest bore is BX23/1222, located approximately 440 metres south-east of the southern boundary of the Sullivan Block. This bore is screened between 115.7 and 118.7 m bgl. All bores screened in the shallower 22.5 to 36.0 m bgl water-bearing layer are either located over 500 metres down-gradient from the Sullivan Block or at least 170 metres cross-gradient.

[1] Refer to Section 2.2 for details of groundwater flow direction

Figure 3. *Location of existing wells down-gradient of the Wheatsheaf Quarry site.*

Table 2. *Details of private wells located down-gradient of the Wheatsheaf Quarry.*

Well No	Down-gradient distance (m)	Cross-gradient distance (m)	Depth (m)	Screened Interval (m bgl)	Use
BX23/0266	950	200	42		Domestic and Stockwater
BX23/1089	880	0	48	46.0 - 48.0	Domestic and Stockwater
BX23/1222	440	0	118.9	115.7 - 118.7	Irrigation
M36/1309	630	60	30.2	27.8 - 30.2	Domestic Supply
M36/1515	120	290	21		Domestic Supply
M36/1516	740	70	33.8	29.8 - 33.8	Domestic Supply
M36/1613	0	170	33.2	30.2 - 33.2	Domestic and Stockwater
M36/2286	620	0	30	27 - 30	Domestic and Stockwater
M36/2816	550	190	37.8		Domestic Supply
M36/2977	430	280	30	28.7 - 30	Domestic and Stockwater
M36/4389	860	0	27.6	25.6 - 27.6	Irrigation
M36/4390	860	0	25		Domestic
M36/4432	530	0	36	33 - 36	Irrigation and Domestic
M36/5185	0	240	36		Irrigation and Domestic

Well No	Down-gradient distance (m)	Cross-gradient distance (m)	Depth (m)	Screened Interval (m bgl)	Use
M36/5310	285	0	44	42.5 - 44.0	Domestic and Stockwater
M36/5665	1020	0	36	34 - 36	Domestic
M36/7348	240	280	35	33.5 - 35.0	Domestic Supply
M36/7411	0	60	42	40.5 - 42	Domestic and Stockwater
M36/7832	710	270	24	22.5 - 24.0	Domestic and Stockwater

2.1.3 Community drinking water supplies

As shown on Figure 4, the Community Drinking Water Protection Zone defined for the Broadfield School (and Hall) supply wells (BX23/0783 and BX23/0864) is located approximately 650 metres from the Sullivan Block (440 metres down-gradient and 480 metres cross-gradient) at its closest point. The supply wells are situated 1,060 and 1,120 metres from the Sullivan Block respectively.

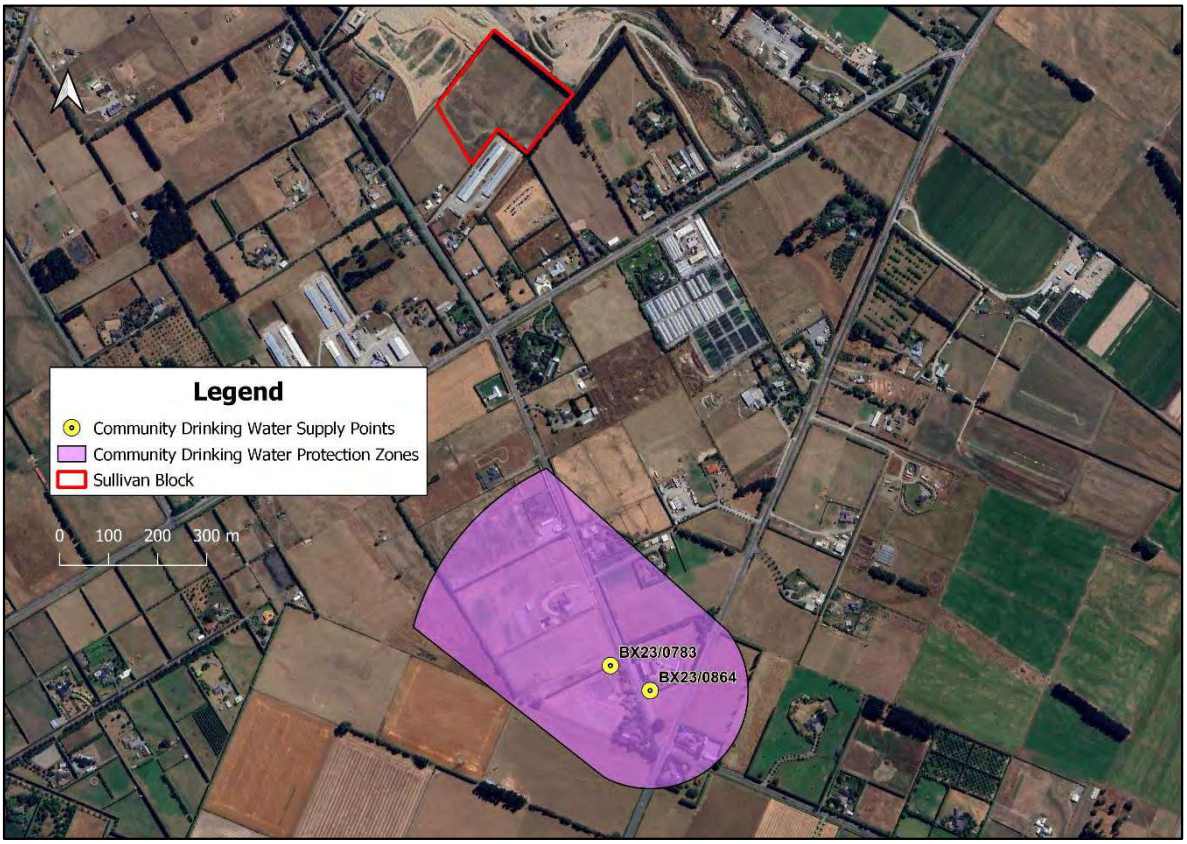

Figure 4. *Location of the Sullivan Block with respect to Community Drinking Water Protection Zone for the Broadfield School and Hall (Source: Canterbury Maps).*

2.1.4 Down-gradient surface waterways

Downgradient surface waterways are shown on Figure 5. These waterways include Dawsons Creek (approximately 5km to the east) and Springs Creek (approximately 5km to the south).

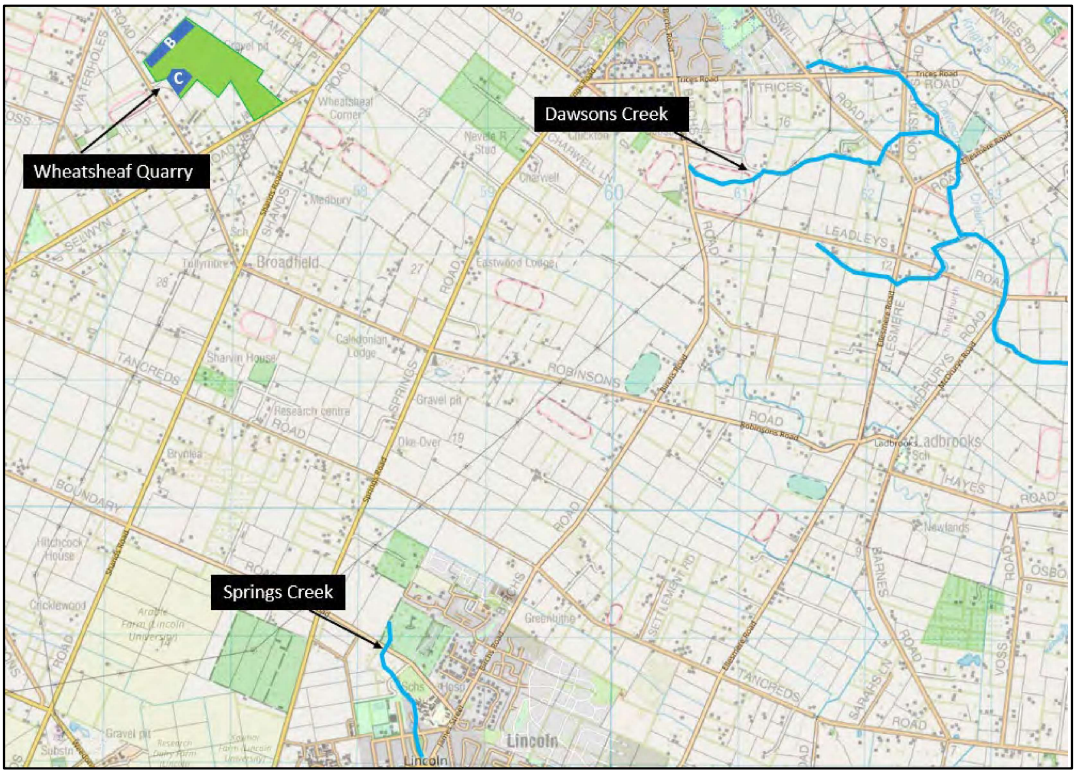

Figure 5. *Surface waterways down-gradient of the Wheatsheaf Quarry site (reproduced from Winstone Aggregates, 2021).*

2.2 Groundwater Levels

Groundwater levels have been measured on a (semi) weekly basis in three monitoring wells on the Wheatsheaf Quarry site (M36/20450, M36/20451 and BX23/0271) since mid-2016. As illustrated on Figure 6 below, groundwater levels in these three bores exhibit a relatively consistent pattern of seasonal variation with lowest levels typically recorded in autumn (March to May) and highest levels in spring (Aug to Nov) following winter recharge.

Water level records from the individual bores are summarised in Table 5 and show median groundwater levels over this period ranged from 16.93 m RL in M36/20451 near Selwyn Road to 19.36 m RL in BX23/0271 located towards the north-eastern corner of the site. The observed spatial variation in median groundwater levels indicates a hydraulic gradient of approximately 0.003 m/m across the site.

Table 3. *Relative groundwater levels recorded in M36/20450, M36/20415 and BX23/0271, 2016 to 2023.*

Well No	Level Count	Minimum (m RL)	Maximum (m RL)	Range (m)	Average (m RL)	Median (m RL)
M36/20451	318	14.03	18.43	4.40	16.70	16.93
M36/20450	314	15.03	19.78	4.75	17.89	18.03
BX23/0271	307	16.96	21.26	4.31	19.23	19.36

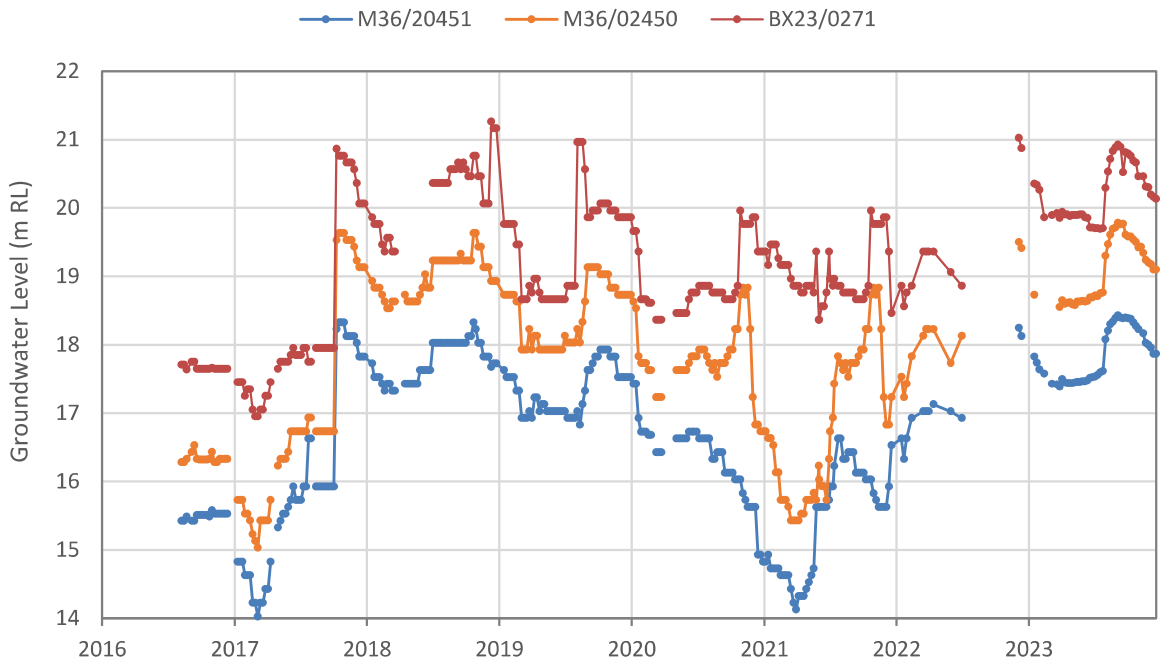

Figure 6. *Groundwater levels (m RL) recorded at the Wheatsheaf Quarry site, 2016-2023.*

Since early 2023 groundwater levels have been monitored continuously in M36/20450 and on a (semi) weekly basis in 5 additional piezometers (Bores 1 to 5) located in active quarry areas (Blocks B and C) under Condition 29 of CRC213142. Figure 7 shows a plot of relative groundwater levels measured over this period. Unsurprisingly the data show relatively consistent temporal variations in groundwater levels across the entire Wheatsheaf Quarry site, with an appreciable rise in groundwater levels recorded during July 2023 in response to significantly above average rainfall (155mm of was recorded at Christchurch Airport in July 2023, equivalent to 230% of the monthly average). It is noted the magnitude of seasonal recovery in groundwater level increased from east to west across the site.

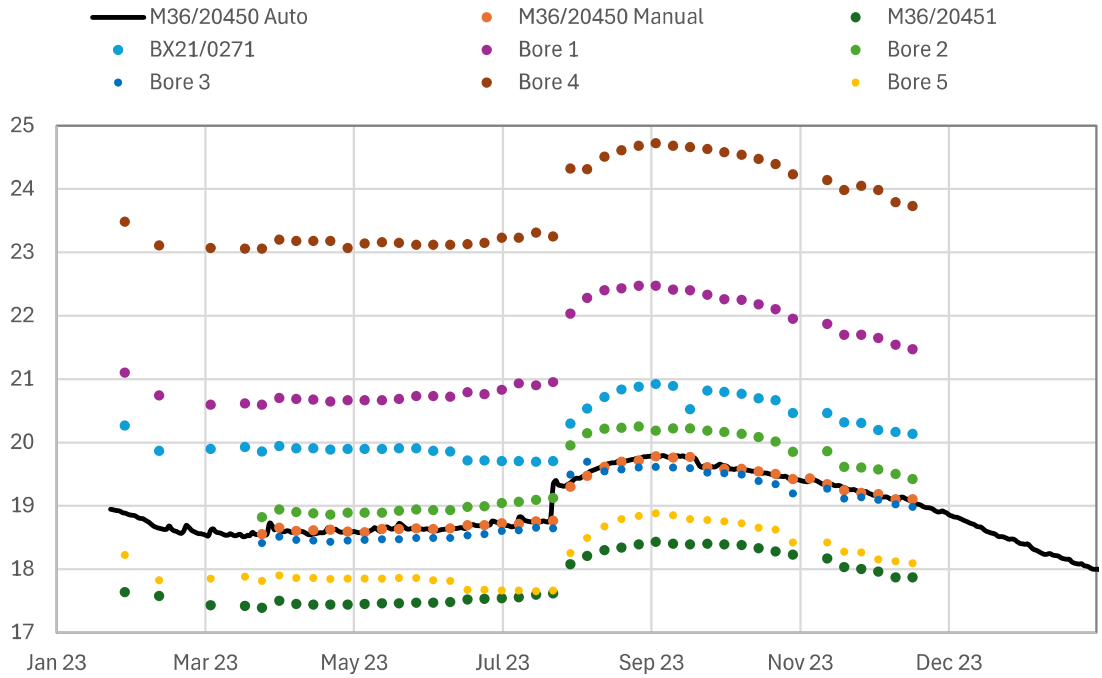

***Figure 7**. Relative groundwater levels measured in Wheatsheaf Quarry piezometers, January 2023 to December 2022 to December 2023.*

2.2.1 Groundwater Flow Direction

The location of Wheatsheaf Quarry, the Christchurch Groundwater Protection Zone and the regional groundwater piezometric contours as reported by Environment Canterbury are shown on Figure 8 below. The figure shows that west of Christchurch groundwater flow generally occurs in an easterly direction towards the coast, while south of Christchurch groundwater flow is diverted in a south-eastly direction around the low permeability volcanic strata of Banks Peninsula.

To confirm the localised groundwater flow direction at the Wheatsheaf Quarry site for the prior Resource Consent application (CRC213142), a piezometric survey was conducted by Tonkin and Taylor Ltd on 8 March 2022. The survey involved an RTK survey of well head elevations and estimation of relative groundwater levels based on measured depth to groundwater in a total of five bores distributed across the quarry site.

Results of the survey confirm groundwater flow in a south-easterly direction (approximate orientation 120°), slightly more to the east than indicated by ECan regional piezometric contours[2]. The hydraulic gradient across the site is estimated to be approximately 0.0031 m/m. Estimated piezometric contours from the 8 March 2022 survey are shown on Figure 9. As further discussed above, given relatively uniform temporal variations in water table elevation over the surrounding area, it is inferred that the direction of groundwater flow will effectively remain constant over time.

[2] Downloaded from Canterbury Maps, based on the Central Plains 1 April 2003 survey in the local area.

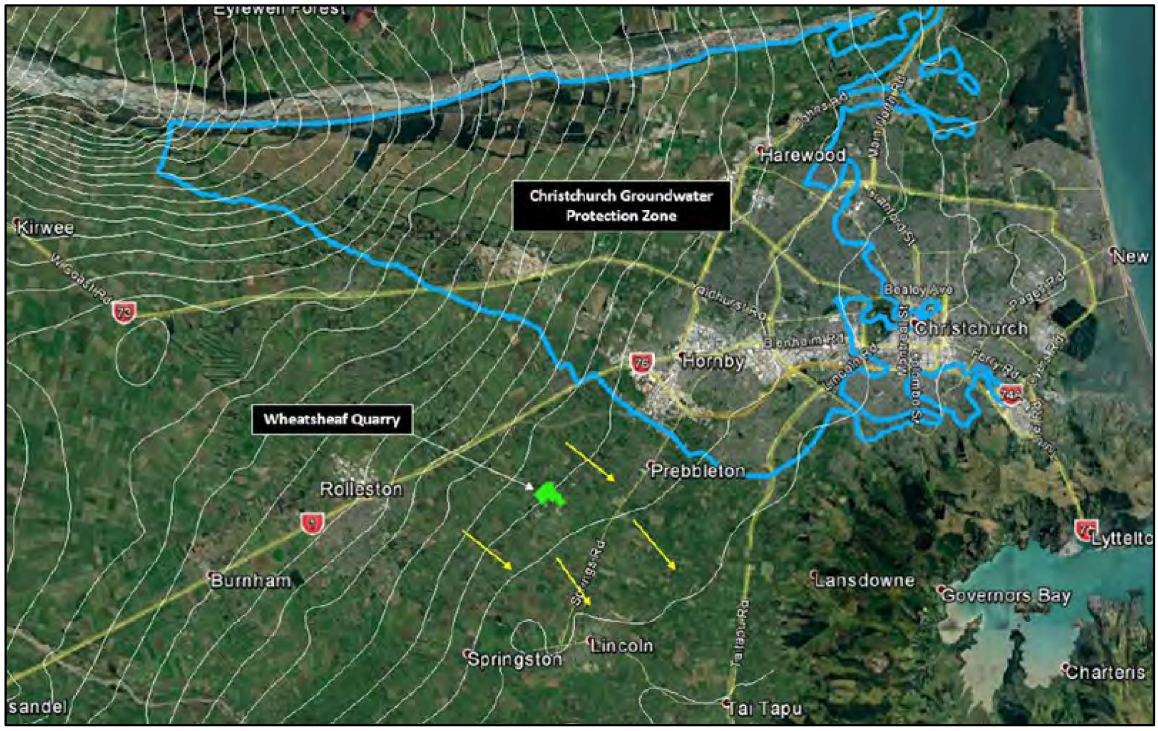

Figure 8. *Regional piezometric contours for the Central Plains area (reproduced from Winstone Aggregates, 2021).*

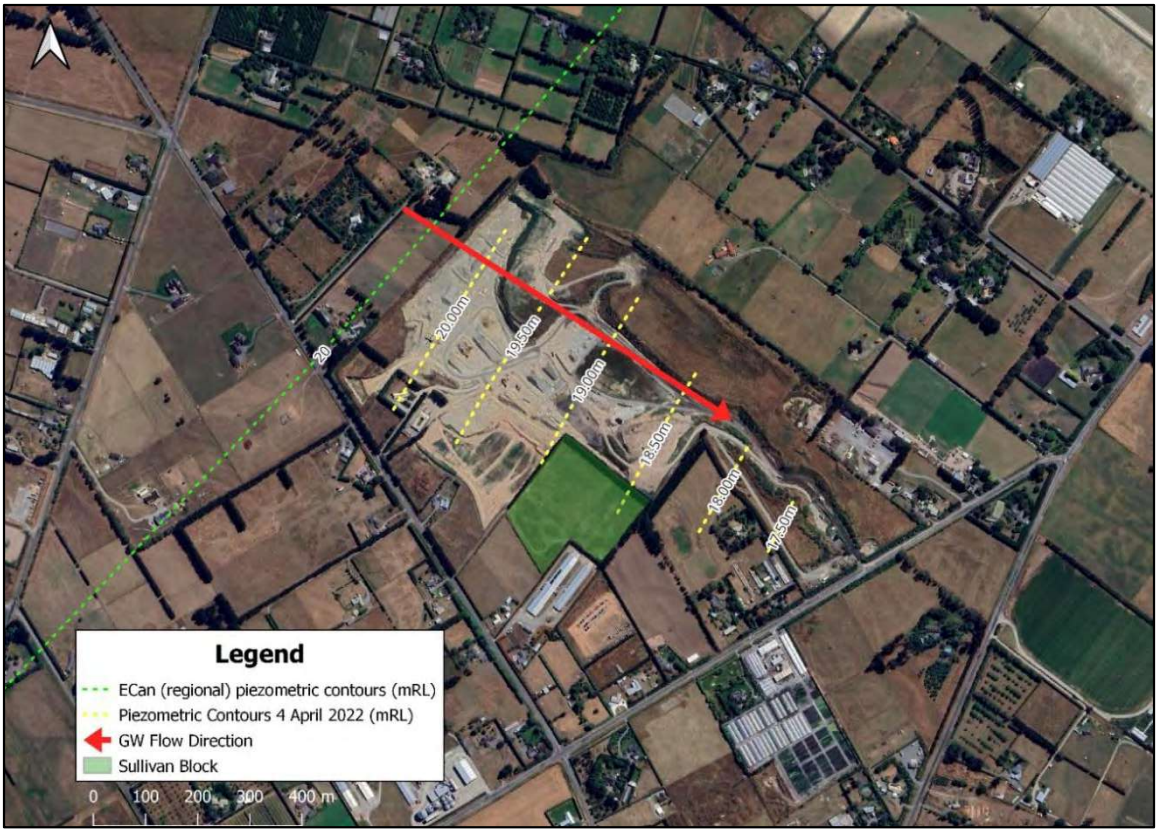

Figure 9. *Piezometric contours (m RL) at the Wheatsheaf Quarry site, 8 March 2022. Interpolated groundwater flow direction indicated by red arrow.*

It is noted that piezometric survey data confirm the area in which the Wheatsheaf Quarry is located does not provide recharge into the Christchurch aquifer system.

2.3 Groundwater Quality

2.3.1 Background groundwater quality

Table 4 below lists 5-year (2019 to 2024) median groundwater quality results from five bores (<35 m deep) monitored by ECan in the general vicinity of the Wheatsheaf Quarry. Locations of the bores are shown on Figure 10. The data indicate shallow groundwater in the general vicinity of the Wheatsheaf Quarry exhibits relatively consistent hydrochemical composition characterised by:

- Low to Moderate Chloride (18 to 21 g/m^3) and Electrical Conductivity (25 to 29 mS/m) values.
- Slightly elevated Total Hardness (82 to 91 g/m^3 as $CaCO_3$) and Nitrate-Nitrogen (5.7 to 8.7 g/m^3) concentrations.
- Trace concentrations of dissolved Iron (<0.02 to 0.13 g/m^3) and Manganese (<0.0005 to 0.023 g/m^3) indicating oxidising to slightly reducing redox conditions.

Table 4. *Median groundwater quality from ECan monitoring sites in the vicinity of Wheatsheaf Quarry, 2014 to 2024.*

Parameter	Units	M36/5248	M36/0271	M36/0297	M36/2285	M36/4227
Total Alkalinity	g/m^3 as $CaCO_3$	57	63	57	67	56
Boron	g/m^3	0.026	0.022	0.024	0.023	0.028
Bromide	g/m^3	0.080	0.063	0.079	0.084	0.076
Calcium	g/m^3	26	24	24	26	23
Chloride	g/m^3	18.1	17.2	21	19.4	19.0
Electrical Conductivity	mS/m	25.3	25.8	29.1	26.6	26.6
Dissolved Oxygen	g/m^3	4.7	6.2	7.6	3.8	8.4
E.coli	MPN/100mL	<1	<1	<1	<1	<1
Total Hardness	g/m^3 as $CaCO_3$	82	84	91	88	85
Iron	g/m^3	0.085	0.02	0.13	<0.020	0.03
Magnesium	g/m^3	3.3	6.0	7.3	6.0	6.7
Manganese	g/m^3	<0.0005	0.0046	0.023	<0.0005	0.0013
Nitrate-Nitrogen	g/m^3	8.4	7.1	8.7	5.7	7.6
pH	g/m^3	7.6	7.3	7.3	7.6	7.2
Potassium	g/m^3	1.54	1.57	1.86	1.46	1.84
Sodium	g/m^3	16.4	16.4	22	19.9	18.4
Sulphate	g/m3	9.4	10.3	13.7	11.2	14.1

***Figure 10**. Location of Environment Canterbury groundwater quality monitoring sites in the vicinity of Wheatsheaf Quarry.*

2.3.2 Groundwater quality at the Wheatsheaf Quarry site

Condition 34 of CRC123412 requires quarterly groundwater samples from 7 monitoring wells on the Wheatsheaf Quarry site (M36/20450, M36/20451 and Bores 1 to 5) to be monitored on a quarterly basis. The condition establishes trigger levels for the parameters specified in Table 5 below. The condition specifies that if any parameters exceeded the nominated trigger values samples will be analysed for a more extensive range of parameters specified in Table 2 [of Condition 34].

***Table 5.** Groundwater quality analyses and Trigger Values specified in Condition 34 of CRC213142.*

Parameter	Trigger Value
Alkalinity	100 mg/L as $CaCO_3$
Ammoniacal-Nitrogen	1.2 mg/L
Electrical Conductivity	50 mS/m
E.coli	1 MPN/100 mL
Total Hardness	100 mg/L
Total Petroleum Hydrocarbons	Above laboratory screen levels

Results of quarterly sampling undertaken from wells on the Wheatsheaf Quarry site between March 2023 and March 2024 are outlined in Table 6 below and show the following exceedances of Condition 34 Table 1 Trigger values:

- Exceedances of the *E.coli* trigger (>1 MPN/100 mL) in Bore 1, Bore 3, Bore 5 and M36/20450. Aside from the March 2024 result from Bore 5 (68 MPN/100 mL), these low-level exceedances (1 MPN/100 mL) do not appear to indicate any significant microbial contamination of groundwater underlying the Wheatsheaf Quarry site.
- Total Petroleum Hydrocarbons in excess of laboratory detection limits was recorded in M36/20450 in March 2023. The reason for this one-off exceedance is uncertain but may be related to the location of M36/20450 immediately adjacent to the main site access road.
- Alkalinity, Electrical Conductivity, *E.coli* and Total Hardness values in excess of the nominated Trigger values were recorded in the March 2024 sample from Bore 4.

Table 7 shows results of analysis of groundwater quality samples from the March 2024 sample round (plus March 2022 sampling in M36/20450 and M36/20451 and a repeat sample in Bore 5 in May 2024) for a full suite of physical and chemical parameters. Again, these results show that, except for Bore 4, groundwater quality was below the Trigger levels specified in Table 2 of Condition 24.

The reason for the elevated Alkalinity, Hardness, Aluminium, Iron, Manganese and *E.coli* concentrations recorded in the March 2024 Bore 4 sample is uncertain, given its location along the northern (up-gradient) boundary of recent quarrying activities. Sample results differ appreciably from the other up-gradient monitoring bore (Bore 1) as well as results from ECan monitoring across the wider Wheatsheaf Quarry area.

It is however noted that Bore 4 was not sampled during the March, June and September 2023 sample rounds due to access constraints[3] and, during repeat sampling in May 2023, no samples could be obtained as the bore could not be adequately purged (recovery after initial pumping was inadequate to enable sample collection). Given these observations, it appears likely that the March 2024 sample from Bore 4 may be influenced by sampling methodology and therefore the representativeness of the results is uncertain, particularly given the bore is up-gradient of all quarrying activities with no obvious alternative contaminant source(s) in the immediate up-gradient area.

Other than results from Bore 4, remaining monitoring sites exhibit groundwater quality which does not indicate historical or current quarrying operations have resulted in more than minor effects on groundwater quality. While the March 2024 sample from Bore 5 recorded an elevated *E.coli* concentration, repeat sampling of this bore in May 2024 did not record the presence of indicator bacteria. Given the prior absence of *E.coli* in this bore, the March 2024 results would appear to reflect a short-term, localised effect, rather than ongoing microbial contamination at this site.

[3] Due to removal of surrounding ground the wellhead could not be accessed

Table 6. *Quarterly sampling results from wells on the Wheatsheaf Quarry site (Values exceeding Condition 24, Table 1 triggers highlighted).*

Site	Parameter	Unit	31/3/23	27/6/23	20/9/23	13/3/24
Bore 1	Alkalinity	mg/L as $CaCO_3$	47	47.4	42.4	47.9
	Ammoniacal-N	mg/L	<0.005	<0.005	<0.005	<0.005
	Electrical Conductivity	mS/m	24.7	29.0	26.1	26.6
	E.coli	CFU/100 mL	<1	**1**	<1	<1
	Total Hardness	mg/L as $CaCO_3$	83	82	88	77
	Total Petroleum Hydrocarbons	mg/L	<0.5	<0.5	<0.5	<0.5
Bore 2	Alkalinity	mg/L as $CaCO_3$	46.7	47.0	45.9	47.9
	Ammoniacal-N	mg/L	<0.005	<0.005	0.007	<0.05
	Electrical Conductivity	mS/m	25.6	30.0	23.8	27.7
	E.coli	CFU/100 mL	<1	<1	<1	<1
	Total Hardness	mg/L as $CaCO_3$	96	87	88	84
	Total Petroleum Hydrocarbons	mg/L	<0.5	<0.5	<0.5	<0.5
Bore 3	Alkalinity	mg/L as $CaCO_3$	60.3	57.9	61.5	63.0
	Ammoniacal-N	mg/L	<0.005	<0.005	<0.005	<0.005
	Electrical Conductivity	mS/m	26.4	30.0	30.4	30.1
	E.coli	CFU/100 mL	**1**	**1**	<1	<1
	Total Hardness	mg/L as $CaCO_3$	100	91	100	92
	Total Petroleum Hydrocarbons	mg/L	<0.5	<0.5	<0.5	<0.5
Bore 4	Alkalinity	mg/L as $CaCO_3$				**163**
	Ammoniacal-N	mg/L				0.14
	Electrical Conductivity	mS/m				**54.6**
	E.coli	CFU/100 mL				**54**
	Total Hardness	mg/L as $CaCO_3$				**160**
	Total Petroleum Hydrocarbons	mg/L				<0.05
Bore 5	Alkalinity	mg/L as $CaCO_3$	53.6		95.1	50.8
	Ammoniacal-N	mg/L	<0.005		<0.005	<0.005
	Electrical Conductivity	mS/m	26.1		29.6	28.8
	E.coli	CFU/100 mL	**1**		<1	**68**
	Total Hardness	mg/L as $CaCO_3$	91		96	80
	Total Petroleum Hydrocarbons	mg/L	<0.5		<0.5	<0.5
M36/20450	Alkalinity	mg/L as $CaCO_3$	55.6	56.8	57.6	57.6
	Ammoniacal-N	mg/L	0.2	0.45	<0.005	0.43
	Electrical Conductivity	mS/m	17.2	20.0	20.2	20.2
	E.coli	CFU/100 mL	<1	**1**	<1	<1
	Total Hardness	mg/L as $CaCO_3$	58	52	62	62
	Total Petroleum Hydrocarbons	mg/L	**16.1**	<0.5	<0.5	<0.5
M36/20451	Alkalinity	mg/L as $CaCO_3$	64.1	58.2	58	58
	Ammoniacal-N	mg/L	<0.005	<0.005	<0.005	<0.005
	Electrical Conductivity	mS/m	26.3	29.0	28.8	28.8
	E.coli	CFU/100 mL	<1	<1	<1	<1
	Total Hardness	mg/L as $CaCO_3$	95	91	95	95
	Total Petroleum Hydrocarbons	mg/L	<0.5	<0.5	<0.5	<0.5

Table 7. Results of groundwater quality analysis from the Wheatsheaf Quarry site for a full suite of physical and chemical parameters (including dissolved metals). Values exceeding Condition 34 Table 2 triggers highlighted.

Parameter	Units	M36/20450		M36/20451		Bore 1	Bore 2	Bore 3	Bore 4	Bore 5	
Date		18/3/22	13/3/24	18/3/22	13/3/24	13/3/24	13/3/24	13/3/24	13/3/24	13/3/24	23/5/24
pH			7.5		7.3	7.0	7.2	6.8	7.6	7.3	6.9
Total Alkalinity	g/m^3 as $CaCO_3$	65	60.8	66	57.2	47.9	47.9	63.0	**163**	50.8	50.6
Total Hardness	g/m^3 as $CaCO_3$	66	59	92	82	77	84	92	**160**	80	88
Electrical Conductivity	mS/m	24.4	21.0	26.4	28.0	26.6	27.7	30.1	54.6	28.8	28.1
Dissolved Aluminium	g/m^3	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**0.072**	0.007	<0.003
Dissolved Boron	g/m^3	0.023	0.016	0.025	0.022	0.023	0.021	0.023	0.068	0.021	0.025
Dissolved Calcium	g/m^3	23	16.1	27	24.2	22.5	24.2	26.8	45.9	23.1	25.4
Dissolved Iron	g/m^3	<0.02	<0.005	<0.02	<0.005	<0.005	<0.005	<0.005	**0.31**	<0.005	<0.005
Dissolved Magnesium	g/m^3	5.5	4.45	6.3	5.25	5.07	5.74	6.12	11.8	5.48	5.9
Dissolved Manganese	g/m^3	0.33	0.013	0.0007	<0.0005	<0.0005	<0.0005	0.014	**1.56**	0.0017	0.0025
Chloride	g/m^3	14.9	15.9	15.3	15.7	15.3	17.0	16.3	38.5	16.4	16.3
Total Ammoniacal-N	g/m^3	<0.01	0.5	<0.010	<0.005	<0.005	<0.005	<0.005	0.14	<0.005	<0.005
Nitrate-N	g/m^3	7.4	0.0174	7.5	7.84	8.22	8.60	8.24	4.95	8.80	8.88
Escherichia coli	cfu/100 mL	1	<1	<1	<1	<1	<1	<1	**54**	**68**	<1
Dissolved Arsenic	g/m^3	<0.0010	<0.0005	<0.0010	<0.0005	<0.0005	<0.0005	<0.0005	0.00067	<0.0005	<0.0005
Dissolved Cadmium	g/m^3	<0.00005	<0.00002	<0.00005	<0.00002	<0.00002	<0.00002	<0.00002	<0.000044	<0.00002	<0.00002
Dissolved Chromium	g/m^3	<0.0005	<0.0002	<0.0005	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Dissolved Copper	g/m^3	<0.0005	<0.0002	<0.0005	0.00027	<0.0002	<0.0002	0.00022	0.0036	<0.0002	0.00022
Dissolved Lead	g/m^3	<0.00010	<0.00005	<0.00010	<0.00005	<0.00005	<0.00005	<0.00005	0.00011	<0.00005	<0.00005
Dissolved Nickel	g/m^3	<0.0005	<0.0002	<0.0005	<0.0002	<0.0002	<0.0002	<0.0002	0.0033	0.0033	<0.0002
Total Petroleum Hydrocarbons											
C7 - C9	g/m^3	<0.1	<0.2	<0.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
C10 - C14	g/m^3	<0.2	<0.5	<0.2	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.2
C15 - C36	g/m^3	<0.4	<0.3	<0.4	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Total Hydrocarbons (C7 - C36)	g/m^3	<0.7	<0.5	<0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

3 Assessment of Effects on the Environment

3.1 Maintenance of minimum separation from groundwater

Depth to groundwater is a key consideration for the purposes of assessing compliance with the rules in the LWRP in relation to excavation and cleanfilling. Unsaturated geological strata overlying the water table prevents direct discharge of contaminants to groundwater and provides attenuation (via natural processes such as adsorption, filtering and retention) of contaminants mobilised in infiltrating soil water prior to their reaching the underlying water table. Removal of this unsaturated material (i.e., for example through quarrying activities) reduces the potential for contaminant attenuation, thereby increasing the potential for adverse effects on groundwater quality.

Condition 17 of CRC213142 specifies a maximum excavation depth for existing quarrying activities in the B and C-blocks of the Wheatsheaf Quarry. This maximum excavation depth was based on extrapolation of the highest historical groundwater levels estimated at M36/20450 along the direction of groundwater flow, assuming a hydraulic gradient of 0.0031 m/m estimated from the March 2022 piezometric survey. The following section outlines calculation of a maximum excavation depth for the Sullivan Block utilising the same methodology.

To estimate the highest historical groundwater level, manual groundwater levels recorded in M36/20450 were compared with data recorded in M36/0142 (using data recorded +/- 7-days). The resulting correlation[4] was then utilised to generate a synthetic hydrograph for M36/20450 extending back to 1984, based on monthly water level data recorded in M36/0142. Figure 11 shows a relatively good match between measured and modelled groundwater levels.

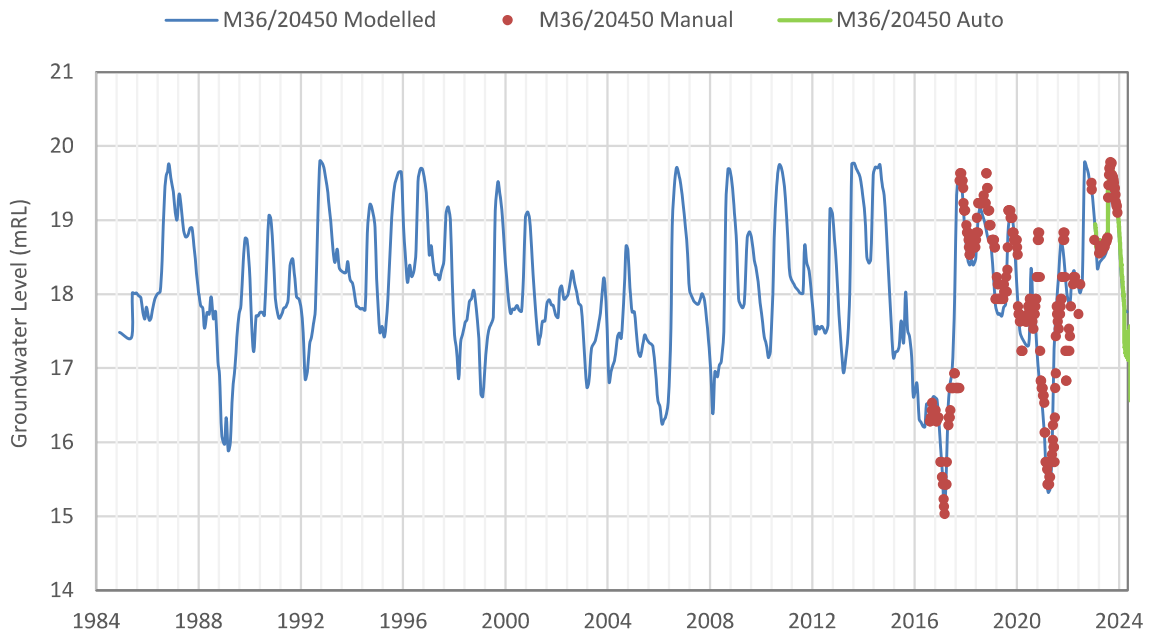

Figure 11. Synthetic hydrograph for M36/20450 compared to manual and automatic groundwater level measurements.

[4] With clearly anomalous data points removed, correlation between M36/0142 and M36/20450 based on 87 data points was $Y = -0.0752x^2 + 4.4034x - 44.613$ ($R^2 = 0.92$)

Based on the synthetic hydrograph shown on Figure 11, the highest historical groundwater level in M36/20450 is estimated to have been 19.80 m RL on 30 September 1992. Given the monitoring record for M36/0142 dates back to late 1984, this level corresponds to an approximately 1 in 40-year return high groundwater level.

The north-western and south-eastern boundaries of the Sullivan Block run approximately perpendicular to the estimated groundwater flow direction. Assuming a hydraulic gradient of 0.031 m/m, Table 8 outlines the minimum invert of the proposed excavation along these boundaries required to maintain a 1-metre separation between the base of the excavation and the maximum groundwater level, following the methodology utilised to establish Condition 17 of CRC213142. The table indicates a minimum invert for the excavation ranging from 21.7 m RL along the north-western boundary to 21.0 m RL along the south-eastern boundary. This invert provides for excavation of around 10 m of surface alluvium across the Sullivan Block.

Table 8. Calculated maximum excavation depth to maintain a minimum 1 metres separation from the highest historical groundwater level.

Location	Distance up-gradient from M36/20450 (m)	Maximum historical groundwater level (m)	Maximum depth of excavation (mRL)	Approximate ground elevation (m RL)
North-western boundary	280	20.7	21.7	31.8
South-eastern boundary	60	20.0	21.0	30.6

It is recommended that the maximum depth of excavation for the Sullivan Block is incorporated into a condition similar in form to Condition 17 of CRC213142.

It is also recommended that Conditions 29 to 33 of CRC213142 be applied to any new consent to require monitoring of groundwater levels and specify a response to periods of high groundwater levels. Suggested amendments to such conditions include:

- Removal of Bore 4 and Bore 5 from the list of sites which require weekly monitoring of groundwater levels. As noted in Section 2.2 above, temporal groundwater level variations are relatively uniform across the Wheatsheaf site and these bores are located upwards of 300 metres cross-gradient from the Sullivan Block.
- The threshold for increasing the frequency of manual groundwater level monitoring should be established as 19.6 m RL (equal to the 95th percentile high groundwater level calculated in M36/20450).

3.2 Effects on proposed quarry expansion on groundwater quality

The existing quarry site comprises the area which has been quarried, cleanfill areas, a hazardous substances storage facility adjacent to Selwyn Road and areas that are currently in grass. The existing areas of extraction and cleanfill occupy a total area of approximately 28 hectares, comprising a lowered basin in which the current aggregate extraction and processing operation occurs. The floor of the existing extraction area is located approximately 9 metres below the surrounding ground level contains a series of stockpiles and operational plant.

The proposed quarry operation in the Sullivan Block consists of the excavation and temporary stockpiling of soils and overburden in perimeter bunds. The proposal includes an extension of the bund as approved by SDC consent RC215749 along the rear boundary of 692 Robinsons Road to 668 Robinsons Road and wrap around the boundary along the rear of properties on Selwyn Road. These will be constructed from the stripped overburden and grassed, prior to excavation of the aggregate. Soils and overburden will be spread directly on completed areas as part of the final restoration.

Following completion of quarrying activities, the Sullivan Block will be rehabilitated using cleanfill meeting the criteria established in the Canterbury Land and Water Regional Plan:

> *Cleanfill material includes virgin natural materials such as clay, soil and rock, and other inert materials such as concrete or brick that are free of:*
>
> 1. *combustible, putrescible, degradable or leachable components;*
> 2. *hazardous substances;*
> 3. *products or materials derived from hazardous waste treatment, hazardous waste stabilisation, or hazardous waste disposal practices;*
> 4. *materials that may present a risk to human or animal health, such as medical and veterinary waste, asbestos, or radioactive substances; or*
> 5. *liquid waste.*

3.2.1 Background investigations

An investigation undertaken by Dr Lisa Scott to determine potential effects of gravel extraction activities, including deposition of cleanfill, on groundwater quality in the Miners Road and Yaldhurst area is documented in ECan (2019). The investigation included a detailed analysis of groundwater quality results up-gradient, within and down-gradient of an extensive area of existing and historical quarry sites. Key findings of the study included:

- Dissolved ion concentrations in groundwater down-gradient of the quarries were measurably higher than in groundwater up-gradient of the quarries. Notable changes in groundwater quality observed were increases in Alkalinity, Hardness (Magnesium and Calcium), Chloride and Sulphate concentrations.
- The origin of the elevated ion concentrations in down-gradient groundwater was attributed to leaching of mobile contaminants from fill materials placed in the quarries.
- Groundwater in some of the consent monitoring wells at the quarries exhibited low dissolved oxygen concentrations indicating the breakdown of organic materials.
- *E.coli* was detected in many monitoring wells, particularly following rainfall.
- Concentrations of dissolved metal species were generally low although some localised elevated concentrations were observed within the quarry areas.
- Poor construction and irregular pumping of consent monitoring bores may contribute to some of the variability in observed dissolved metal concentrations.

The study concluded that gravel quarries and associated cleanfill operations have had an effect on groundwater quality in terms of aesthetic properties (e.g., hardness, taste, potential

discolouration) down-gradient of the quarry sites. However, such effects are localised and generally dissipate within a few hundred metres of the quarry and fill areas.

A memorandum prepared for the 2019 Land and Water Regional Plan (LWRP) Plan change process by Dr Lisa Scott (Scott, 2019) provides a review of potential effects of cleanfill deposition on groundwater quality based on experience from multiple sites. Key conclusions reached by Dr Scott included:

- Cleanfill materials can generate an associated discharge of contaminated water, but the concentrations of contaminants are generally low and mainly affect the aesthetic quality of groundwater;
- Deposition of cleanfill poses a low risk to groundwater quality, if the quality of fill is stringently controlled;
- Cured asphalt containing coal tar poses a higher risk to groundwater quality than other types of cured asphalt;
- Waste slurries (e.g. concrete slurry and hydro-excavation slurry) pose a risk to groundwater quality

3.2.2 Effects of the proposed activity

Findings of investigations undertaken by ECan to characterise potential effects of cleanfill deposition are consistent with results of groundwater quality monitoring undertaken at the Wheatsheaf Quarry. Monitoring results generally indicate quarrying and cleanfill activities have had a limited effect on groundwater quality, with a slight elevation of aesthetic determinants (Total Alkalinity, Hardness and Electrical Conductivity) in monitoring wells toward the eastern (down-gradient) end of the site compared to those located further up-gradient. Intermittent low-level detections of indicator bacteria (*E.coli*) are noted in several monitoring wells, with positive detection of Total Petroleum Hydrocarbons (TPH) recorded on one occasion in a well adjacent to the site access road. These results indicate any contamination of groundwater occurring on the Wheatsheaf Quarry site is intermittent, localised and does not represent ongoing contamination of groundwater at levels exceeding the Trigger Values established under Condition 34 of CRC213142[5].

Section 3.1 above calculates the maximum depth of excavation in the Sullivan Block required to maintain a minimum separation of 1 metre between base of cleanfill and the highest historical groundwater level. Maintenance of a minimum 1 metre unsaturated zone under the fill materials will eliminate the potential for direct mobilisation of contaminants into groundwater and provide some degree of attenuation for any contaminants entrained in infiltrating soil water. Additional separation between cleanfill materials and groundwater during periods of extreme high groundwater levels will be achieved by placement of a 1.0-metre-thick layer of VENM along the base of the excavation under any areas where cleanfill is deposited.

As outlined in Section 2.1.2 above the nearest bore located directly down-gradient of the Sullivan Block is M36/5310. This bore is located approximately 285 metres from the southern margin of the Sullivan Block and is recorded as being screened between 42.5 and 44.0 m bgl. The log from this bore records layers of '*claybound gravel*' from 18 to 34 and 36 to 40 m bgl

[5] Which, with the exception of Nitrate-Nitrogen, are set at levels <50 percent of the relevant Maximum Acceptable Values (MAV) established by the Water Services (Drinking Water Standards for New Zealand) Regulations 2022.

indicating the is likely to be an indirect hydraulic connection between shallow groundwater underlying the Wheatsheaf Quarry and the screened interval in this bore. The next closest bore immediately down-gradient of the quarry site is BX23/1222, located approximately 440 metres south-east of the southern boundary of the Sullivan Block. This bore is screened between 115.7 and 118.7 m bgl so again is unlikely to be in direct hydraulic connection with shallow groundwater. All bores screened in the shallower 22.5 to 36.0 m bgl water-bearing layer are either located over 500 metres down-gradient from the Sullivan Block or at least 170 metres cross-gradient. Consequently, the construction and location of private wells downgradient of the Wheatsheaf Quarry significantly reduce the potential for cleanfilling activities to adversely affect water quality in neighbouring bores.

Similarly, the Community Drinking Water Protection Zone defined for the Broadfield School (and Hall) supply wells (BX23/0783 and BX23/0864) is located approximately 650 metres from the Sullivan Block (440 metres down-gradient and 480 metres cross-gradient) at its closest point, significantly reducing the potential for adverse effects arising from land use activities in the Wheatsheaf Quarry.

It is noted that existing groundwater quality monitoring sites (including Bore 2 and Bore 3) will be retained during quarrying in the Sullivan Block. It is recommended that a condition requiring Groundwater Quality Monitoring and Reporting similar in form to Condition 34 of CRC213142 be included in any new consent. Suggested amendments to such a condition include:

- Removal of the requirement to sample Bore 4 (given difficulties obtaining representative samples and its location approximately 500 metres from the proposed activity).
- Given excavation of the Sullivan Block represents the maximum extent of potential quarry expansion, a reduction in the frequency of groundwater quality monitoring to annually (provided no significant changes in groundwater quality are observed) two years after quarrying activities cease in the Sullivan Block and a cessation of monitoring after 5-years.

4 Summary

Winstone Aggregates is seeking resource consent to enable expansion of existing quarrying activities at the Wheatsheaf Quarry into an approximately 4 Ha area referred to as the Sullivan Block. Proposed operations in this area comprise gravel extraction followed by site rehabilitation back to existing ground level with cleanfill.

Monitoring of groundwater quality at the Wheatsheaf Quarry indicates historical quarrying and cleanfill activities have resulted in some minor effects on aesthetic water quality (slightly elevated Total Alkalinity, Hardness and Electrical Conductivity). While some relatively minor exceedances of groundwater quality triggers specified in Condition 34 of CRC213412 are recorded, these are short-term, localised and do not appear to indicate any significant or ongoing adverse effects on groundwater quality from historical or ongoing activities on the Wheatsheaf Quarry site.

The potential for the proposed quarry expansion to adversely affect groundwater quality will be significantly mitigated by:

- Maintenance of a minimum separation of 1 metre between the base of the excavation and underlying groundwater. Maximum excavation depths for the Sullivan Block are proposed following the methodology utilised to establish equivalent figures in Condition 17 of CRC213142. The proposed maximum excavation depth is based on an approximately 1 in 40-year return high groundwater level, based on available data.
- Placement of a 1.0-metre layer of VENM at the base of the excavation to increase separation between maximum groundwater levels and overlying cleanfill thereby increasing the potential for attenuation of any contaminants which may be mobilised.
- Use of cleanfill materials meeting the LWRP cleanfill definition (generally equivalent to Class 4 Controlled Fill under the Wasteminz 2023 guidelines).

The potential for adverse effects on existing wells downgradient of the Wheatsheaf site will be further reduced by their depth and distance downgradient of the Sullivan Block.

With some minor amendments it is recommended that conditions similar to those specified in CRC213142 be established for the monitoring and reporting of groundwater levels and groundwater quality for the duration of quarrying and rehabilitation activities in the Sullivan Block.

References

Environment Canterbury, 2019: Groundwater quality investigation at Miners Road quarries, Yaldhurst Christchurch, Environment Canterbury Technical Report R19/05, January 2019, 69 p.

Scott, L. 2019b; Effects of cleanfill deposition on groundwater quality and recommendations for LWRP Omnibus Plan Change 2019. Memo prepared by Lisa Scott to Andrea Richardson, 20 February 2019.

WasteMINZ, 2023; Technical Guidelines for Disposal to Land. Waste Management Institute New Zealand, September 2023.

Winstone Aggregates, 2021; Wheatsheaf Quarry Groundwater Report. July 2021.

Laboratory Results

March 2023

Site	Wheatsheaf March 2023							Consent Criteria
Sample Date	30 - 31/03/2023							
Bore Name	1	2	3	4*	5	M36/20450	M36/20451	Trigger Value
Parameter								
Alkalinity	47	46.7	60.3	N/A	53.6	55.6	64.1	100 mg/L
Ammoniacal - Nitrogen	<0.005	<0.005	<0.005	N/A	<0.005	0.2	<0.005	1.2 mg/L
Electrical Conductivity	247	256	264	N/A	261	172	263	50 mS/m
Escherichia coli	<1	<1	1	N/A	1	<1	<1	1 per 100ml
Hardness = Calcium + Magnesium	83	96	100	N/A	91	58	95	100 mg/L
Total Petroleum Hydrocarbons	<0.5	<0.5	<0.5	N/A	<0.5	16.1	<0.5	Above laboratory screen levels

*NOTE: BORE 4 IS NOT ACCESSIBLE.

June 2023

Site	Wheatsheaf June 2023							Consent Criteria
Sample Date	27/06/2023							
Bore Name	1	2	3	4*	5*	M36/20450	M36/20451	Trigger Value
Parameter								
Alkalinity (g $CaCO_3/m^3$)	47.4	47	57.9	N/A	N/A	56.8	58.2	100
Ammonia - N (mg/L)	<0.005	<0.005	<0.005	N/A	N/A	0.45	<0.005	1.2
Electrical Conductivity (mS/M)	29	30	30	N/A	N/A	20	29	50
E. coli	1	<1	1	N/A	N/A	1	<1	1
Hardness (g CaCO3/m3)	82	87	91	N/A	N/A	52	91	100
Total Petroleum Hydrocarbons	<0.5	<0.5	<0.5	N/A	N/A	<0.5	<0.5	Above laboratory screen levels

Notes

* BORE 4 not accessible & BORE 5 damaged. Access and repairs to be undertaken prior to next sampling round

< Denotes values below laboratory detection

September 2023

Site	Wheatsheaf September 2023							Consent Criteria
Sample Date	20/09/2023							
Bore Name	1	2	3	4*	5	M36/20450	M36/20451	Trigger Value
Parameter								
Alkalinity	42.4	45.9	61.5	N/A	95.1	57.6	58	100 mg/L
Ammoniacal - Nitrogen	<0.005	0.007	<0.005	N/A	<0.005	0.43	<0.005	1.2 mg/L
Electrical Conductivity	261	283	304	N/A	296	202	288	50 mS/m
Escherichia coli	<1	<1	<1	N/A	<1	<1	<1	1 per 100ml
Hardness = Calcium + Magnesium	88	88	100	N/A	96	62	95	100 mg/L
Total Petroleum Hydrocarbons	<0.5	<0.5	<0.5	N/A	<0.5	<0.5	<0.5	Above laboratory screen levels

*NOTE: BORE 4 IS NOT ACCESSIBLE.

March 2024

ANALYTICA LABORATORIES

Analytica Laboratories Limited
Ruakura Research Centre
10 Bisley Road
Hamilton
sales@analytica.co.nz
www.analytica.co.nz

Certificate of Analysis

Enviroco
7/158 Cavendish Road, Casebrook

Attention: Nick Wilson
Phone: 0272269290
Email: Nick@enviroco.nz

Lab Reference: 24-08467
Submitted by: Nick/Richard
Date Received: 14/03/2024
Testing Initiated: 14/03/2024
Date Completed: 21/03/2024
Order Number:
Reference: Wheatsheaf

Sampling Site: Wheatsheaf Quarry

Report Comments

Samples were collected by yourselves (or your agent) and analysed as received at Analytica Laboratories (or at the subcontracted laboratories, when applicable). Samples were in acceptable condition unless otherwise noted on this report. Specific testing dates are available on request.

Water Aggregate Properties

	Client Sample ID		Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
	Date Sampled		13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
pH	pH	1	7.0	7.2	6.8	7.6	7.3
Electrical Conductivity	µS/cm	0.2	266	277	301	546	288
Total Alkalinity (CaCO3)	g $CaCO_3/m^3$	1	47.9	47.9	63.0	163	50.6

Water Aggregate Properties

	Client Sample ID		M36/20450	M36/20451
	Date Sampled		13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
pH	pH	1	7.5	7.3
Electrical Conductivity	µS/cm	0.2	210	280
Total Alkalinity (CaCO3)	g $CaCO_3/m^3$	1	60.8	57.2

Inorganic Nutrients and Nutrient Species in Water

Client Sample ID			Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Date Sampled			13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
Ammonia as N	g/m³	0.005	<0.005	<0.005	<0.005	0.14	<0.005
Nitrate-N	g/m³	0.002	8.22	8.60	8.24	4.95	8.80

Inorganic Nutrients and Nutrient Species in Water

Client Sample ID			M36/20450	M36/20451
Date Sampled			13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
Ammonia as N	g/m³	0.005	0.50	<0.005
Nitrate-N	g/m³	0.002	0.0174	7.84

Anions in Water

Client Sample ID			Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Date Sampled			13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
Chloride	g/m³	0.5	15.3	17.0	16.3	38.5	16.4

Anions in Water

Client Sample ID			M36/20450	M36/20451
Date Sampled			13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
Chloride	g/m³	0.5	15.9	15.7

Elements in Water (Soluble)

Client Sample ID			Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Date Sampled			13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
Aluminium	g/m³	0.003	<0.0030	<0.0030	<0.0030	0.0072	0.0070
Arsenic	g/m³	0.0005	<0.00050	<0.00050	<0.00050	0.00067	<0.00050
Boron	g/m³	0.01	0.023	0.021	0.023	0.068	0.021
Cadmium	g/m³	0.00002	<0.000020	<0.000020	<0.000020	0.000044	<0.000020
Chromium	g/m³	0.0002	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Copper	g/m³	0.0002	<0.00020	<0.00020	0.00022	0.0036	<0.00020
Iron	g/m³	0.005	<0.0050	<0.0050	<0.0050	0.31	<0.0050
Lead	g/m³	0.00005	<0.000050	<0.000050	<0.000050	0.00011	<0.000050
Manganese	g/m³	0.0005	<0.00050	<0.00050	0.014	1.56	0.0017
Nickel	g/m³	0.0002	<0.00020	<0.00020	<0.00020	0.0033	<0.00020
Calcium	g/m³	0.05	22.5	24.2	26.8	45.9	23.1
Magnesium	g/m³	0.01	5.07	5.74	6.12	11.8	5.48

Elements in Water (Soluble)

Client Sample ID			M36/20450	M36/20451
Date Sampled			13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
Aluminium	g/m³	0.003	<0.0030	<0.0030
Arsenic	g/m³	0.0005	<0.00050	<0.00050
Boron	g/m³	0.01	0.016	0.022
Cadmium	g/m³	0.00002	<0.000020	<0.000020
Chromium	g/m³	0.0002	<0.00020	<0.00020
Copper	g/m³	0.0002	<0.00020	0.00027
Iron	g/m³	0.005	<0.0050	<0.0050
Lead	g/m³	0.00005	<0.000050	<0.000050
Manganese	g/m³	0.0005	0.013	<0.00050
Nickel	g/m³	0.0002	<0.00020	<0.00020
Calcium	g/m³	0.05	16.1	24.2
Magnesium	g/m³	0.01	4.45	5.25

Water Hardness

Client Sample ID			Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Date Sampled			13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
Soluble Hardness	g eqv. $CaCO_3/m^3$	0.05	77	84	92	160	80

Water Hardness

Client Sample ID			M36/20450	M36/20451
Date Sampled			13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
Soluble Hardness	g eqv. $CaCO_3/m^3$	0.05	59	82

Total Petroleum Hydrocarbons - Water

Client Sample ID			Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
Date Sampled			13/03/2024	13/03/2024	13/03/2024	13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-1	24-08467-2	24-08467-3	24-08467-4	24-08467-5
C7-C9	g/m³	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
C10-C14	g/m³	0.2	<0.2	<0.2	<0.2	0.4	<0.2
Sum C15-C36	g/m³	0.3	<0.3	<0.3	<0.3	<0.3	<0.3
C7-C36 (Total)	g/m³	0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Total Petroleum Hydrocarbons - Water

Client Sample ID			M36/20450	M36/20451
Date Sampled			13/03/2024	13/03/2024
Analyte	Unit	Reporting Limit	24-08467-6	24-08467-7
C7-C9	g/m³	0.2	<0.2	<0.2
C10-C14	g/m³	0.2	<0.2	<0.2
Sum C15-C36	g/m³	0.3	<0.3	<0.3