

UPDATE ON RESULTS OF GROUNDWATER MONITORING UNDERTAKEN BY THE NORTHLAND REGIONAL COUNCIL - PAPARORE TO PUKENUI

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The Northland Regional Council (the Council) has collected groundwater level and groundwater quality information for the Aupouri aquifer since the 1980's. As more information is obtained the Council updates its understanding and knowledge of the aquifer. This includes undertaking assessments and producing reports such as Aupouri Peninsula Water Resource Assessment 1991, Aupouri Aquifer Sustainable Yield Modelling Study 2000, Awanui Modelling Report 2007, and the most recent comprehensive modelling report Aupouri Aquifer Review 2015.

The Aupouri Aquifer Review 2015 (Review 2015) describes the conceptual understanding, and the current state of the aquifer system. This includes assessment and interpretation of the groundwater quality and groundwater level monitoring. The report also assesses the rainfall recharge mechanisms and recharge rates based on soil moisture balance modelling.

The Review 2015 divides the aquifer into nine subzones based on a number of factors including; land use, groundwater flow direction, topography and areas of high demand. A numerical model of the aquifer was then used to assess how much water could be taken from each subzone on an annual basis without causing saltwater intrusion into the aquifer along the coast. The levels of uncertainty in the results for each zone were assessed and climate change predictions were also applied.

The Review 2015 also recommends specific annual limits for each of the nine subzones based on all the information available at the time. These limits have been recommended to be adopted in the proposed Regional Plan for Northland.

This document provides a brief update on the groundwater monitoring and investigations undertaken by the Council since 2015 in the area between Paparore and Pukenui.

STATE OF ENVIRONMENT GROUNDWATER LEVEL MONITORING

In the 1970's and 1980's a network of multilevel piezometers were installed throughout the Aupouri Peninsula. These have formed the basis of the Councils' State of Environment (SoE) groundwater level monitoring network. Additional monitoring sites have been added to the network to provide improved spatial coverage.

There are currently 12 SoE groundwater level monitoring sites in the Paparore to Pukenui area. The locations of these sites are shown in Figure 1. The locations of bores registered with the Council and the consented groundwater takes are also shown on Figure 1.

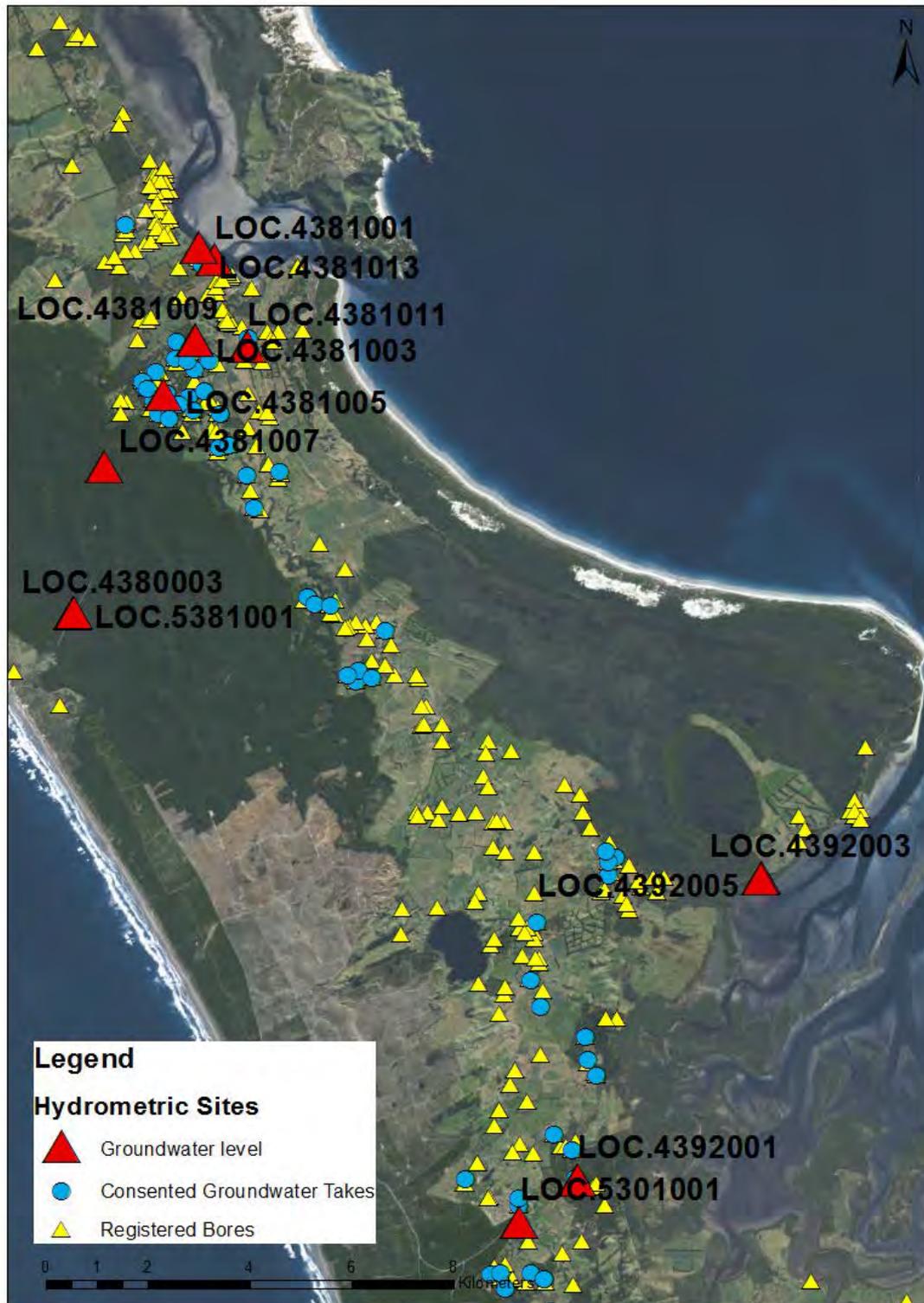


Figure 1 Locations of SoE Groundwater Level Sites, Consented Groundwater Takes and Registered Bores.

Groundwater level sites LOC.4392005 and LOC.4392003 are new monitoring bores located approximately 2 kilometres southwest of Kaimaumau settlement adjacent to the Rangaunu Harbour foreshore. The bores were installed in June 2017. The bores are drilled to a depth of 20 metres below ground level (m bgl) and 87 m bgl, respectively. The bore log for the deep bore indicates basement at 87 m bgl. The

deep bore is screened from 65 to 72 m bgl in a layer of fine sands and fine to medium shell. The shallow bore is screened from 14 to 20 m bgl in a sand layer.

The static water levels recorded for these bores in metres above mean sea level (m amsl) are shown in Figure 2 below. Water level recorders have been installed in the bores, however the data has not been processed to date.

The static water levels for LOC.4392005 and LOC.4392003 indicate a higher level in the deep bore compared to the shallow bore. This is consistent with the upward flow trends identified at LOC.4381001 Houhora Waterfront to the north and LOC.4392001 Paparore Road to the South. The Review 2015 attributes these trends to discharge through the sea bed and potential increase in confinement with depth. The water levels measured at LOC.4392005 and LOC.4392003 have a relatively low head above mean sea level compared to the sites at Houhora and Paparore Road.

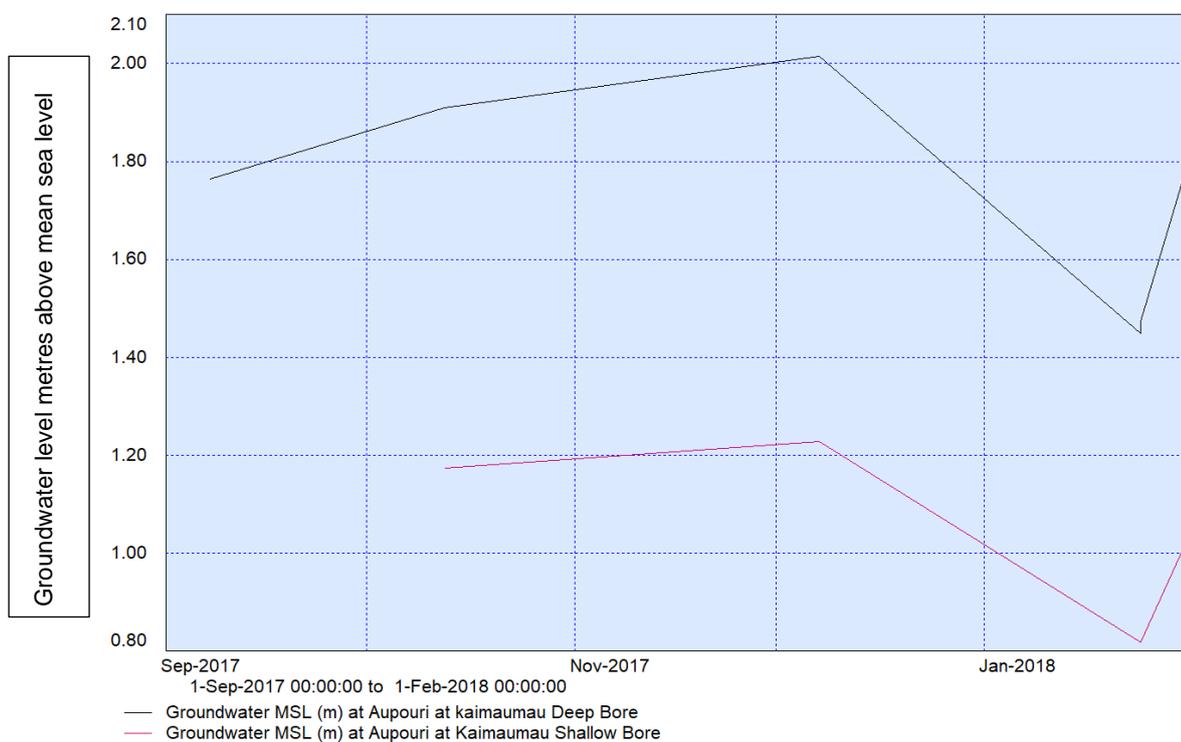


Figure 2 Results of Groundwater Level Monitoring at LOC.4392003 Kaimaumau Deep Bore and LOC.4392005 Kaimaumau Shallow Bore.

All other sites shown in Figure 1 are long-term monitoring sites and in most cases the Council has recorded monthly groundwater levels at the sites since the mid 1980's. As previously indicated the groundwater level trends and piezometric contouring are described in the Review 2015.

Figures 3 to Figure 7 provide an update of the groundwater levels recorded at selected sites to March 2018. In general, there has been an increase in groundwater levels since the 1997 reflecting the increase in recharge. Several of the piezometers do show the effects of pumping of neighbouring production bores, however, water levels at these sites recover quickly at the end of each irrigation season.

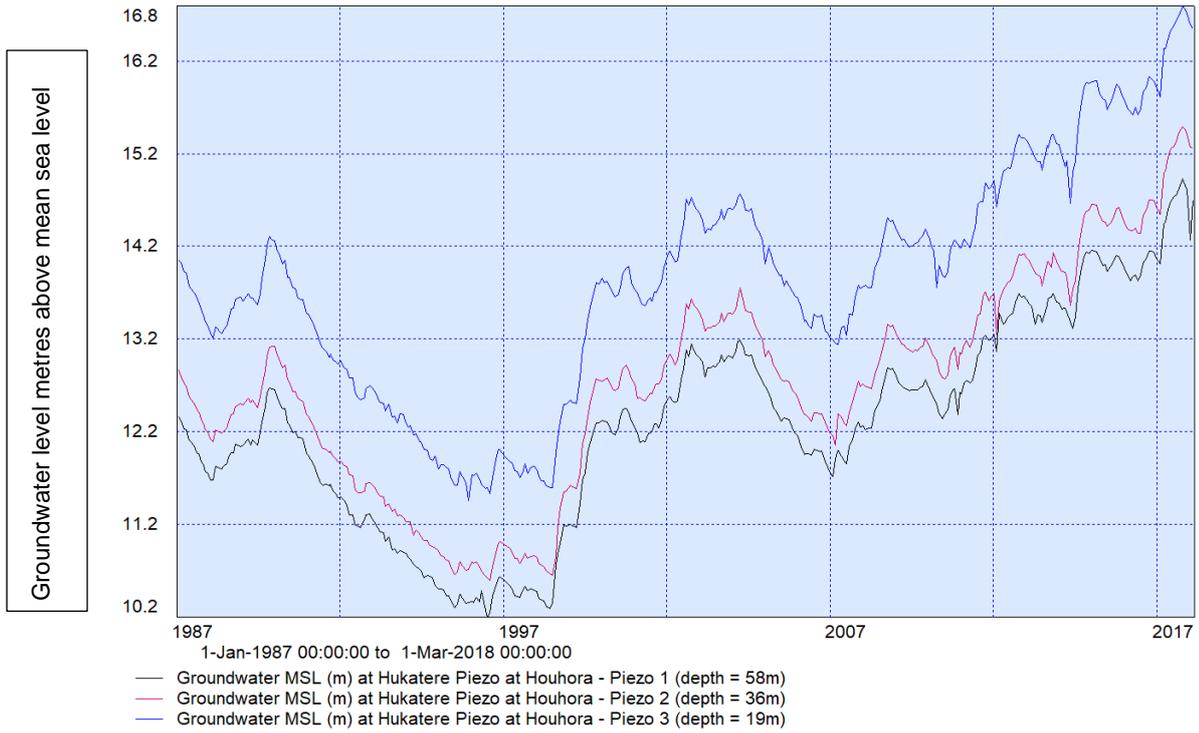


Figure 3 Results of Groundwater Level Monitoring at LOC.483 0003 Hukatere Piezo at Houhora

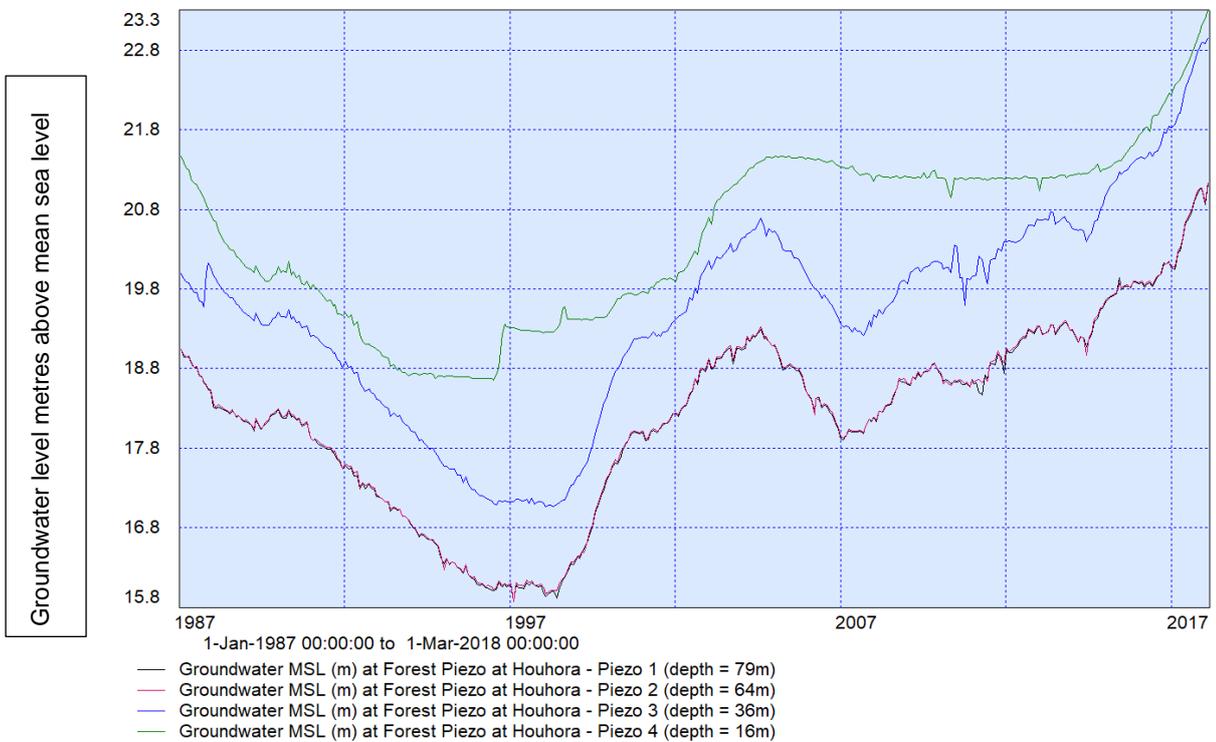


Figure 4 Results of Groundwater Level Monitoring at LOC.4381007 Forest Piezo at Houhora

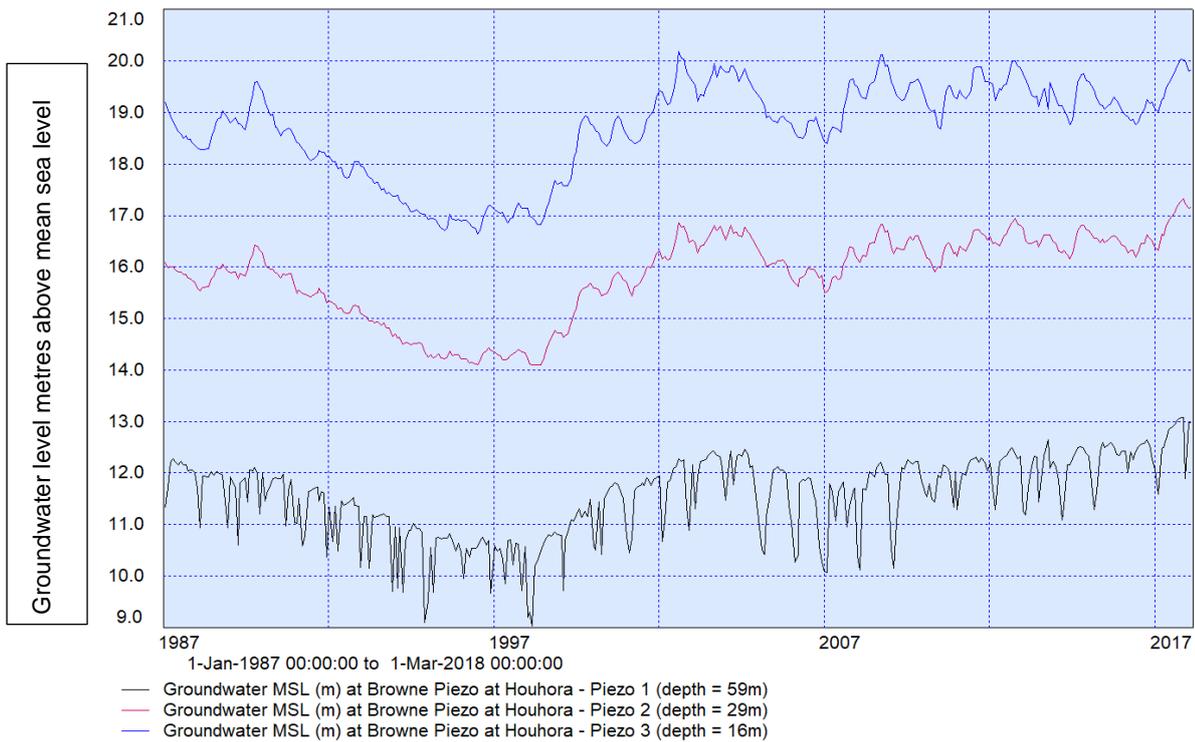


Figure 5 Results of Groundwater Level Monitoring at LOC.4381005 Brown Piezo at Houhora

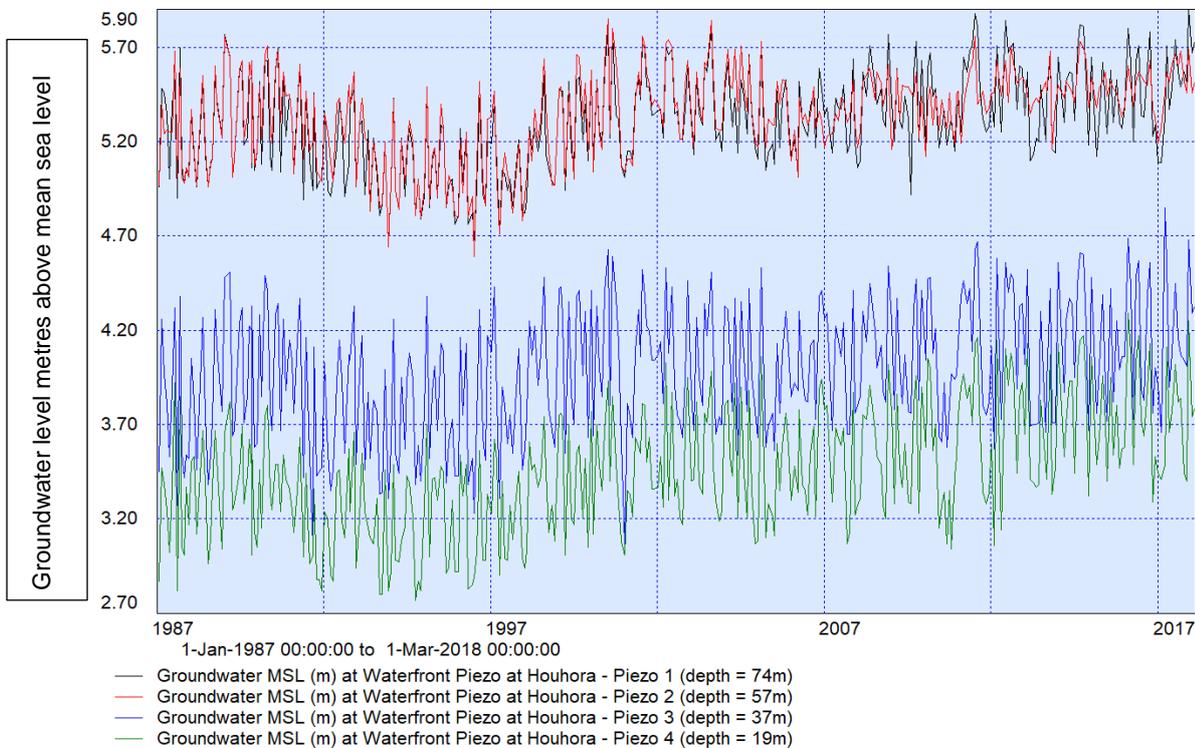


Figure 6 Results of Groundwater Level Monitoring at LOC.4381001 Water Front Piezo at Houhora

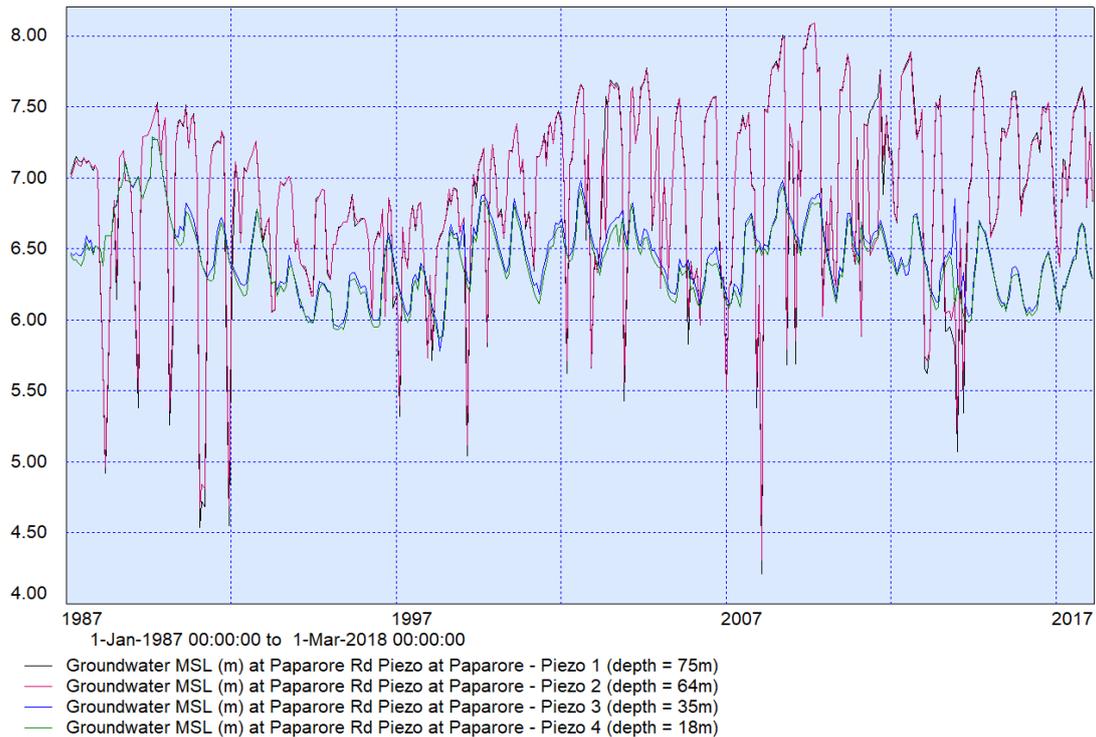


Figure 7 Results of Groundwater Level Monitoring at LOC4392001 Paparore Road Piezo at Paparore.

STATE OF ENVIRONMENT GROUNDWATER QUALITY MONITORING

The Council monitors three sites in the area between Paparore and Pukenui as part of SoE groundwater quality monitoring network. These sites have been sampled every 3 months for a wide range of water quality parameters for at least 14 years. The locations of these SoE groundwater quality sites and indicative groundwater quality sites are shown in Figure 8. The indicative groundwater quality sites are bores where one-off water quality results are available or where short-term investigations have occurred. The results of the indicative groundwater quality are discussed in the next section of this document.

The Review 2015 summarises the trends in the SoE groundwater quality monitoring. Assessment of the recent groundwater quality results (June 2012 to December 2017) indicates no significant trends in the water quality parameters monitored in the area from Paparore to Pukenui with the exception of LOC.104890.

As detailed in the Review 2015, LOC104890 showed an increasing trend in chloride and other parameters suggesting the inflow of older groundwater. However, between December 2015 and March 2016 this trend ceased and there is a marked change in many of the water quality parameters monitored.



Figure 8 Location of SoE Groundwater Quality Monitoring Site and Indicative Groundwater Quality Sites

Council staff contacted the owner of the bore LOC104890 and were informed that the bore had been redeveloped and a new pump installed. The general trend noted prior to March 2016 may have been a result of the gradual silting of the screen in the bore.

The redevelopment of the bore and installation of a new pump appears to have resulted in the marked change in water quality.

The water delivered from the bore since March 2016 has lower concentrations of chloride, sodium, sulphate, magnesium, manganese and higher concentrations of calcium. This suggests the water is potentially younger but has had greater exposure to shell substrate.

Isotope age analysis prior to 2015 indicates the mean resident age for the groundwater delivered from the bore was approximately 70 years. Further isotopes age analysis will be undertaken later this year to confirm the mean resident age of the water now being delivered from the bore.

The results for chloride concentrations in the SoE groundwater quality bores for the last 8 years are shown in Figure 9.

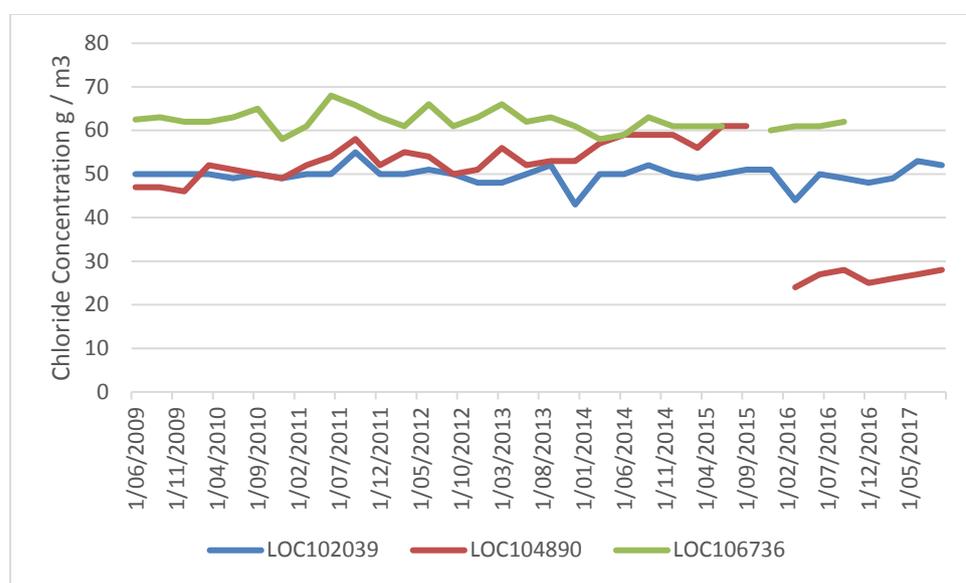


Figure 9 Chloride concentrations from June 2009 to September 2017.

SALINE MONITORING AT KAIMAUMAU

In early February 2018 Aquadrill identified saltwater during the installation of bores near the Kaimaumau settlement foreshore. The locations of the bores are shown as Bore A, B and C on Figure 10. The following is a summary of the key details provided by the driller and the subsequent investigations undertaken by the Council.

Aquadrill installed Bore A to a depth of 54.5 m bgl at the Kaimaumau settlement near the foreshore. The driller noted saltwater in a shell layer at a depth of 51-54.5 m bgl. The driller collected a water sample, recorded a static water level of 3.2 m bgl and backfilled the bore.

The driller then installed Bore B, adjacent to Bore A, targeting the grey sand at 33 to 36 m bgl. The driller noted saltwater at 33 to 36 m bgl, collected a water sample, recorded the same static water of 3.2 m bgl and backfilled the bore.

The driller subsequently installed a shallow bore to a depth of 10 m bgl (Bore C). The static water level of this bore was recorded by the driller as 2.5 m bgl. No saltwater was noted.

The driller notified the Council of the presence of saltwater and forwarded the Council water samples from the two deep bores and a bore log detailing the geology encountered.

The Council received the water samples from the driller on 12 February and measured the conductivity of the samples. The results of the measured conductivity are provided in Table 1 below.

Table 1. Conductivity Results for Bore A and B

	Bore A (54.5 m bgl)	Bore B (36 m bgl)
Conductivity (mS/m @ 25 deg C)	4835	4115

As a result of the elevated conductivity measured, the water sample for Bore A was sent for analysis of additional saline indicators Chloride, Bicarbonate, Calcium and Magnesium.

Desktop Assessment

The Council undertook a desktop assessment of the registered bores and groundwater quality result available in the surrounding area. The registered bores in the Kaimaumau area are shown on Figure 10.

The key points to note from the initial desktop assessment are:

- The bores registered with the Council in the immediate area surrounding Bores A, B and C (Kaimaumau settlement) are drilled to depths between 4 and 22.5 m bgl.
- The existing groundwater quality results for saline indicators chloride and conductivity for bores located between Paparore to Pukenui typically range between 30 to 90 g/m³, 15 to 53 mS/m @ 25degC, respectively.

Field Monitoring Undertaken

Fifteen registered bores were selected for a saline indicator monitoring. These bores range in depth from shallow (10 m bgl) to deep (85 m bgl). The locations of the selected bores and their depths are shown on Figure 10 and Figure 11, respectively.

A field survey was undertaken on the 20 and 21 February 2018. Static water levels, conductivity measurements and groundwater samples were obtained for each selected monitoring bore, where possible. The groundwater samples were forwarded to the Water Care laboratory for analysis.

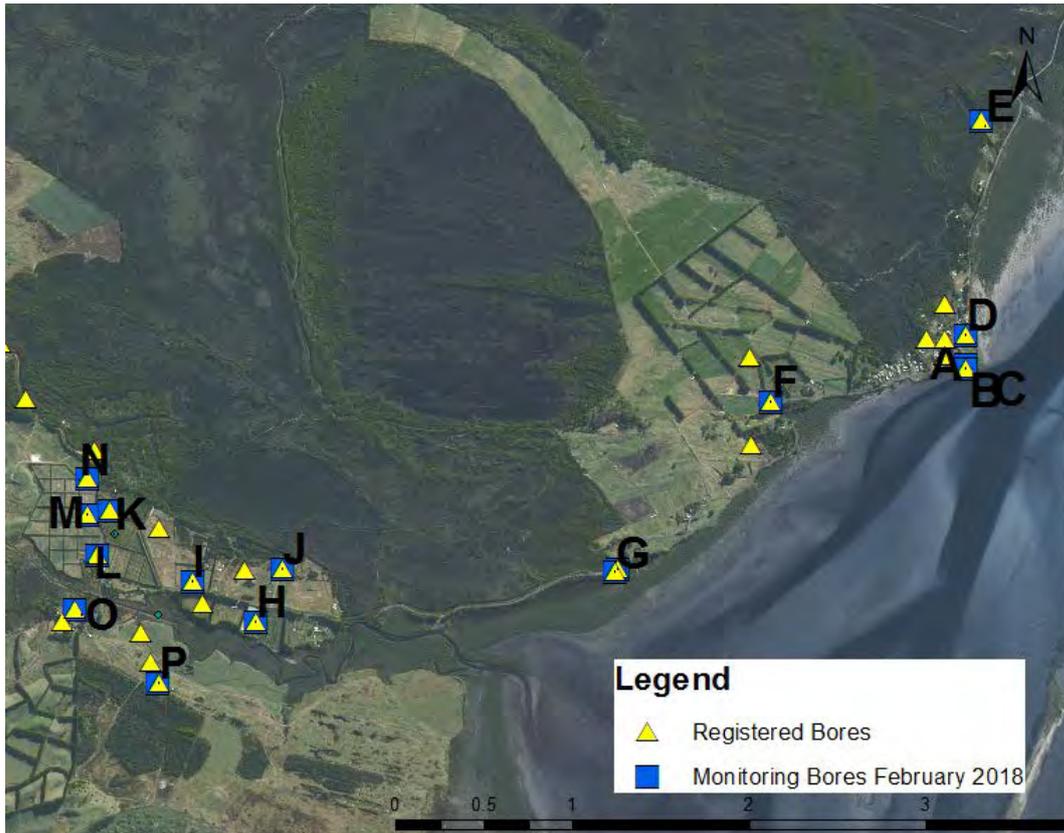


Figure 10 Registered Bores and Selected Monitoring Bores in the Kaimaumau area

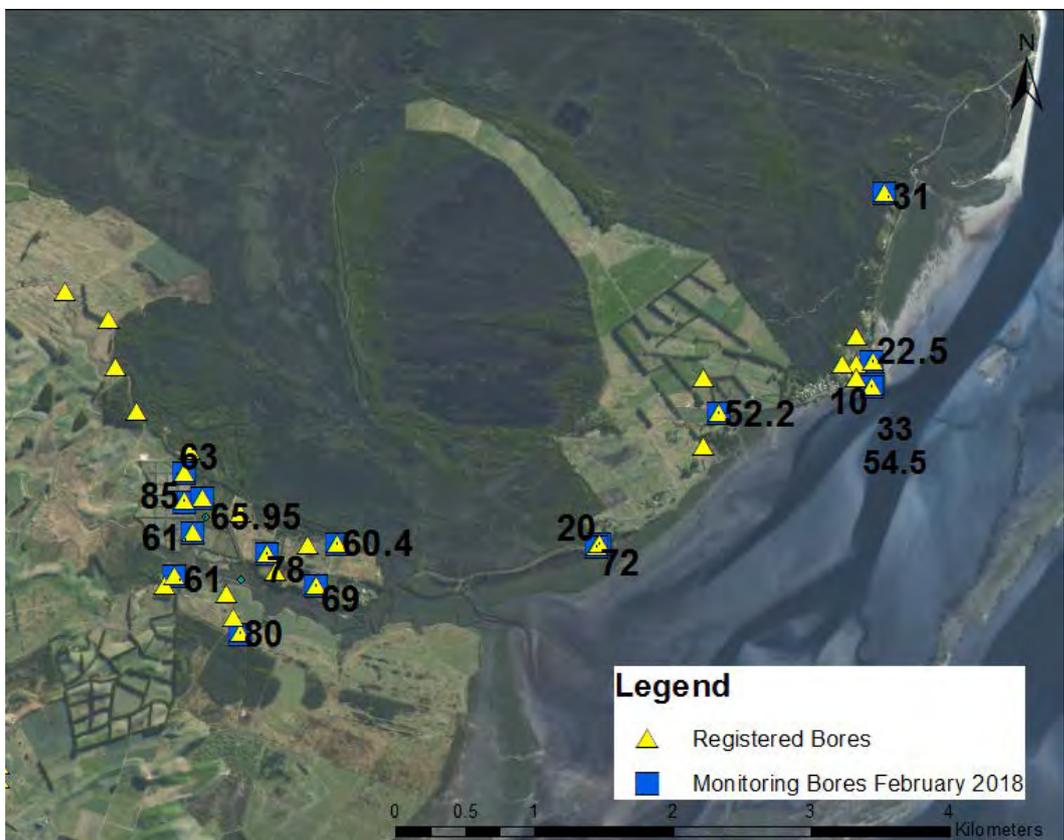


Figure 11 Depth of the Selected Monitoring Bores (metres below ground level)

Results of Monitoring

Summary details of the construction and lithology of the selected monitoring bores and the groundwater quality monitoring results are provided in Appendix 1.

The key points to note from the monitoring results to date are summarised below.

The bicarbonate, chloride, sodium, magnesium and conductivity levels for Bore A (54.5m bgl) are provided in Table A. These levels are highly elevated and within 80% of the typical values for undiluted seawater reported in the New Zealand Guidelines for the Monitoring and Management of Sea Water Intrusion Risks on Groundwater. pdp 2011.

Table 2. Bore A Monitoring Result Compared to Typical Composition of Seawater

	Chloride g/m3	Conductivity mS/m @25 deg C	Calcium g/m3	Magnesium g/m3	Bicarbonate g/m3 HC
Bore A (Early February)	16000	4835	460	1200	170
Range of values recorded at selected monitoring sites (20-21 February)	45 to 76	27 to 55.5			
Typical major ion composition in Seawater. pdp 2011	1900	4800	410	1350	142

The conductivity measured for Bore B (36m bgl) is also elevated at 4,115 mS/m @ 25 deg C.

All other samples collected by the Council in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand 2006, show conductivity ranging from 27 to 55.5 mS/m and chloride concentrations ranging from 45 to 76 g/m3. These levels are reasonably typical for the freshwater in the Aupouri sand and shell system.

The monitoring suggests the saline water is localised in extent along the Rangaunu Harbour foreshore. Bore F and Bore E are drilled to similar depths as Bore A and Bore B, respectively. Bore F is located 1.4 kilometres east of Bore A, while Bore E is located 1.2 km south west of Bore A. Bore E and Bore F do not show elevated chloride or conductivity levels.

The monitoring also suggests a steep vertical change in the saline indicators at Bore A. Generally, an interface zone exists between the freshwater in an aquifer and sea water. This zone is an area of mixing between the two water types. The depth of this interface zone can be simplistically estimated using the Ghyben-Herzberg Equations. This equation calculates the interface zone relative to the head of freshwater above mean sea level. The presence of such elevated conductivity levels at 36 m bgl suggests the groundwater level for this site would be near mean sea level.

The groundwater levels of Bore A, B and C were recorded at the time of drilling. These levels suggest that the deeper bores have a lower groundwater level than the shallow

bore. This is inconsistent with the Council's new SoE groundwater level monitoring bores located approximately 2 km south west of the Bores A, and the multi-level piezometers near the coast at Houhora and Paparore. These sites show increasing groundwater levels with depth indicating discharge towards the coast.

Future work relating to the saline monitoring at Kaimaumu

The Council is undertaking a relative level survey in the Kaimaumu area in April to determine the groundwater level relative to mean sea level for key saline monitoring bores. This will enable assessment of the interface relationship at Bores A and B and will also provide an improved understanding of the localised groundwater flow direction in the Kaimaumu area.

Further assessment including an electromagnetic survey for the area between Bores G to E is also being considered by the Council. Such a survey would assist in delineating the extent of elevated saline water and any faults in the area.

APPENDIX 1

Summary of Bore Details and Water Quality Results for Saline Monitoring Bores February 2018

Survey Reference	Sampling Site ID	Bore Log ID	Screen Interval(mb.gl)	Drillers general description of lithology at screen and overlying geology	Specific Conductivity mS/m @25 deg C	Chloride g/ m ³	Dissolved Calcium	Dissolved Magnesium	Bicarbonate	Comment
A	LOC.318896	317504	51 - 54.5	Shell (layers of sand /clayey sand above)	4835	16000	460	1200	170	Bore decommissioned Sample collection /storage not in accordance with National Sampling Protocol i.e. sample not chilled.
B	N/A	317504	33 - 36	Fine sand (layers of sand/clayey sands above)	4115					Saltwater noted by driller and bore Decommissioned
C	LOC.318478	317504	7 - 10	Fine sand (layers of peat and sand above)	42.76	76				Sample collection/storage not in accordance with National Protocol i.e. sample not chilled.
D	LOC.318541	201593	19.2 – 22.2	Fine sand (layers of sand and sandstone above)	28.81	45				

E	LOC.318544	309384	28 - 31	Shell (layers of sand above)	45.8	60				
F	LOC.318540	201602	46 - 52	Shell & sand (layers of sand and silt)	34.99	53				
G	LOC.316185	315766	66 - 72	Fine sand with shell (layers of sand and peat above)	39.12	50	16	4.5	140	Note: sample taken on 31 Jan 18
	LOC.316184	316222	14 - 20	Sand and fine sand (layers of peat, clayey sands above)	27.72	52	12	3.4	52	Note: sample taken on 31 Jan 18
H	LOC.318539	201370	66 - 69	Shell (layers of peat and sand above)	53.8	69				
I	LOC.318538	209711	72 - 78	Shell (layers of clayey sand and sand above)	51.7	65				
J	LOC.318557	209452	54.4 - 60.4	Sand and shell (layers of peat, and sand above)	52.6	64				
K	LOC.318558	201561	58.5 - 65.5	Coarse shell (sand layers above)	53.4	65				
L	LOC.318559	209646	55 - 61	Shell gravel sand	50.4	65				

				(layers of mud and sand above)						
M	LOC.318560	315705	79 - 85	Shell (layers of peat, sand and mud above)	56.8*					Note unable to purge bore in accordance with National Protocol. *Conductivity measurement recorded at screen depth 80-85 m bgl
N	LOC.318561	209598	56 - 63	Shell and sand (layers of sand and mudstone above)	54.4	64				Hit basement at 92 m but bore screened at 63 m in productive shell.
O	LOC.318587	210481	58 - 61	Shell with sand (layers peat and sand above)	55.5	58				Limestone at 61 m? Discussed with driller who indicated this may have been consolidated shell
P	LOC.318588	210275	77 - 80	Med. sand with shell (layers of peat and sand above)	52.4	65				

Samples were collected in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand 2006 unless noted under comments.