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Dear Susie

NRC Coastal Aquifers Study - Taupo Bay

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 **Taupo Bay sand/alluvium 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

Taupo Bay is a small bay located near the head of Whangaroa Harbour, approximately 40 km north west of the Bay of Islands (**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 predominantly comprises Waipapa Group greywacke and argillite basement rocks with cherts and marbles, overlain by undifferentiated Quaternary sand and alluvium along the low lying valley and coastal fringe. Miocene age Wairakau andesitic fragmental rocks outcrop in the hills south of Taupo Bay.

NRC records indicate initial drilling at Taupo Bay in 1972 with records for ten bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** One of the ten bores does not have geological information available and is shown on the figures but without an NRC bore reference. Summary geological, bore construction and testing information from available borelogs is provided in **Appendix B**.

- **Figure 1. Taupo Bay Sand/Alluvium Aquifer Management Map**
  (See A4 attachment at rear)
- **Figure 2. Taupo Bay Greywacke Aquifer Management Map**
  (See A4 attachment at rear)

In general, bore geology correlates with the regional geological map, with the majority of bores having a layer of sand/alluvium overlying greywacke. The sand/alluvium is up to 11

metres thick and contains interbedded sand, gravel and shell layers with the weathered greywacke surface encountered below this.

The bores in the Taupo Bay area range in depth from 8 to 133 metres below ground level (mBGL). Four of the bores abstract from the sand/alluvium while five bores abstract from the greywacke. No bores are located within the Wairakau andesite.

Static groundwater levels for the sand aquifer range between 3.0 mBGL (bore 201349) and 4.5 mBGL (bore 200221). Groundwater levels in the greywacke are slightly higher, ranging between 0.0 mBGL (bore 200223) and 4.0 mBGL (bore 201321).

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

- All four bores within the sand/alluvium have test pumping results with low to moderate yields ranging between 65.4 m^3/day (0.8 L/s) and 336 m^3/day (3.9 L/s);
- All five bores within the greywacke have also been tested, again with low yields ranging between 21.6 m^3/day (0.25 L/s) and 54.5 m^3/day (0.63 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally low to moderate measuring 17.8 m^3/day/m and 44.8 m^3/day/m for the sand/alluvium aquifer (2 tests). Test pumping of the greywacke aquifer indicate a much lower specific capacity of between 3.9 m^3/day/m and 5.1 m^3/day/m (2 tests).

The testing results confirm the greywacke is generally low permeability. This is typical of greywacke other than in areas where there is strong faulting. Where greywacke is exposed, high surface runoff is expected with little percolation of rainfall into the greywacke. At locations where sand/alluvium or andesite overlies the greywacke, a higher infiltration rate of rainfall percolating through and into the greywacke may be expected. In the low lying valley and coastal areas where sand/alluvium occurs, the higher infiltration rate is generally governed more so by flatter slope than the permeability of the greywacke in these locations.

Aquifer Extent

The previous management area for Taupo Bay sand/alluvium aquifer (obtained from NRC) was based on the overlying undifferentiated sand/alluvium defined by drilling which covered an area of 0.22 km^2. Following review of borelogs in the Taupo Bay area and the regional geological map, the sand/alluvium management area has been slightly extended inland and now covers an area of 0.31 km^2. The revised management area is shown in **Figure 1** and coincides with all cadastral boundaries.

The physical aquifer extent based on the regional geological map is approximately 0.2 km^2 larger than the management area at 0.51 km^2 (**Figure 1**, red dashed line). The physical aquifer extent of the sand/alluvium aquifer has been used in the recharge estimations for this aquifer.

The management area for the greywacke aquifer is shown in **Figure 2** and comprises an area of approximately 2.95 km^2. The management area has been defined by the geology and topographic divide, and adjusted to coincide with the cadastral boundaries. This management area excludes the area of andesite outcropping in the south. As a consequence the management area is approximately 1.9 km^2 smaller than the anticipated groundwater recharge area (**Figure 2)**, although the latter area (4.87 km^2) including the andesite 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 1033, Kaeo Northland) located approximately 7.5 km south of Taupo Bay. The data is for the period between 1981 and 2008, and indicates the following annual rainfall statistics:

- Minimum: 1,079 mm (1994)
- Maximum: 2,092 mm (1989)
- **Average: 1,580 mm**

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

Sand/Alluvium Recharge Estimate

Groundwater recharge estimates for the Taupo Bay sand/alluvium 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 in the Russell gravel aquifer (SKM, 2001), located approximately 40 km to the south east 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 generally coarse nature of the sediments described from the bores drilled within the Taupo Bay sand/alluvium aquifer and recharge estimates determined for similar sediments,

a range of **30 - 40 % of annual average rainfall** has been used to estimate the most likely range of rainfall recharge. This accounts for a proportion of gravel and shell material reported in a number of bores, but is towards the lower end of the Russell gravel aquifer recharge rates due to the frequent presence of sand. Using the physical aquifer extent for the recharge estimate adds further conservatism 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 Taupo Bay sand/alluvium 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. Taupo Bay sand/alluvium 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)
1,580	0.51	805,800	30 % (min.)	241,740
1,580	0.51	805,800	40% (max.)	322,320

The groundwater recharge assessment for the Taupo Bay sand/alluvium aquifer indicates that annual recharge is likely to be between 241,740 and 322,320 m^3/year for the 30% and 40% recharge proportions, respectively. Accordingly, the interim default allocation limit under the NES (15% of groundwater recharge) would be between **36,261** and **48,348 m^3/year**.

Greywacke Recharge Estimate

The recharge estimate for the greywacke aquifer utilises recharge rates previously determined for the Russell greywacke aquifer located approximately 40 km south east of Taupo Bay. 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. On this basis the resulting groundwater recharge estimate for the greywacke is between **1% and 5 % of annual average rainfall** which is also applied to this study.

The catchment area for the Taupo Bay greywacke aquifer also includes 1.85 km^2 of andesitic fragmental rocks in the south. The nature of these andesitic rocks suggests a greater infiltration capacity than the greywacke and a slightly higher recharge estimate has been applied to this area of the catchment. Based on previously determined recharge rates for other non-scoriaceous Northland volcanics (**Appendix A**), a groundwater recharge estimate of **10% of annual average rainfall** has been applied to this portion of the catchment.

Likely minimum and maximum annual groundwater recharge to the Taupo Bay 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. Taupo Bay greywacke groundwater recharge volume**

Catchment Geology	Average Annual Rainfall (mm/yr)	Recharge Area (km^2)	Total Recharge Volume (m^3/yr)	% GW Recharge	GW Recharge Volume (m^3/yr)
Greywacke	1,580	3.02	4,771,600	1% (min.)*	47,716
Andesite	1,580	1.85	2,923,000	10% **	292,300
Combined Min	**1,580**	**4.87**	**7,694,600**		**340,016**
Greywacke	1,580	3.02	4,771,600	5% (max.)*	238,580
Andesite	1,580	1.85	2,923,000	10% **	292,300
Combined Max	**1,580**	**4.87**	**7,694,600**		**530,880**

Notes: * 1% and 5% have been used for respective minimum and maximum percentage groundwater recharge values for 3.02 km^2 of the catchment area. ** 10% has been used for the remaining 1.85 km^2 of the catchment to account for andesite with higher infiltration capacity.

The groundwater recharge assessment for the Taupo Bay greywacke aquifer indicates that annual recharge is likely to be between 340,016 and 530,880 m^3/year for the 1% and 5% recharge proportions, respectively. Accordingly, the interim default allocation limit for the greywacke aquifer under the Proposed NES (15% of groundwater recharge) would be between **51,002** and **79,632 m^3/year**.

Yours sincerely

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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
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				
200163	P4 758-893	0.0 – 11.0 11.0 - *?*	Sand and shell beds Basalt	*Unknown*	Casing (0 - 5 m) Screen (5 – 8 m)	Sand / Shell	SWL = 3.8 mBGL Q = 81.8 m^3/day Sc = 17.8 m^3/day/m
200221	P4 758-892	0.0 – 8.0	Soil, sand and gravel	8.0 m	PVC casing (0 – 5 m) Screen (5 – 8 m)	Sand / Gravel	SWL = 4.5 mBGL Q = 65.4 m^3/day
200222	P4 758-892	0.0 – 8.0	Soil, sand and gravel	8.0 m	PVC casing (0 – 5 m) PVC screen (5 – 8 m)	Sand / Gravel	SWL = 3.7 mBGL Q = 81.8 m^3/day
200223	P4 756-897	0.0 – 4.6 4.6 – 30.5	Soil and boulders Greywacke	30.5 m	Steel casing (0 – 4.6 m) Open hole (4.6 – 30.5 m)	Greywacke	SWL = ~0.0 mBGL Q = 27.3 m^3/day
201321	P4 754-893	0.0 – 20.0 20.0 – 133	Clay and weathered greywacke Greywacke	133.0 m	PVC casing (0 – 21.4 m) Open hole (21.4 – 133 m)	Greywacke	SWL = 4.0 mBGL Q = 36.3 m^3/day
201322	P4 756-894	0.0 – 5.0 5.0 – 7.0 7.0 – 61.0	Soil and basalt boulders Clay Greywacke	61.0 m	Steel casing (0 – 7.4 m) Open hole (7.4 – 61 m)	Greywacke	SWL = 2.4 mBGL Q = 54.5 m^3/day
201349	P4 757-893	0.0 – 4.5 4.5 – 6.0 6.0 – 8.8 8.8 – 11.0	Sand and shell Gravel and boulders Sand and shell Sand	11.0 m	PVC casing (0 – 6 m) PVC screen (6 – 8.7 m)	Sand / Shell	SWL = 3.0 mBGL Q = 336 m^3/day Sc = 44.8 m^3/day/m
201356	P4 755-895	0.0 – 5.0 5.0 – 12.0 12.0 – 32.0	Gravels Weathered greywacke Hard greywacke	32.0 m	Steel casing (0 – 6 m) Open hole (6 – 32.0 m)	Greywacke	SWL = 3.0 mBGL Q = 21.6 m^3/day Sc = 3.9 m^3/day/m
201436	P4 756-897	0.0 – 30.0	Greywacke (with quartz bands at 30 m)	30.0 m	PVC casing (0 – 5 m) Open hole (5 – 30 m)	Greywacke	SWL = 2.5 mBGL Q = 36.0 m^3/day Sc = 5.1 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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