Sinclair Knight Merz
25 Teed Street
PO Box 9806
Newmarket, Auckland New Zealand

Tel: +64 9 913 8900
Fax: +64 9 913 8901
Web: www.skmconsulting.com

Susie Osbaldiston
Northland Regional Council
Private Bag 9021
Whangarei

25 July 2008

AE03531A0008.docx
AE03531

Dear Susie,

NRC Coastal Aquifers Study - Whananaki North

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 **Whananaki North 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

Whananaki North is located on the northern side of the Whananaki Inlet, approximately 30 km north east of Whangarei (**Figure 1**). The geology for the area is described on the 1:250,000 Geological Map Sheet 1 for North Cape (Kear and Hay, 1961). The local geology comprises almost entirely Waipapa Group greywacke and argillite basement rocks, overlain by undifferentiated Quaternary sand and alluvium along the low lying coastal fringe.

NRC records indicate initial drilling at Whananaki North in 1964 with records for 8 bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** One of the bores does not have geological information available; the location of this bore is shown in the figures but without an NRC bore reference. Summary geological, bore construction and aquifer testing information from available borelogs is provided in **Appendix B**.

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

In general, bore geology correlates with the regional geology map, with the majority of bores having a layer of sand overlying greywacke. The sand aquifer is up to 8 metres thick and contains predominately sand with lesser interbedded sand, gravel and silt layers.

The bores in the Whananaki North area are all shallow ranging in depth from 5.0 to 24.0 metres below ground level (mBGL). The majority of bores abstract from the sand aquifer, with 2 bores abstracting from the greywacke. All bores are located within 150 metres of the coast.

Static groundwater levels for the sand aquifer range between 1.4 mBGL (bore 209220) and 3.7 mBGL (bore 202091). Groundwater levels in the greywacke are generally higher, ranging between 0.5 mBGL (bore 202087) and 1.0 mBGL (bore 209159). This is an indication of an upward pressure gradient as is expected near the coastal groundwater discharge environment.

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

- Four bores have test pumping results within the sand aquifer with low yields ranging between 21.6 m^3/day (0.25 L/s) and 57.6 m^3/day (0.67 L/s);
- Test pumping data provided for 2 bores abstracting from the greywacke have slightly lower yields ranging between 14.4 m^3/day (0.17 L/s) and 22.7 m^3/day (0.26 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally low measuring 4.56 m^3/day/m and 14.4 m^3/day/m for the sand aquifer (4 tests) and 2.06 m^3/day/m for the greywacke (1 test), respectively.

Aquifer Extent

The previous management area for Whananaki North sand aquifer (obtained from NRC) was based on the overlying undifferentiated sand which covered an area of 0.58 km^2. Following review of borelogs and the regional geological map, the extent of the sand aquifer management area has been decreased to coincide with the extent of undifferentiated material in the Whananaki North area as the previous boundary extended into the Whananaki Inlet and included areas of outcropping greywacke. Subsequently, the revised management area covers 0.43 km^2 and is shown in **Figure 1**. In this instance, the decrease in management area was unable to coincide with all cadastral boundaries (where these were sparse) and four properties have been bisected to match the geological boundary.

The physical aquifer extent based solely on geology is approximately 12 % larger than the management boundary at 0.48 km^2 (**Figure 1**, red dashed line). The physical aquifer extent has been used in the recharge estimations for the sand aquifer.

The management area for the greywacke aquifer is shown in **Figure 2** and is approximately 1.06 km^2. The management boundary has been defined by the geology and anticipated groundwater recharge area, and adjusted to coincide with the cadastral boundaries where possible. However, sparse cadastral boundaries have resulted in the management area bisecting five properties to match the topographic divide.

The groundwater recharge area (**Figure 2**, red dashed line**)**, has the same area as the management area (1.06 km^2) and this 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 5 km south of Whananaki. 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 Whananaki North sand and greywacke aquifers using recharge calculated in similar aquifer types in the Northland region.

Sand Recharge Estimate

Groundwater recharge estimates for the Whananaki North sand aquifer 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. Based on the nature of the sediments described from the bores drilled within the Whananaki North sand aquifer, a range of **15 - 25 % of annual average rainfall** has been used to estimate the most likely range of rainfall recharge. This accounts for a small proportion of gravel material reported in some borelogs and occasional presence of lower permeability material 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.

The likely range of annual groundwater recharge to the Whananaki North 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. Whananaki North 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	0.48	652,800	15% (min.)	97,920
1,360	0.48	652,800	25% (max.)	163,200

The groundwater recharge assessment for the Whananaki North sand aquifer indicates that annual recharge is likely to be between 97,920 and 163,200 m^3/year for the 15% and 25% recharge proportions, respectively. Accordingly, the interim default allocation limit under the NES (15% of groundwater recharge) would be between **14,688** and **24,480 m^3/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 Whananaki. 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 Whananaki North 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. Whananaki North 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	1.06	1,441,600	1% (min.)	14,416
1,360	1.06	1,441,600	5% (max.)	72,080

The groundwater recharge assessment for the Whananaki North greywacke aquifer indicates that annual recharge is likely to be between 14,416 and 72,080 m^3/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 **2,162** and **10,812 m^3/year**.

Yours sincerely

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

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
Kaikohe	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				
202087	Q6 427-308	0.0 – 21.3 21.3 – 24.0	Greywacke Blue greywacke	24.0 m	PVC casing (0 – 12.0 m) Open hole (12.0 – 24.0 m)	Greywacke	SWL = 0.5 mBGL Q = 22.7 m^3/day
202088	Q6 428-307	0.0 – 5.3	Sand	5.3 m	Galvanised Steel (0 – 4.2 m) Screen (4.2 – 5.3 m)	Sand	SWL = 3.3 mBGL Q = 21.6 m^3/day Sc = 5.84 m^3/day/m
202089	Q6 429-309	0.0 – 7.0	Sand	7.0 m	Galvanised Steel (0 – 6.5 m) Screen (6.5 – 7.0 m)	Sand	SWL = 3.5 mBGL Q = 31.8 m^3/day
202091	Q6 427-308	0.0 – 8.0	Sand	8.0 m	Galvanised Steel (0 – 6.5 m) Johnson screen (6.5 – 7.5 m)	Sand	SWL = 3.7 mBGL Q = 27.4 m^3/day Sc = 4.56 m^3/day/m
209159	Q6 441-328	0.0 – 14.4 14.4 – 18.0 18.0 – 19.5 19.5 – 23.6	Clay and silt Firm clay and soft greenish brown rock Soft brown greywacke Brown greywacke	23.6 m	Casing (0 – 18.0 m) Open hole (18.0 – 23.6 m)	Greywacke	SWL = 1.0 mBGL Q = 14.4 m^3/day Sc = 2.06 m^3/day/m
209220	Q6 430-310	0.0 – 3.0 3.0 – 5.0	Sand Sand and gravel	5.0 m	Casing (0 – 3.0 m) Screen (3.0 – 5.0 m)	Sand / Gravel	SWL = 1.4 mBGL Q = 26.4 m^3/day Sc = 5.8 m^3/day/m
209736	Q6 427-308	0.0 – 3.0 3.0 – 7.0	Sand Alternate cemented and sand layers	7.0 m	PVC casing (0 – 5.0 m) Screen (5.0 – 7.0 m)	Sand	SWL = 2.2 mBGL Q = 57.6 m^3/day Sc = 14.4 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.

References

David Kear and R. F. Hay (1961). Sheet 1 – North Cape. New Zealand Geological Survey.

Northland Regional Council (1987). Tara Groundwater Resources Report.

Sinclair Knight Merz (2001). Russell Hydrogeology Update Report – Final Rev B. Report for Northland Regional Council.

Sinclair Knight Merz (2003). Ruawai Aquifer Management Zone Bore Survey and Preliminary Hydrogeological Study – Final Rev D. Report for Northland Regional Council.

Sinclair Knight Merz (2005a). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Glenbervie Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2005b). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Mangawhai Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2005c). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Coopers Beach, Cable Bay and Mangonui Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2006a). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Maungakaramea Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2006b). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Three Mile Bush Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2007a). Preliminary Hydrogeological Investigations – Four Northland Aquifers, Kaikohe Groundwater Resource. Report for Northland Regional Council.

Sinclair Knight Merz (2007b). Awanui Artesian Aquifer Numerical Modelling. Report for Northland Regional Council.