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Dear Susie,

NRC Coastal Aquifers Study - Pataua North and Pataua South

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 **Pataua North and Pataua South 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

Pataua is located approximately 20 km east of Whangarei (**Figure 1**). Pataua North is situated on the northern side of the Pataua River mouth, and Pataua South situated on the southern. 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 with frequent cherts and manganese, overlain by undifferentiated Quaternary sand along the low lying coastal fringe.

Pataua North

NRC records indicate initial drilling at Pataua North occurred in 1980 with records for 18 bores in the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** Two of these bores do not have geological information available and are shown in the figures but without NRC bore references. Summary geological, bore construction and aquifer testing information from available borelogs is provided in **Appendix B1**.

- **Figure 1. Pataua North & Pataua South Alluvium Aquifer Management Map**
  (See A4 attachment at rear)
- **Figure 2. Pataua North Greywacke Aquifer Management Map**
  (See A4 attachment at rear)

In general, bore geology correlates with the regional geological map. The majority of bores encounter 5 to 10 metres of clean sand overlying a shell and gravel layer which sits atop the erosional surface of greywacke basement. The alluvium aquifer pinches out approximately 500 metres west of the coast against outcropping greywacke.

The bores in the Pataua North area are all shallow ranging in depth from 7.0 to 28.5 metres below ground level (mBGL). The majority of bores abstract from the alluvium aquifer, with 3 bores abstracting from the greywacke.

Static groundwater levels for the alluvium aquifer range between 4.2 mBGL (bore 209252) and 9.2 mBGL (bore 209153). Groundwater levels in the greywacke are generally higher, ranging between 2.7 mBGL (bore 205440) and 5.2 mBGL (bore 209277). 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 Pataua North area have the following hydraulic characteristics:

- Thirteen bores have test pumping results within the alluvium aquifer with low yields ranging between 18.2 m^3/day (0.21 L/s) and 48.0 m^3/day (0.56 L/s);
- Test pumping data provided for 2 bores abstracting from the greywacke have similar yields ranging between 19.2 m^3/day (0.22 L/s) and 43.2 m^3/day (0.50 L/s); and
- Maximum drawdown measurements recorded during the test pumping exercises indicate that bore specific capacities are generally moderate, measuring between 16.0 m^3/day/m and 48.0 m^3/day/m for the sand aquifer (6 tests) and 33.2 m^3/day/m for the greywacke (1 test), respectively.

Pataua South

NRC records indicate initial drilling at Pataua South occurred in 1977 with a total of 8 bore records for the area to date. The approximate locations of the boreholes are shown in **Figure 1** and **Figure 2.** Two of these bores do not have geological information available and are shown in the figures but without NRC bore references. Summary geological, bore construction and aquifer testing information from available borelogs is provided in **Appendix B2**.

In general, bore geology correlates with the regional geological map with all bores indicating a surficial sand layer overlying a layer of shell and gravel to a maximum bore depth of 6 metres. All bores abstract from this aquifer and none are reported to have encountered the greywacke basement.

Static groundwater levels for the alluvium aquifer range between 0.5 mBGL (bore 205458) and 2.0 mBGL (3 bores).

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

- Four bores have test pumping results within the alluvium aquifer with low yields ranging between 14.4 m^3/day (0.17 L/s) and 48.0 m^3/day (0.56 L/s); and
- Maximum drawdown measurements recorded during these tests indicate that bore specific capacities are generally low to moderate measuring 3.6 m^3/day/m and 48.4 m^3/day/m for the alluvium aquifer (6 tests).

These characteristics are closely comparable to the hydraulic characteristics of the Pataua North bores

Aquifer Extent

Pataua North

The previous management area for Pataua North alluvium aquifer (obtained from NRC) was based on the undifferentiated sand defined by drilling and covered an area of 0.36 km^2. Following review of borelogs and the regional geological map, the extent of the management area has been increased to coincide with the mapped extent of undifferentiated sand and gravel material in the Pataua North area and include all bores drilled to date. Southern and eastern boundaries have been delineated by the Pataua River and coast respectively, while the western margin is defined by the lithological change to greywacke and associated basement rocks. The revised management area covers 1.97 km^2 and is shown in **Figure 1**. In this instance, the increase in management area was unable to coincide with all cadastral boundaries (where these were sparse) and one property has been bisected to match the geological boundary.

The management area is 0.08 km^2 larger than the physical aquifer extent (**Figure 1**, red dashed line) which is based solely on geology, although the latter (1.89 km^2) has been used in recharge estimations for the Pataua North alluvium aquifer

The management area for the greywacke aquifer is shown in **Figure 2** and is approximately 6.57 km^2. The management area 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 boundary bisecting one property to match the topographic divide.

The aquifer management area is approximately 0.14 km^2 larger than the groundwater recharge area (**Figure 2**, red dashed line), although the latter area (6.43 km^2) is used for the recharge estimations.

Pataua South

The previous management area for Pataua South alluvium aquifer (obtained from NRC) was based on the undifferentiated sand defined by drilling and covered an area of 0.14 km^2. Following review of borelogs and the regional geological map, the management area has been increased to coincide with the mapped and drilled extent of sand and gravel material in the Pataua South area. Subsequently, the revised management area covers 0.42 km^2 (which coincides with all cadastral boundaries) and is shown in **Figure 1**.

The physical aquifer extent based solely on geology is approximately 17 % larger than the management area at 0.49 km^2 (**Figure 1**, red dashed line). The physical aquifer extent has been used in the Pataua South alluvium aquifer 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 1292, Parua Bay) located approximately 3.4 km south west of Pataua. The data is for the period between 1974 and 1985, and indicates the following annual rainfall statistics:

- Minimum: 940 mm (1978)
- Maximum: 1,637 mm (1979)
- **Average: 1,260 mm**

In the absence of streamflow data to calibrate a Soil Moisture Water Balance Model (SMWBM) groundwater recharge has been estimated for Pataua North and Pataua South sand/gravel and greywacke aquifers using recharge calculated in similar aquifer types in the Northland region.

Alluvium Recharge Estimate

Groundwater recharge estimates for the Pataua North and Pataua South alluvium aquifers 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), provided a groundwater recharge estimate of 26 -52% for a 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 Pataua alluvium aquifers, 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 the majority of bores, but remains towards the lower end of the Russell gravel aquifer recharge rates due to the predominance of sand in the upper part of the aquifer.

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 aquifers are potentially very sensitive to overuse due to the limited depth and lateral extents of the alluvium and the fact that the vast majority of bores in both Pataua North and Pataua South are abstracting from this aquifer.

The likely range of annual groundwater recharge to the Pataua North alluvium aquifer based on the local rainfall record and the physical aquifer extent, as a percentage of annual rainfall is given in **Table 1**. Estimates of annual groundwater recharge to Pataua South alluvium aquifer are presented in **Table 2**.

- **Table 1. Pataua North alluvium annual 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)
1,260	1.89	2,381,400	30% (min.)	714,420
1,260	1.89	2,381,400	40% (max.)	952,560

The groundwater recharge assessment for the **Pataua North** alluvium aquifer indicates that annual recharge is likely to be between 714,420 and 952,560 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 **107,163** and **142,884 m^3/year.**

- **Table 2. Pataua South alluvium annual 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)
1,260	0.49	617,400	30% (min.)	185,220
1,260	0.49	617,400	40% (max.)	246,960

The groundwater recharge assessment for the **Pataua South** alluvium aquifer indicates that annual recharge is likely to be between 185,220 and 246,960 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 **27,783** and **37,044 m^3/year.**

Greywacke Recharge Estimate

The greywacke recharge estimate utilises recharge rates previously determined for the Russell greywacke aquifer located approximately 40 km north west of Pataua. 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 Pataua North 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. Pataua 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)
1,260	6.43	8,101,800	1% (min.)	81,018
1,260	6.43	8,101,800	5% (max.)	405,090

The groundwater recharge assessment for the Pataua North greywacke aquifer indicates that annual recharge is likely to be between 81,018 and 405,090 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 **12,153** and **60,764 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.

B1. Summary of Pataua North geological borelogs

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205399	Q7 483-086	0.0 – 9.0	Sand	9.0 m	Galvanised steel (0 – 8.3 m) Johnson screen (8.3 – 9.0 m)	Sand	SWL = 6.0 mBGL Q = 27.3 m^3/day
205440	Q7 472-106	0.0 – 2.5 2.5 – 9.0	Clay and silt Grey to blue greywacke	9.0 m	PVC casing (0 – 3.5 m) Open hole (3.5 – 9.0 m)	Greywacke	SWL = 2.7 mBGL Q = 19.3 m^3/day
205450	Q7 479-089	0.0 – 8.5 8.5 – 11.3	Sand Sand, shell and gravel	11.3 m	Galvanised steel (0 – 9.8 m) PVC screen (9.8 – 11.3 m)	Sand / Gravel	SWL = 8.3 mBGL Q = 22.7 m^3/day
205451	Q7 479-090	0.0 – 9.0 9.0 – 11.0	Sand Sand, shell and gravel	11.0 m	Galvanised steel (0 – 9.75 m) PVC screen (9.75 – 11.0 m)	Sand / Gravel	SWL = 7.9 mBGL Q = 18.2 m^3/day
205453	Q7 479-088	0.0 – 10.8 10.8 – 12.0	Sand Sand, shell and gravel	12.0 m	Galvanised steel (0 – 10.5 m) PVC screen (10.5 – 12.0 m)	Sand / Gravel	SWL = 7.8 mBGL Q = 24.0 m^3/day
205510	Q7 481-092	0.0 – 11.0	Sand and gravel	11.0 m	PVC casing (0 – 10.0 m) Johnson screen (10.0 – 11.0 m)	Sand / Gravel	SWL = 8.2 mBGL Q = 22.7 m^3/day
205821	Q7 482-089	0.0 – 5.0 5.7 – 11.0	Sand Sand, gravel and cemented layer	11.0 m	Casing (0 – 8.8 m) Screen (8.8 – 10.8 m)	Sand / Gravel	SWL = 7.8 mBGL Q = 33.6 m^3/day Sc = 28.0 m^3/day/m
205840	Q7 482-091	0.0 – 8.5 8.5 – 14.0	Sand Sand and gravel	14.0 m	Casing (0.0 – 10.5 m) Screen (10.5 – 12.5 m)	Sand / Gravel	SWL = 8.5 mBGL Q = 36.0 m^3/day
205846	Q7 483-087	0.0 – 4.4 4.4 – 9.5	Sand Sand and gravel	9.5 m	PVC casing (0 – 7.5 m) Johnson screen (7.5 – 8.5 m)	Sand / Gravel	SWL = 6.2 mBGL Q = 48 m^3/day Sc = 32 m^3/day/m
205867	Q7 482-090	0.0 – 14.0	Sand	14.0 m	Casing (0 – 12.0 m) Screen (12.0 – 14.0 m)	Sand	SWL = 8.0 mBGL Q = 24 m^3/day Sc = 48 m^3/day/m
209149	Q7 484-087	0.0 – 10.0 10.0 – 14.0	Sand Sand and gravel	14.0 m	Casing (0 – 11.0 m) Screen (11.0 – 13.0 m)	Sand / Gravel	SWL = 7.5 mBGL Q = 36.0 m^3/day Sc = 24.0 m^3/day/m

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
209150	Q7 471-097	0.0 – 14.5 14.5 – 18.0	Sand and silty sand Gravel	18.0 m	Casing (0 – 16.0 m) Screen (16.0 – 18.0 m)	Gravel	SWL= 7.0 mBGL Q = 48 m^3/day
209152	Q7 477-096	0.0 – 12.0 12.0 – 20.0 20.0 – 26.0	Sand, silt and gravel Weathered greywacke Brown to blue greywacke	26.0 m	Casing (0 – 14.0 m) Open hole (14.0 – 26.0 m)	Greywacke	SWL = 3.5 mBGL Q = 43.2 m^3/day Sc = 33.2 m^3/day/m
209153	Q7 478-098	0.0 – 9.0 9.0 – 10.9 10.9 – 14.0	Sand Gravel Silty sand and gravel	14.0 m	Casing (0 – 8.9 m) Screen (8.9 – 10.9 m)	Sand / Gravel	SWL = 9.2 mBGL Q = 24 m^3/day Sc = 16 m^3/day/m
209252	Q7 485-087	0.0 – 4.0 4.0 – 7.0	Sand Sand and gravel	7.0 m	Casing (0 – 5.4 m) Johnson screen (5.4 – 6.4 m)	Sand / Gravel	SWL = 4.2 mBGL Q = 43.2 m^3/day Sc = 24.0 m^3/day
209277	Q7 473-099	0.0 – 5.5 5.5 – 12.0 12.0 – 28.5	Topsoil and sand Weathered greywacke Brown to blue greywacke	28.5 m	Casing (0 – 13.0 m) Open hole (13.0 – 28.5 m)	Greywacke	SWL = 5.2 mBGL

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.

B2. Summary of Pataua South geological borelogs

Bore #	Location**	Geology		Total Depth	Casing / Screen Details	Screened Geology	Additional Testing Information
		Depth (m)	Lithology				
205458	Q7 484-082	0.0 – 4.2	Sand, shell and gravel	4.2 m	Galvanised steel (0 – 2.8 m) PVC screen (2.8 – 4.2 m)	Sand / Gravel	SWL = 0.5 mBGL Q = 36.3 m^3/day Sc = 48.4 m^3/day/m
205459	Q7 484-082	0.0 – 5.0	Sand, shell and gravel	5.0 m	Galvanised steel (0 – 3.5 m) PVC screen (3.5 – 5.0 m)	Sand / Gravel	SWL = 2.0 mBGL Q = 31.8 m^3/day Sc = 39.7 m^3/day/m
205836	Q7 483-084	0.0 – 3.0 3.0 – 4.5	Sand Sand, shell and gravel	4.5 m	Casing (0 – 2.1 m) Screen (2.1 – 4.0 m)	Sand / Gravel	SWL = 1.8 mBGL Q = 14.4 m^3/day Sc = 3.6 m^3/day/m
209161	Q7 482-081	0.0 – 3.0 3.0 – 6.0	Sand Sand and gravel	6.0 m	Casing (0 – 3.0 m) Screen (3.0 – 5.0 m)	Sand / Gravel	SWL = 2.0 mBGL Q = 48 m^3/day Sc = 19.2 m^3/day/m
209162	Q7 483-081	0.0 – 3.0 3.0 – 6.0	Sand Sand and gravel	6.0 m	Casing (0 – 3.0 m) Screen (3.0 – 5.0 m)	Sand / Gravel	SWL = 2.0 mBGL Q = 48 m^3/day Sc = 19.2 m^3/day/m
209257	Q7 438-081	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 = 1.5 mBGL Q = 48 m^3/day Sc = 19.2 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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