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Dear Susie,

NRC Coastal Aquifers Study - Bland 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 **Bland Bay sand/gravel 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

Bland Bay is located on the east coast approximately 25 km south east of the Bay of Islands (**Figure 1**). The low lying coastal area comprises an aeolian sand tombolo wedged between hard rock headlands consisting of greywacke and argillite basement rocks (SKM, 2000). The geology is described on the 1:250,000 Geological Map Sheet 1 for North Cape (Kear and Hay, 1961).

NRC records indicate initial drilling at Bland Bay occurred in 1956 with records for 38 bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** A number of these records do not have geological information available and although shown in the figures they have not been specifically labelled. Summary geological, bore construction and testing information from available borelogs is provided in **Appendix B**.

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

In general, bore geology correlates with the regional geological map; the majority of bores indicate an aquifer comprising 4 to 6 metres of clean sand overlying shells and gravels sitting atop the erosional surface of greywacke basement rocks. The aquifer abruptly pinches out to the north west and south east of the beach against greywacke headlands.

The bores drilled within the Bland Bay sand/gravel are all shallow ranging in depth from 5.6 to 10.0 metres below ground level (mBGL). Bores drilled within the deeper greywacke range between 12.0 and 76.2 mBGL with the majority abstracting from this hard rock aquifer.

Static groundwater levels for the sand/gravel aquifer range between 2.8 mBGL (bore 202220) and 3.7 mBGL (bore 202210). Groundwater levels in the greywacke are similar but have a greater range between 0.0 mBGL (bore 205307) and 7.0 mBGL (bores 202103 & 202104).

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

- Six bores within the sand/gravel have test pumping results with low yields ranging between 19.2 m^3/day (0.22 L/s) and 84.0 m^3/day (0.97 L/s);
- Fourteen bores within the greywacke have also been tested with low yields which range between 21.6 m^3/day (0.25 L/s) and 82.5 m^3/day (0.96 L/s), apart from bore 202075 which is significantly more productive at 218.0 m^3/day (2.52 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally low measuring between 6.4 m^3/day/m and 16.0 m^3/day/m for the sand/gravel aquifer (6 tests). Test pumping of the greywacke aquifer indicate a similar range of specific capacity of between 0.96 m^3/day/m and 11.16 m^3/day/m (6 tests).

Aquifer Extent

The previous management area for the Bland Bay sand/gravel aquifer (obtained from NRC) was based on the overlying undifferentiated sand/gravel as defined in a previous SKM report (SKM, 2000) which covered an area of 1.08 km^2 (**Figure 1**). This management area was based on marked changes in topography associated with the pinching out of the sands on the pronounced headlands, the coast on either side and has been drawn to coincide with the closest cadastral boundaries. The management area remains unchanged following review of additional borelogs obtained since the previous study was undertaken. The area is shown in **Figure 1**.

The physical aquifer extent based solely on mapped geology is approximately 3 % larger than the management boundary at 1.11 km^2 (**Figure 1**, red dashed line). The physical aquifer extent has been used in the recharge estimations of the sand/gravel aquifer.

The available borelog information indicates that the majority of bores abstract water from the greywacke. The management area for the greywacke aquifer is shown in **Figure 2** and is approximately 2.02 km^2. The management area has been defined by the geology and anticipated groundwater recharge area, and adjusted to coincide with the cadastral boundaries.

The aquifer management area is approximately 0.47 km^2 smaller than the groundwater recharge area (**Figure 2)**, although the latter area (2.49 km^2) 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 two rainfall stations located approximately 20 km either side of the Bland Bay area. These two stations have similar rainfall statistics which are summarised in **Table 1.** A combined average annual rainfall from the two stations was used for the Bland Bay groundwater recharge estimates (**1230 mm/yr**).

Table 1. Summary rainfall statistics

	Matapouri - 1221	Cape Brett Lighthouse - 1197
Location	Approx. 25 km south	Approx. 19.5 km north
Data period	1967 - 2008	1935 - 1978
Minimum	787 mm/yr	772 mm/yr
Maximum	2131 mm/yr	1815 mm/yr
Average	1360 mm/yr	1100 mm/yr

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

Sand/Gravel Recharge Estimate

Groundwater recharge estimates for the Bland Bay sand/gravel 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 20 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 Bland Bay sand/gravel aquifer, 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 predominance of sand. 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. This conservative approach has been adopted as the aquifer is potentially very sensitive to overuse due to the limited depth and lateral extents of the sand/gravel.

Likely annual groundwater recharge to the Bland Bay sand/gravel aquifer based on rainfall records and the physical aquifer extent, as a percentage of annual rainfall is given in **Table 2**.

- **Table 2. Bland Bay sand/gravel 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)
1,230	1.11	1,365,300	30% (min.)	409,590
1,230	1.11	1,365,300	40% (max.)	546,120

The groundwater recharge assessment for the Bland Bay sand/gravel aquifer indicates that annual recharge is likely to be between 409,590 and 546,120 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 **61,438** and **81,918 m^3/year**.

Greywacke Recharge Estimate

The greywacke recharge estimate utilises recharge rates previously determined for the Russell greywacke aquifer located approximately 20 km north west of Bland 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. 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 Bland Bay greywacke aquifer based on the local rainfall record and the groundwater recharge area, as a percentage of annual rainfall is given in **Table 3.**

- **Table 3. Bland Bay 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)
1,230	2.49	3,062,700	1% (min.)	30,627
1,230	2.49	3,062,700	5% (max.)	153,135

The groundwater recharge assessment for the Bland Bay greywacke aquifer indicates that annual recharge is likely to be between 30,627 and 153,135 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 **4,595** and **22,970 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				
202066	Q5 338-495*	0.0 – 6.7 6.7 – 7.9 7.9 – 14.6	Sand, shell and gravel Soft green greywacke Brown and blue greywacke	14.6 m	PVC casing (0 – 9.0 m) Open hole (9.0 – 14.6 m)	Greywacke	SWL = 5.2 mBGL Q = 49.1 m^3/day
202070	Q5 338-495*	*0.0 – 21.3*	*Greywacke*	21.3 m	PVC casing (0 – 9.7 m) Open hole (9.7 – 21.3 m)	Greywacke	SWL = 4.5 mBGL Q = 38.2 m^3/day
202071	Q5 338-495*	0.0 – 8.0 8.0 – 13.7	Sand and gravel Greywacke	13.7 m		*Greywacke*	SWL = 5.2 mBGL Q = 33.1 m^3/day
202075	Q5 338-495*	*0.0 – 16.0*	*Greywacke*	16.0 m	PVC casing (0 – 6.0 m) Open hole (6.0 – 16.0 m)	Greywacke	SWL = 2.0 mBGL Q = 82.5 m^3/day
202076	Q5 338-495*	0.0 – 6.1	Sand	6.1 m	Galvanised steel (0 – 4.5 m) Johnson screen (4.5 – 6.0 m)	Sand	
202079	Q5 338-495*	0.0 – 10.0	Sand and gravel	10.0 m	PVC casing (0 – 9.6 m)	Sand / Gravel	
202097	Q5 334-497	0.0 – 20.0 20.0 – 49.0	Yellow clay Brown to blue greywacke	49.0 m	PVC casing (0 – 22.8 m) Open hole (22.8 – 49.0 m)	Greywacke	SWL = 2.0 mBGL
202103	Q5 333-501	0.0 – 12.0 12.0 – 17.0 17.0 – 25.0	Sand, shell and yellow clay Weathered brown greywacke Blue greywacke	25.0 m	PVC casing (0 – 14.0 m) Screen (14.0 – 17.0 m) Open hole (17.0 – 25.0 m)	Greywacke	SWL = 7.0 mBGL Q = 81.7 m^3/day
202104	Q5 333-490	0.0 – 19.5 19.5 – 53.6	Sand, shell and yellow clay Greywacke	53.6 m	Casing (0 – 19.5 m) Open hole (19.5 – 53.6 m)	Greywacke	SWL = 7.0 mBGL Q = 36.3 m^3/day
202105	Q5 335-495	0.0 – 30.5 30.5 – 49.0	Soil, sand and silt Greywacke	49.0 m	Casing (0 – 30.5 m) Open hole (30.5 – 49.0 m)	Greywacke	SWL = 4.5 mBGL Q = 218 m^3/day
202109	Q5 344-494	0.0 – 5.0 5.0 – 27.0 27.0 – 76.2	Soil, sand and shell Silt Greywacke	76.2 m	Casing (0 – 29.0 m) Open hole (29.0 – 76.2 m)	Greywacke	SWL = 4.8 mBGL Q = 22.7 m^3/day Sc = 0.96 m^3/day/m
202139	Q5 342-495	0.0 – 4.5 4.5 – 10.0 10.0 – 16.0 16.0 – 26.0	Sand and gravel Silt and clay Weathered greywacke Brown to blue greywacke	26.0 m	Casing (0 – 18.0 m) Open hole (18.0 – 26.0 m)	Greywacke	SWL = 3.2 mBGL Q = 52.8 m^3/day Sc = 9.1 m^3/day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
202140	Q5 341-495	0.0 – 4.5 4.5 – 9.4 9.4 – 12.0 12.0 – 23.8	Sand and gravel Clay and sandy silt Weathered greywacke Brown to blue greywacke	23.8 m	Casing (0 – 15.6 m) Open hole (15.6 – 23.6 m)	Greywacke	SWL = 3.0 mBGL Q = 21.6 m^3/day Sc = 4.3 m^3/day/m
202209	Q5 339-494	0.0 – 4.0 4.0 – 18.0 18.0 – 20.2 20.2 – 26.6	Sand and silty sands Sandy silt, silt and clay Grey shale-like rock Brown to blue greywacke	26.6 m	Casing (0 – 22.0 m) Open hole (22.0 – 26.6 m)	Greywacke	SWL = 1.9 mBGL Q = 48.0 m^3/day Sc = 11.2 m^3/day/m
202210	Q5 338-496	0.0 – 4.0 4.0 – 5.0 5.0 – 7.0	Sand Cemented gravel Sand and gravel	7.0 m	Casing (0 – 6.0 m) Screen (6.0 – 7.0 m)	Sand / Gravel	SWL = 3.7 mBGL Q = 33.6 m^3/day Sc = 11.2 m^3/day/m
202214	Q5 343-457	0.0 – 5.5 5.5 – 12.0 12.0 – 30.0	Clay Weathered greywacke Brown to blue greywacke	30.0 m	Casing (0 – 16.0 m) Screen (16.0 – 24.0 m) Open hole (24.0 – 30.0 m)	Greywacke	SWL = 5.4 mBGL Q = 48.0 m^3/day Sc = 10.4 m^3/day/m
202215	Q5 342-493	0.0 – 5.0 5.0 – 8.0 8.0 – 14.8	Clay and sandy silt Blue-green greywacke Brown to blue greywacke	14.8 m	Casing (0 – 8.0 m) PVC screen (8.0 – 14.0 m)	Greywacke	SWL = 1.2 mBGL Q = 43.2 m^3/day Sc = 6.2 m^3/day/m
202218	Q5 337-497	0.0 – 6.2 6.2 – 7.5	Sand, gravel and shell Blue clay	7.5 m	Casing (0 – 5.2 m) Johnson screen (5.2 – 6.2 m)	Sand / Gravel	SWL = 3.2 mBGL Q = 48.0 m^3/day Sc = 16.0 m^3/day/m
202219	Q5 336-498	0.0 – 6.0 6.0 – 8.0	Sand, gravel and shell Blue silty sand	8.0 m	Casing (0 – 5.0 m) Johnson screen (5.0 – 6.0 m)	Sand / Gravel	SWL = 3.0 mBGL Q = 36.0 m^3/day Sc = 12.0 m^3/day/m
202220	Q5 337-496	0.0 – 3.0 3.0 – 9.0	Sand Sand, gravel and silt	9.0 m	Casing (0 – 3.0 m) Screen (3.0 – 9.0 m)	Sand / Gravel	SWL = 2.8 mBGL Q = 19.2 m^3/day Sc = 6.4 m^3/day/m
205307	Q5 338-495	0.0 – 5.8 5.8 – 12.0	Clay and peat Brown greywacke	12.0 m	Galvanised steel (0 – 9.0 m) Open hole (9.0 – 12.0 m)	Greywacke	SWL = 0.0 mBGL Q = 13.1 m^3/day
209256	Q5 337-497	0.0 – 5.6	Sand	5.6 m	Casing (0 – 4.6 m) Screen (4.6 – 5.6 m)	Sand	SWL = 3.0 mBGL Q = 40.8 m^3/day Sc = 7.3 m^3/day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
209276	Q5 337-496	0.0 – 4.0 4.0 – 5.5 5.5 – 7.5	Sand Sand, shell and gravel Sand and silt	7.5 m	Casing (0 – 5.0 m) Screen (5.0 – 6.0 m)	Sand / Gravel	SWL = 4.1 mBGL Q = 84.0 m^3/day Sc = 14.0 m^3/day/m
209693	Q5 334-497	0.0 – 5.0	Sand and gravel	5.0 m	Not used	Not used	SWL = bore dry

Notes: * Identical coordinate references – only one bore displayed at this location on figure. * *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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