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Dear Susie

NRC Coastal Aquifers Study – Whangaumu

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 **Whangaumu 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

Whangaumu is located 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 Whangaumu in 1970 with records for approximately 40 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. Summary geological and bore construction information from available borelogs is provided in **Appendix B**.

- **Figure 1. Whangaumu Sand Aquifer Management Map**
(See A4 attachment at rear)
- **Figure 2. Whangaumu 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 sand overlying greywacke. The upper sand aquifer is up to 25 metres thick and contains interbedded gravel, shell and silt layers. Further inland these deposits become progressively thinner with increasing alluvial clay content. The sand aquifer pinches out approximately 150 metres inland where greywacke outcrops.



The bores in the Whangauamu area are all shallow ranging in depth from 6.2 to 38.7 metres below ground level (mBGL). The majority of bores abstract from the greywacke with the upper weathered greywacke surface generally encountered between 10 and 15 mBGL.

Static groundwater levels for the sand aquifer range between 2.7 mBGL (bore 205478) and 4.8 mBGL (bore 205480). Groundwater levels in the greywacke are generally deeper, ranging between 1.0 mBGL (bore 209458) and 10.0 mBGL (bore 205561). Bore 205001 (screened within the greywacke) has a static groundwater level recorded at 24.3 mBGL. This is not likely to be the true groundwater level for this bore given the measurements recorded in neighbouring bores.

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

- Three bores have test pumping results within the sand aquifer with low yields ranging between 16.4 m³/day (0.19 L/s) and 43.2 m³/day (0.50 L/s);
- Test pumping data provided for 27 bores abstracting the greywacke, indicate very low to low yields ranging between 6.9 m³/day (0.08 L/s) and 73.9 m³/day (0.86 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally also low measuring 8m³/day/m for the sand aquifer (1 test) and ranging between 0.8 m³/day/m and 10.6 m³/day/m for the greywacke (9 tests).

Aquifer Extent

The management area for the Whangauamu undifferentiated sand covers an area of 0.13 km². This extent remains unchanged from the boundary provided by NRC following review of borelogs, the regional geology map and cadastral boundaries. The management area is shown in **Figure 1**.

The physical aquifer extent based solely on geology is approximately 23 % larger at 0.16 km². This is also shown in **Figure 1** (red dashed line) and has been used in the recharge estimations for the sand aquifer.

The available borelog information indicates that the majority of bores abstract water from the greywacke. The management area for the greywacke is shown in **Figure 2** and is approximately 1.02 km². The management boundary has been defined by the geology and groundwater recharge area, and adjusted to coincide with the cadastral boundaries. As a consequence the management area is approximately 0.09 km² smaller than the groundwater recharge area (**Figure 2**, red dashed line), although the latter area (1.11 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 7.9 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**

In the absence of streamflow data to calibrate a Soil Moisture Water Balance Model (SMWBM) groundwater recharge has been estimated for Whangaumu sand and greywacke aquifers using previous studies in similar aquifers in the Northland region.

Sand Recharge Estimate

Groundwater recharge estimates for the Whangaumu 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 groundwater recharge rate of 16% for a similar sand aquifer. This recharge rate was based on calculations of estimates from previous experience pro-rated by area. An earlier study in the Russell gravel aquifer (SKM, 2001), located approximately 35 km to the north west provided a groundwater recharge estimate of 26 -52% for the sand and gravel aquifer. This study of the Russell aquifer 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.

Based on the nature of the sediments described from the bores drilled within the Whangaumu sand aquifer, a range of **20 - 30 % 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 the borelogs, but is at the lower end of the Russell aquifer recharge rates due to the predominance of sand and occasional presence of silt. 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 Whangaumu sand aquifer based on the local rainfall record and the physical aquifer extent, as a percentage of annual rainfall is given in **Table 1**.

■ **Table 1. Whangaumu 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	0.16	217,600	20% (min.)	43,520
1,360	0.16	217,600	30% (max.)	65,280

The groundwater recharge assessment for the Whangaumu sand aquifer indicates that annual recharge is likely to be between 43,520 and 65,280 m³/year for the 20% and 30% recharge proportions, respectively. Accordingly, the interim default allocation limit under the NES (15% of groundwater recharge) would be between **6,528** and **9,792 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 Whangaumu. 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 Whangaumu 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. Whangaumu 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	1.11	1,509,600	1% (min.)	15,096
1,360	1.11	1,509,600	5% (max.)	75,480

The groundwater recharge assessment for the Whangaumu greywacke aquifer indicates that annual recharge is likely to be between 15,096 and 75,480 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 **2,264** and **11,322 m³/year**.



Yours sincerely

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

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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)
Maungakaramēa	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)
Maungakaramēa	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				
205001	Q6 493-173	0.0 – 10.6 10.6 – 22.7 22.7 – 38.7	Soil and clay Boulders and broken blue greywacke Blue greywacke	38.7 m	PVC casing (0 – 18.2 m) Open hole (18.2 – 38.7 m)	Greywacke	SWL = 24.3 mBGL Q = 16.4 m ³ /day Sc = 5.5 m ³ /day/m
205151	Q6 492-174	0.0 – 9.2 9.2 – 13.5	Sand Brown to blue greywacke	13.5 m	Casing (0 – 9.3 m) Open hole (9.3 – 13.5 m)	Greywacke	SWL = 5.0 mBGL Q = 12 m ³ /day Sc = 4.8 m ³ /day/m
205460	Q6 487-172	0.0 – 4.5 4.5 – 17.3	Clay and weathered greywacke Grey to blue greywacke	17.3 m	PVC casing (0 – 6.0 m) Open hole (6.0 – 17.3 m)	Greywacke	Q = 38.2 m ³ /day
205463	Q6 488-174	0.0 – 10.7 10.7 – 20.4 20.4 – 22.8	Sand, gravel and shell Clay and greywacke Blue greywacke	22.8 m	Galvanised steel (0 – 13.0 m) Open hole (13.0 – 22.8 m)	Greywacke	Q = 27.4 m ³ /day
205464	Q6 488-174	0.0 – 4.8 4.8 – 5.7 5.7 – 8.0	Sand Small gravel Alluvial silts	8.0 m	Galvanised steel (0 – 4.5 m) Stainless steel screen (4.5 – 7.5m)	Sand / gravel / silt	
205466	Q6 489-172	0.0 – 14.6 14.6 – 26.8	Sand, mud and clays Firm to hard brown greywacke	26.8 m	Galvanised steel (0 – 16.4 m) Open hole (16.4 – 26.8 m)	Greywacke	SWL = 8.5 mBGL Q = 54.7 m ³ /day
205467	Q6 489-172	0.0 – 15.0 15.0 – 22.0	Sand, silt, gravel and some wood Greywacke	22.0 m	PVC casing (0 – 15.0 m) Open hole (15.0 – 22.0 m)	Greywacke	Q = 48.9 m ³ /day
205468	Q6 489-173	0.0 – 12.0 12.0 – 22.0	Sand, shell and gravel Weathered greywacke and greywacke	22.0 m	Galvanised steel (0 – 14.5 m) Open hole (14.5 – 22.0 m)	Greywacke	SWL = 6.4 mBGL Q = 16.4 m ³ /day
205469	Q6 489-173	0.0 – 7.6 7.6 – 17.3	Red clay Greywacke	17.3 m	Galvanised steel (0 – 8.8 m) Open hole (8.8 – 17.3 m)	Greywacke	Q = 27.4 m ³ /day
205471	Q6 489-174	0.0 – 9.0 9.0 – 20.0	Sand and gravel Weathered greywacke and greywacke	20.0 m	Galvanised steel (0 – 15.0 m) Open hole (15.0 – 20.0 m)	Greywacke	Q = 21.6 m ³ /day
205472	Q6 489-174	0.0 – 6.5 6.5 – 14.8 14.8 – 24.5	Sand White, yellow and pink clay Brown to blue greywacke	24.5 m	Galvanised steel (0 – 13.0 m) Open hole (13.0 – 24.5 m)	Clay / Greywacke	SWL = 2.1 mBGL Q = 18.2 m ³ /day

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205473	Q6 489-174	0.0 – 16.7 16.7 – 27.4	Sand, gravel, silt and shells Weathered greywacke and greywacke	27.4 m	Galvanised steel (0 – 20.0 m) Open hole (20.0 – 27.4 m)	Greywacke	SWL = 3.6 mBGL Q = 27.4 m ³ /day
205478	Q6 490-173	0.0 - ?	Sand	Unknown	Galvanised steel (0 – 6.4 m) Johnson screen (6.4 - ? m)	Sand	SWL = 2.7 mBGL Q = 43.2 m ³ /day
205480	Q6 490-174	0.0 – 9.0 9.0 - ?	Sand Blue greywacke	Unknown	Galvanised steel (0 – 6.5 m) Johnson screen (6.5 – 7.0 m)	Sand	SWL = 4.8 mBGL Q = 16.4 m ³ /day
205486	Q6 491-172	0.0 – 9.0 9.0 – 18.0	Sand, wood and gravel Weathered greywacke and greywacke	18.0 m	PVC casing (0 – 10.0 m) Open hole (10.0 – 18.0 m)	Greywacke	SWL = 1.8 mBGL Q = 12.9 m ³ /day
205491	Q6 492-173	0.0 – 25.0 25.0 – 29.0	Sand Blue greywacke	29.0 m	PVC casing (0 – 25.0 m) Open hole (25.0 – 29.0 m)	Greywacke	SWL = 1.5 mBGL Q = 11.5 m ³ /day Sc = 0.8 m ³ /day/m
205497	Q6 493-172	0.0 – 20.7 20.7 – 25.0	Sand, silt and gravel Brown to blue greywacke	25.0 m	Galvanised steel (0 – 21.5 m) Open hole (21.5 – 25.0 m)	Greywacke	SWL = 3.9 mBGL Q = 6.9 m ³ /day
205498	Q6 493-175	0.0 – 8.2 8.2 – 9.2 9.2 – 12.1	Orange clay Weathered brown greywacke Brown to blue greywacke	12.1 m	PVC casing (0 – 10.9 m) Open hole (10.9 – 12.1 m)	Greywacke	SWL = 2.4 mBGL Q = 32.7 m ³ /day Sc = 5.9 m ³ /day/m
205499	Q6 494-172	0.0 – 7.6 7.6 – 19.2	Sand and gravel Greywacke	19.2 m	Galvanised steel (0 – 9.0 m) Open hole (9.0 – 19.2 m)	Greywacke	SWL = 1.8 mBGL Q = 73.8 m ³ /day
205500	Q6 494-173	0.0 – 6.0 6.0 – 16.5	Yellow clay Brown greywacke	16.5 m	PVC casing (0 – 8.0 m) Open hole (8.0 – 16.5 m)	Greywacke	SWL = 4.0 mBGL Q = 63.6 m ³ /day Sc = 10.6 m ³ /day/m
205502	Q6 495-173	0.0 – 1.5 1.5 – 12.5 12.5 – 18.0	Yellow clay Red soft rock Brown to blue greywacke	18.0 m	Galvanised steel (0 – 9.76 m) Open hole (9.76 – 18.0 m)	Weathered greywacke / Greywacke	SWL = 4.1 mBGL Q = 63.6 m ³ /day
205508	R6 643-165	0.0 – 9.4 9.4 – 24.9	Sand and clay Brown to blue greywacke and gravel	24.9 m	PVC casing (0 – 9.0 m) Open hole (9.0 – 24.9 m)	Weathered greywacke / Greywacke	SWL = 1.8 mBGL Q = 16.3 m ³ /day Sc = 5.4 m ³ /day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205559	Q6 485-175	0.0 – 6.0 6.0 – 12.0 12.0 – 24.0	Sand, shell and gravel Clay and soft rock Brown to blue greywacke	24.0 m	Casing (0 – 12.0 m) Open hole (12.0 – 24.0 m)	Greywacke	SWL = 2.8 mBGL Q = 21.6 m ³ /day
205561	Q6 485-175	0.0 – 12.0 12.0 – 19.8	Sand Brown to blue greywacke	19.8 m	Casing (0 – 13.0 m) Open hole (13.0 – 19.8 m)	Greywacke	SWL = 10.0 mBGL Q = 30 m ³ /day
205563a	Q6 484-166	0.0 – 17.0 17.0 – 18.5 18.5 – 30.5	Sand, silt, gravel and clay Weathered brown greywacke Brown to blue greywacke	30.5 m	Casing (0 – 18.5 m) Open hole (18.5 – 30.5 m)	Greywacke	
205563b	Q6 484-166	0.0 – 9.0 9.0 - ?	Sand and gravel Silt	<i>Unknown</i>	Casing (0 – 5.5 m) Johnson screen (5.5 – 7.0 m)	Sand / Gravel	SWL = 2.8 mBGL Q = 28.8 m ³ /day Sc = 8.0 m ³ /day/m
205864	Q6 494-172	0.0 – 4.0 4.0 – 12.5	Clay, sand and gravel Brown to blue greywacke	12.5 m	Casing (0 – 4.5 m) Open hole (4.5 – 12.5 m)	Greywacke	SWL = 1.6 mBGL Q = 19.2 m ³ /day Sc = 2.6 m ³ /day/m
209458	Q6 494-174	0.0 – 1.5 1.5 – 3.0 3.0 – 6.2	Yellow clay Sand Brown to blue greywacke	6.2 m	PVC casing (0 – 3.5 m) Screen (3.5 – 6.0 m)	Greywacke	SWL = 1.0 mBGL Q = 33.6 m ³ /day Sc = 6.7 m ³ /day/m
209680	R6 644-162	0.0 – 8.0 8.0 – 9.0 9.0 – 15.0	Soil, vegetation and clay Weathered brown greywacke Brown to blue greywacke	15.0 m	PVC casing (0 – 8.5 m) Open hole (8.5 – 15.0 m)	Greywacke	SWL = 2.2 mBGL Q = 24.0 m ³ /day Sc = 6.0 m ³ /day/m

Notes: **Locations are approximate only. **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 reference in Figure 1 and Figure 2.



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