



Susie Osbaldiston
Northland Regional Council
Private Bag 9021
Whangarei

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Dear Susie

NRC Coastal Aquifers Study – Ngunguru

Introduction

Sinclair Knight Merz (SKM) was commissioned by Northland Regional Council (NRC) to undertake hydrogeological reviews of ten coastal aquifers in the Northland region, with particular emphasis on determining likely groundwater recharge rates and reviewing aquifer management boundaries. The work was commissioned to partially fulfil NRC's knowledge requirements following the release of a discussion document by the Ministry for the Environment's (MfE) in March 2008 on Proposed National Environmental Standard (NES) on Ecological Flows and Water Levels.

The Proposed NES sets interim default allocation limits for shallow coastal aquifers of whichever is the greater of,

- *15% of the average annual recharge as calculated by the regional council; or*
- *The total allocation from the groundwater resource on the date that the standard comes into force less any resource consents surrendered, lapsed, cancelled or not replaced.*

This report presents the results of the hydrogeological review undertaken for the **Ngunguru sand and greywacke aquifers**.

Methodology

The review of the aquifer management areas and determination of the recharge rate was achieved through compilation and review of various data sources, primarily provided by NRC. These datasets are summarised as follows:

- Geological borelogs;
- Geological maps;



- Legal property boundaries (cadastral);
- Topographical contours;
- Rivers;
- Meteorological data; and
- Existing NRC aquifer management boundaries.

In addition to these site specific datasets, a compilation of recharge estimates from previous coastal aquifer studies in the Northland region has been undertaken to categorise the range in likely recharge rates by aquifer type. This data is presented in **Appendix A** and has been used to assist recharge calculations within the current study, particularly in those areas where there is insufficient local data (e.g. stream flow records) to permit more detailed analysis such as the development of a Soil Moisture Water Balance Model (SMWBM), or other method with similar outcomes.

For the purpose of this study, aquifer management boundaries have been refined where appropriate to coincide with cadastral boundaries. This was implemented to avoid potential conflict with and between landowners resulting from future management decisions based on these extents.

Aquifer Description

Ngunguru is located adjacent to Whangaumu, near the mouth of the Ngunguru River approximately 20 km north east of Whangarei (**Figure 1**). The geology for the area is described on the 1:250,000 Geological Map Sheet 2A for Whangarei (Thompson, 1961). The local geology predominantly comprises Waipapa Group greywacke and argillite basement rocks, overlain by undifferentiated Quaternary sand along the low lying coastal fringe.

NRC records indicate initial drilling at Ngunguru in 1962 with records for approximately 55 bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2**. A number of these bores do not have geological information available and are shown in the figures but without NRC bore references. There are also a number of bores situated at the same locations and therefore not all labels are displayed on the figures. Summary geological, bore construction and aquifer testing information from available borelogs is provided in **Appendix B**.

- **Figure 1. Ngunguru Sand Aquifer Management Map**
(See A4 attachment at rear)
- **Figure 2. Ngunguru Greywacke Aquifer Management Map**
(See A4 attachment at rear)

In general, the borelogs correlate with the regional geology map with the majority of bores having a layer of predominately sand overlying greywacke. The sand aquifer is up to 10



metres thick near the coast and contains interbedded gravel, shell, silt and clay layers. Further inland these deposits become progressively thinner and with increasing clay content.

The bores in the Ngunguru area are all shallow ranging in depth from 2.8 to 36.8 metres below ground level (mBGL). The majority of bores abstract from the greywacke with the upper weathered greywacke surface generally encountered between 5 and 10 mBGL.

Static groundwater levels for the sand aquifer range between 0.5 mBGL (bores 205849c & 205849d) and 3.6 mBGL (bore 205876). Groundwater levels in the greywacke are similar but have a greater range recorded between 0.4 mBGL (bore 205537) and 5.0 mBGL (bores 205441 and 205394). An additional bore (205420), has a groundwater level much lower than all other bores of 15.3 mBGL.

The available test pumping information indicates that the bores in the Ngunguru area have the following hydraulic characteristics:

- There are no test pumping results within the sand aquifer;
- Test pumping data provided for 41 bores abstracting from the greywacke, indicate very low to modest yields ranging between 8.2 m³/day (0.09 L/s) and 129.6 m³/day (1.5 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally also low to moderate, measuring between 0.8 m³/day/m and 72.0 m³/day/m for the greywacke (22 tests). One bore (205397), is significantly more productive than the others with a specific capacity of 152.0 m³/day/m.

Aquifer Extent

The previous management area for the Ngunguru sand aquifer (obtained from NRC) was based on the overlying undifferentiated sand which covered an area of 0.47 km². Following review of borelogs and the regional geological map, the extent of the management area has been increased as shown in **Figure 1**. The increase coincides with the sand extent as defined by the regional geological map in the east, and is defined by recent drilling in the west (which extends beyond the sand defined by the regional geological map). The revised management area coincides with all cadastral boundaries and covers an area of 1.42 km².

The physical aquifer extent based solely on mapped geology is approximately 5 % larger than the management boundary at 1.49 km² (**Figure 1**, red dashed line). The physical aquifer extent has been used in the recharge estimations for the sand aquifer.

The available borelog information indicates that the majority (70 %) of bores abstract water from the greywacke. The management area for the greywacke is shown in **Figure 2** and is



approximately 2.61 km². The management area has been defined by the geology and anticipated groundwater recharge area, and adjusted to coincide with the cadastral boundaries.

The management area for the greywacke aquifer is approximately 0.66 km² larger than the groundwater recharge area (**Figure 2**), although the latter area (3.27 km²) is used for the recharge estimations.

Recharge Estimate

Groundwater recharge is a function of the rainfall and evapotranspiration regimes, as well as geomorphological characteristics of a catchment (e.g. slope, soil and land cover characteristics, etc.).

Local rainfall data was obtained from a rainfall station (station 1221, Matapouri) located approximately 7.5 km north of the catchment area. The data is for the period between 1967 and 2008, and indicates the following annual rainfall statistics:

- Minimum: 787 mm (1991)
- Maximum: 2,131 mm (1985)
- **Average: 1,360 mm**

Streamflow records were available in the Ngunguru area, however they were not located in the study catchments. Due to this, the flow gauge catchment is not representative of, or comparable to, the coastal Ngunguru aquifers. The location of the rainfall station, situated 7.5 km away, also made calibration of the Soil Moisture Water Balance Model (SMWBM) for groundwater recharge unable to provide accurate results in this instance. Subsequently (in the absence of the SMWBM), groundwater recharge has been estimated for Ngunguru sand and greywacke aquifers using previous studies in similar aquifers in the Northland region.

Sand Recharge Estimate

Groundwater recharge estimates for the Ngunguru sand were based on various calibration studies undertaken in the Northland region. These previous studies are summarised in **Appendix A** and provide a range of groundwater recharge rates.

A study undertaken at Mangawhai (SKM, 2005b) provided a range of groundwater recharge rates of 10 – 16 % for a similar sand aquifer. Based on the nature of the sediments described from the bores drilled within the Ngunguru sand aquifer, a range of **10 - 20 % of annual average rainfall** has been used to estimate the most likely range of rainfall recharge. This accounts for a small proportion of gravel and shell material reported in some borelogs and occasional presence of lower permeability material (silt, clay) in others. The physical aquifer extent provides a conservative approach as the calculation assumes the majority of recharge will be from direct rainfall recharge. Additional recharge to the aquifer but not specifically



incorporated in this assessment includes seepage from greywacke, foothill runoff, and stream bed leakage.

Likely annual groundwater recharge to the Ngunguru sand aquifer based on rainfall records and the physical aquifer extent, as a percentage of annual rainfall is given in **Table 1**.

■ **Table 1. Ngunguru sand groundwater recharge volume**

Average Annual Rainfall (mm/yr)	Aquifer Extent (km ²)	Total Recharge Volume (m ³ /yr)	% GW Recharge	GW Recharge Volume (m ³ /yr)
1,360	1.49	2,026,400	10% (min.)	202,640
1,360	1.49	2,026,400	20% (max.)	405,280

The groundwater recharge assessment for the Ngunguru sand aquifer indicates that annual recharge is likely to be between 202,640 and 405,280 m³/year for the 10% and 20% recharge proportions, respectively. Accordingly, the interim default allocation limit under the NES (15% of groundwater recharge) would be between **30,396** and **60,792 m³/year**.

Greywacke Recharge Estimate

The greywacke recharge estimate utilises recharge rates previously determined for the Russell greywacke aquifer located approximately 35 km north west of Ngunguru. This study (SKM, 2001) utilised the SMWBM, which was adjusted during calibration of a numerical groundwater model to provide the most likely estimate of groundwater recharge in accordance with measured aquifer hydraulic properties assigned in the groundwater model. The resulting groundwater recharge estimate was between **1-5 % of annual average rainfall** which is also applied to this study.

Likely annual groundwater recharge to the Ngunguru greywacke aquifer based on the local rainfall record and the groundwater recharge area, as a percentage of annual rainfall is given in **Table 2**.

■ **Table 2. Ngunguru greywacke groundwater recharge volume**

Average Annual Rainfall (mm/yr)	Recharge Area (km ²)	Total Recharge Volume (m ³ /yr)	% GW Recharge	GW Recharge Volume (m ³ /yr)
1,360	3.27	4,447,200	1% (min.)	44,472
1,360	3.27	4,447,200	5% (max.)	222,360

The groundwater recharge assessment for the Ngunguru greywacke aquifer indicates that annual recharge is likely to be between 44,472 and 222,360 m³/year for the 1% and 5% recharge proportions, respectively. Accordingly, the interim default allocation limit under the Proposed NES (15% of groundwater recharge) would be between **6,670** and **33,354 m³/year**.



Yours sincerely

A handwritten signature in blue ink that reads 'V. Coombe'.

Vanessa Coombe

Graduate Hydrogeologist

Phone: +64 9 985 3627
Fax: +64 9 985 3686
E-mail: vcoombe@skm.co.nz

A handwritten signature in blue ink that reads 'Ken Mackenzie'.

Ken Mackenzie

NZ Manager - Natural Resource Management Team

Phone: +64 9 985 3828
Fax: +64 9 913 8901
E-mail: kmackenzie@skm.co.nz

Appendix A. Summary of recharge rates by aquifer type

Aquifer	Type	Recharge estimate	Recharge Method	Reliability	Source
Glenbervie	Weathered Taheke Basalt	5 - 15%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005a)
Coopers Beach	Tangihua Basalts	5 - 15%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005c)
Tara	Parahaki Volcanics?	7 - 10%	Estimate		NRC Report
Kaikohē	Horeke or Taheke Basalt	13.2%	SMWBM	HIGH Calibrated to stream flow.	SKM (2007a)
Monument Hill	Horeke or Taheke Basalt	16.5%	SMWBM	HIGH Calibrated to stream flow.	SKM (2007a)
Maungakaramea	Taheke Basalt	22 - 44%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006a)
Three Mile Bush	Taheke Basalt	28 - 49%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006b)
Maungakaramea	Scoria Cone	55 - 65%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2006a)
Ruawai	Alluvium	30%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2003)

Aquifer	Type	Recharge estimate	Recharge Method	Reliability	Source
Awanui	Alluvium	4.2%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2007b)
Awanui	Dune Sands	43.7%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2007b)
Mangawhai	Sand	10.2 - 16%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005b)
Russell	Gravel	26 - 52%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2001)
Mangawhai	Sandstone	1 - 10%	Estimate	LOW Calculated using annual average rainfall and recharge coefficient estimates from previous experience pro-rated by area.	SKM (2005b)
Russell	Greywacke	1 - 5%	SMWBM	MODERATE Calculated indirectly during calibration of a groundwater model.	SKM (2001)

Appendix B. Summary of geological borelogs

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205393	Q6 454-173	0.0 – 10.5 10.5 – 20.9	Alluvials Brown greywacke	20.9 m	PVC casing (0 – 12.0 m) Open hole (12.0 – 20.9 m)	Greywacke	SWL = 2.0 mBGL Q = 63.6 m ³ /day Sc = 7.9 m ³ /day/m
205394	Q6 466-177	0.0 – 8.0 8.0 – 20.0	Clay and weathered greywacke Brown to blue greywacke	20.0 m	PVC casing (0 – 9.0 m) Open hole (9.0 -20.0 m)	Greywacke	SWL = 5.0 mBGL Q = 20.0 m ³ /day
205395	Q6 458-172	0.0 – 2.8 2.8 – 10.0 10.0 – 24.0	Yellow and brown clay Blue sandy fractured rock Brown to blue greywacke	24.0 m	Galvanised steel (0.0 – 8.5 m) Steel screen (8.5 – 11.5 m) Open hole (11.5 – 24.0 m)	Greywacke	SWL = 4.2 mBGL Q = 13.6 m ³ /day
205396	Q6 458-173	0.0 – 13.4 13.4 – 19.1 19.1 – 24.3	Vegetation and clay Rock and sandstone Greywacke	24.3 m	PVC casing (0 – 13.7 m) Open hole (13.7 – 24.3 m)	Greywacke	SWL = 2.5 mBGL Q = 27.2 m ³ /day
205397	Q6 459-170	0.0 – 3.0 3.0 – 5.0 5.0 – 24.0	Soil and sand Weathered greywacke Greywacke	24.0 m	Galvanised steel (0 – 5.0 m) Open hole (5.0 – 24.0 m)	Greywacke	SWL = 1.4 mBGL Q = 76 m ³ /day
205398	Q6 459-170	0.0 – 10.6 10.6 – 21.6	Clay Brown greywacke	21.6 m		Greywacke	Q = 38.3 m ³ /day
205400	Q6 459-176	0.0 – 9.5	Sand	9.5 m	Galvanised steel (0 – 4.0 m) PVC screen (4.0 – 9.5 m)	Sand	Q = 31.7 m ³ /day Sc = 4.5 m ³ /day/m
205403	Q6 464-171	0.0 – 4.5 4.5 – 5.4 5.4 – 13.7	Yellow brown clay Gravel and shell Grey-brown greywacke	13.7 m			SWL = 4.5 mBGL Q = 13.1 m ³ /day
205405	Q6 465-175	0.0 – 1.2 1.2 – 2.4 2.4 – 4.3 4.3 – 11.3	Clay Sand Yellow clay Greywacke	11.3 m	PVC casing (0 – 5.5 m) Open hole (5.5 – 11.3 m)	Greywacke	Q = 54.5 m ³ /day
205408	Q6 466-174	0.0 – 10.6 10.6 – 20.4 20.4 – 22.4	Sand and gravel Weathered greywacke Hard blue greywacke	22.4 m	Casing (0 – 12.8 m) Open hole (12.8 – 22.4 m)	Greywacke	SWL = 3.0 mBGL Q = 26.2 m ³ /day

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205409	Q6 466-174	0.0 – 10.6 10.6 – 20.4 20.4 – 22.5	Sand and gravel Weathered greywacke Blue greywacke	22.5 m	Casing (0 – 13.1 m) Open hole (13.1 – 22.5 m)	Greywacke	SWL = 3.0 mBGL Q = 26.2 m ³ /day
205410	Q6 467-175	0.0 – 10.3 10.3 – 22.2 22.2 – 23.8	Sand and yellow clay Weathered greywacke Blue greywacke	23.8 m		Greywacke	Additional comments included saltwater pumping at 1.2 L/s.
205411	Q6 467-176	0.0 – 3.6 3.6 – 10.3 10.3 – 10.6	Sand Weathered greywacke Hard blue greywacke	10.6 m	Casing (0 – 5.2 m) Open hole (5.2 – 10.6 m)	Greywacke	SWL = 1.8 mBGL Q = 49.2 m ³ /day
205412	Q6 467-176	0.0 – 3.6 3.6 – 10.3 10.3 – 10.6	Sand Weathered greywacke Hard blue greywacke	10.6 m	Casing (0 – 5.2 m) Open hole (5.2 – 10.6 m)	Greywacke	SWL = 1.8 mBGL Q = 49.2 m ³ /day Sc = 8.2 m ³ /day/m
205413	Q6 467-177	0.0 – 2.4 2.4 – 5.4	Yellow clay Weathered greywacke	5.4 m	Casing (0 – 3.3 m) Open hole (3.3 – 5.4 m)	Greywacke	SWL = 2.2 mBGL Q = 120.4 m ³ /day
205414	Q6 467-179	0.0 – 1.2 1.2 – 10.0	Clay Brown to blue greywacke	10.0 m	PVC casing (0 – 6.0 m) Open hole (6.0 – 10.0 m)	Greywacke	Q = 129.6 m ³ /day Sc = 64.8 m ³ /day/m
205415	Q6 468-179	0.0 – 14.0 14.0 – 21.3	Alluvials and clay Brown greywacke	21.3 m	PVC casing (0 – 16.0 m) Open hole (16.0 – 21.3 m)	Greywacke	SWL = 2.8 mBGL Q = 8.5 m ³ /day Sc = 3.0 m ³ /day/m
205418	Q6 469-178	0.0 – 0.9 0.9 – 15.2	Brown weathered greywacke Blue greywacke	15.2 m	Galvanised steel (0 – 6.4 m) Open hole (6.4 – 15.2 m)	Greywacke	Q = 39.5 m ³ /day
205419	Q6 469-177	0.0 – 3.0 3.0 – 10.4 10.4 – 11.6	Peat and clay Weathered greywacke Brown to blue greywacke	11.6 m	Galvanised steel (0 – 6.0 m) Open hole (6.0 – 11.6 m)	Greywacke	Q = 49.2 m ³ /day
205420	Q6 469-178	0.0 – 13.7 13.7 – 35.9 35.9 – 36.8	Clay Weathered greywacke Blue greywacke	36.8 m		Greywacke	SWL = 15.3 mBGL Additional comments included methane gas from 32 – 36.8 m?

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205428	Q6 471-180	0.0 – 1.8 1.8 – 7.9	Yellow clay Brown weathered greywacke	7.9 m	Casing (0 – 3.9 m) Open hole (3.9 – 7.9 m)	Weathered greywacke	SWL = 1.3 mBGL Q = 112.5 m ³ /day
205441	Q6 474-182	0.0 – 14.0 14.0 – 18.0 18.0 – 23.0 23.0 – 24.0	Clay Soft brown weathered greywacke Hard brown greywacke Brown to blue greywacke	24.0 m	PVC casing (0 – 18.0 m) Open hole (18.0 – 24.0 m)	Greywacke	SWL = 5.0 mBGL Q = 16.2 m ³ /day Sc = 2.0 m ³ /day
205442	Q6 474-182	0.0 – 4.2 4.2 – 9.1	Sand Sandy gravel	9.1 m		<i>Sand / Gravel</i>	Q = 19.7 m ³ /day
205443	Q6 474-182	0.0 – 14.3 14.3 – 14.9 14.9 – 15.2	Clay Hard brown greywacke Blue greywacke	15.2 m		<i>Greywacke</i>	Q = 10.4 m ³ /day
205447	Q6 476-182	0.0 – 4.8 4.8 – 7.9 7.9 – 8.3	Clay Weathered greywacke Blue greywacke	8.3 m	Casing (0 – 5.5 m) Open hole (5.5 – 8.3 m)	Greywacke	SWL = 3.0 mBGL Q = 65.7 m ³ /day
205448	Q6 479-181	0.0 – 2.0 2.0 – 4.0 4.0 – 8.0 8.0 – 18.0	Yellow clay Sand Yellow clay Brown to blue greywacke	18.0 m	PVC casing (0 – 9.0 m) Open hole (9.0 – 18.0 m)	Greywacke	SWL = 3.2 mBGL Q = 25.4 m ³ /day Sc = 3.6 m ³ /day/m
205509	Q6 472-182	0.0 – 8.2 8.2 – 20.0 20.0 – 22.7	Yellow clay and grey shale Brown weathered greywacke Blue greywacke	22.7 m	PVC casing (0 – 8.6 m) Open hole (8.6 – 22.7 m)	Greywacke	Q = 28.8 m ³ /day Sc = 3.6 m ³ /day/m
205521	Q6 476-178	0.0 – 3.0 3.0 – 9.0	Clay and sand Brown greywacke	9.0 m	PVC casing (0 – 4.0 m) Open hole (4.0 – 9.0 m)	Greywacke	SWL = 2.0 mBGL Q = 54.7 m ³ /day Sc = 54.7 m ³ /day/m
205537	Q6 471-181	0.0 – 10.0 10.0 – 15.0 15.0 – 23.5 23.5 – 29.5	Soil, silt and sand Red and yellow clay Brown weathered greywacke Brown to blue greywacke	29.5 m	PVC casing (0 – 15.5 m) Open hole (15.5 – 29.5 m)	Greywacke	SWL = 0.4 mBGL Q = 28.8 m ³ /day
205541	Q6 468-179	0.0 – 20.0 20.0 – 29.0	Sand and silt Brown to blue greywacke	29.0 m	PVC casing (0 – 21.0 m) Open hole (21.0 – 29.0 m)	Greywacke	SWL = 2.5 mBGL Q = 64.8 m ³ /day Sc = 9.3 m ³ /day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205542	Q6 459-171	0.0 – 2.0 2.0 – 15.0	Sand Brown to blue greywacke	15.0 m	PVC casing (0 – 6.0 m) Open hole (6.0 – 15.0 m)	Greywacke	SWL = 1.2 mBGL Q = 37.4 m ³ /day Sc = 7.5 m ³ /day/m
205543	Q6 465-175	0.0 – 6.0 6.0 – 10.0 10.0 – 17.0	Sand, shell and gravel Silty sand and gravel Brown greywacke	17.0 m	Casing (0 – 11.5 m) Open hole (11.5 – 17.0 m)	Greywacke	SWL = 1.8 mBGL Q = 52.8 m ³ /day
205676	Q6 460-170	0.0 – 10.5 10.5 – 19.0	Clayey sand and clay Brown to blue greywacke	19.0 m	Casing (0 – 14.0 m) Open hole (14.0 – 19.0 m)	Greywacke	SWL = 1.6 mBGL Q = 9.6 m ³ /day Sc = 0.8 m ³ /day/m
205682	Q6 464-176	0.0 – 2.5 2.5 – 4.5 4.5 – 13.8	Yellow clay Soft brown greywacke Brown to blue greywacke	13.8 m	Casing (0 – 6.0 m) Open hole (6.0 – 13.8 m)	Greywacke	SWL = 1.1 mBGL Q = 48.0 m ³ /day Sc = 16.0 m ³ /day/m
205697	Q6 465-175	0.0 – 7.5 7.5 – 9.0 9.0 – 12.0	Sand, silt and some organics Clay Brown to blue greywacke	12.0 m	Casing (0 – 10.0 m) Open hole (10.0 – 12.0 m)	Greywacke	SWL = 1.5 mBGL Q = 72.0 m ³ /day Sc = 12.0 m ³ /day/m
205743	Q6 466-175	0.0 – 5.0 5.0 – 15.0 15.0 – 25.0	Sand Red clay to weathered greywacke Hard brown to blue greywacke	15.0 m	Casing (0 – 15.0 m) Open hole (15.0 – 25.0 m)	Greywacke	SWL = 2.5 mBGL Q = 28.8 m ³ /day Sc = 2.2 m ³ /day/m
205818	Q6 459-171	0.0 – 4.0 4.0 – 11.6	Sand and gravel Brown to blue greywacke	11.6 m	Casing (0 – 6.0 m) Open hole (6.0 – 11.6 m)	Greywacke	SWL = 1.9 mBGL Q = 28.8 m ³ /day Sc = 3.2 m ³ /day/m
205824	Q6 465-177	0.0 – 5.0 5.0 – 8.9	Clay Brown greywacke	8.9 m	Casing (0 – 7.0 m) Open hole (7.0 – 8.9 m)	Greywacke	SWL = 2.6 mBGL Q = 84.0 m ³ /day Sc = 24.0 m ³ /day/m
205825	Q6 466-175	0.0 – 5.0 5.0 – 17.0	Sand and clay Brown greywacke	17.0 m	Casing (0 – 6.0 m) Open hole (6.0 – 17.0 m)	Greywacke	SWL = 2.2 mBGL Q = 21.6 m ³ /day
205831	Q6 459-173	0.0 – 5.0 5.0 – 17.0	Sand, clay and silt Hard brown greywacke	17.0 m	Casing (0 – 9.0 m) Open hole (9.0 – 17.0 m)	Greywacke	SWL = 3.0 mBGL Q = 60 m ³ /day Sc = 12.0 m ³ /day/m
205849a	Q6 471-181	0.0 – 1.3 1.3 – 4.3	Sand Clayey silt and gravel	5.8 m	Casing (0 – 1.0 m) Screen (1.0 – 5.8 m)	Sand	SWL = 0.75 mBGL

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
		4.3 – 5.8	Sand				
205849b	Q6 471-181	0.0 – 3.0 3.0 – 4.6 4.6 – 5.5	Sand and silt Silt and gravel Sand	5.5 m	Casing (0 – 0.8 m) Screen (0.8 – 5.5 m)	Sand	SWL = 0.8 mBGL
205849c	Q6 471-181	0.0 – 1.3 1.3 – 1.7 1.7 – 4.3	Sand and shell Clayey silt Sand	4.3 m	Casing (0 – 0.4 m) Screen (0.4 – 4.3 m)	Sand	SWL = 0.5 mBGL
205849d	Q6 471-181	0.0 – 2.8	Sand	2.8 m	Casing (0 – 0.4 m) Screen (0.4 – 2.8 m)	Sand	SWL = 0.5 mBGL
205876	Q6 461-174	0.0 – 11.0 11.0 – 14.0 14.0 – 18.0	Clay Sand Brown greywacke	18.0 m	Casing (0 – 6.0 m) Screen (6.0 – 17.5 m)	Sand / Greywacke	SWL = 3.6 mBGL
209156	Q6 453-172	0.0 – 3.0 3.0 – 12.0	Clay Brown greywacke	12.0 m	Casing (0 – 6.0 m) Screen (6.0 – 12.0 m)	Greywacke	SWL = 2.1 mBGL Q = 72.0 m ³ /day Sc = 72.0 m ³ /day/m
209591	Q6 459-173	0.0 – 16.0 16.0 – 25.0	Sand and silt Brown to blue greywacke	25.0 m	Casing (0 – 17.0 m) Open hole (17.0 – 25.0 m)	Greywacke	SWL = 3.0 mBGL Q = 36.0 m ³ /day Sc = 4.5 m ³ /day/m
209594	Q6 458-175	0.0 – 5.0 5.0 – 12.0	Sand and gravel Brown greywacke	12.0 m	Casing (0 – 6.1 m) Open hole (6.1 – 12.0 m)	Greywacke	SWL = 1.1 mBGL Q = 8.2 m ³ /day Sc = 1.0 m ³ /day/m

Notes: **Locations are approximate only. *Italics* refer to incomplete information given on borelogs. **SWL** is static water level measured in metres below ground level. **Q** is discharge rate measured during test pumping. **Sc** is specific capacity. Borelogs that did not contain geological information have not been included in this table, or labelled with NRC references in Figure 1 and Figure 2.



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