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Groundwater resource investigations of the Western Bay of Plenty area stage 1 – conceptual geological and hydrological models and preliminary allocation assessment

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EXECUTIVE SUMMARY

Environment Bay of Plenty commissioned GNS Science to assess groundwater availability in the Western Bay of Plenty area of the Bay of Plenty.

Geological development of the area began about 4 to 5.6 million years ago with volcanism and the formation of the Coromandel and Kaimai mountains. Since then, a sequence of ignimbrites and rhyolite domes has been deposited in the area, latterly with one ignimbrite unit deposited by eruptions sourced from the Rotorua caldera. Deposition of currently preserved sediments began approximately 0.2 million years ago.

The most important aquifers in the area on the basis of water storage volumes, groundwater use and groundwater flow are:

- Tauranga Group Sediments;
- Waiteariki Ignimbrite – a volcanic unit erupted from near the Kaimai Range;
- Aongatete Ignimbrite – a volcanic unit that is not exposed at the ground surface and has a considerable thickness.

Groundwater allocation zones are useful for assessing groundwater availability and groundwater use. Groundwater allocation zones in the Western Bay of Plenty area suggested in this report are:

- thirty six surface catchments for aquifers (e.g. Tauranga Group Sediments) that have a likely connection to surface water;
- three broad geographic areas for the Waiteariki Ignimbrite aquifer and the Aongatete Ignimbrite aquifer where groundwater use is less likely to impinge on surface water flow.

Groundwater available for allocation in the Western Bay of Plenty area is estimated as 13.7 m^3/s using a water budget that includes: rainfall recharge to groundwater; surface water baseflow; groundwater discharge to the Lake Rotorua catchment from the Western Bay of Plenty area; surface water inflows to the Western Bay of Plenty area from the Kaituna River; and groundwater inflows to the Western Bay of Plenty area, possibly from the Pokopoko Stream catchment to the east of the Western Bay of Plenty. This estimate of groundwater available for allocation assumes that groundwater flow that supports surface water baseflow (an estimated 64.2 m^3/s of flow in the Western Bay of Plenty area) is not available for allocation because Environment Bay of Plenty aims to avoid depletion of stream flow by groundwater pumping.

Groundwater available for allocation in some catchments is set at zero in this report where estimated groundwater recharge is the same as, or less than, estimated water discharge. For example groundwater available for allocation is set at zero in the Wairoa hydropower scheme catchments upstream of Ruahihi power station because estimated groundwater recharge from rainfall of 14.5 m^3/s is less than estimated surface water discharge of 14.6 m^3/s.

This report suggests the groundwater available for allocation is:

- 7.2 m^3/s across thirty six groundwater zones with surface catchment boundaries. For

example groundwater available for allocation is estimated as 71 L/s in the Tauranga City catchment (groundwater zone) from Tauranga Group Sediments;
- 6.5 m^3/s across three allocation zones for Waiteariki Ignimbrite and Aongatete Ignimbrite aquifers. For example groundwater available for allocation is estimated as 3.7 m^3/s in zone WAI1, in the area between Waihi and Te Puna.

Current groundwater allocation as of January 2009 is approximately 3.4 m^3/s in the Western Bay of Plenty area. Current groundwater allocation is generally less than groundwater available for allocation.

Potential stress on the groundwater resource in 15 catchments in the Western Bay of Plenty area is indicated by groundwater allocation that is greater than 30% of estimated groundwater available for allocation or estimated use that is greater than 50% of estimated groundwater available for allocation.

Potential stress on the thermal groundwater resource is indicated by allocation that is greater than estimated groundwater available for allocation in the Otumoetai catchment.

Salt water intrusion of groundwater is an environmental limit on the use of groundwater in the Western Bay of Plenty area. Several dozen wells are identified in Environment Bay of Plenty's records that are at risk from salt water intrusion because:

- groundwater level is close to, or below, sea level; and
- chemistry data identifies a decline in water quality over time consistent with salt water intrusion.

Environment Bay of Plenty policies are key to sustainable management of the groundwater resource. Therefore, recommendations in this report include:

- Environment Bay of Plenty assess the groundwater allocation zone boundaries suggested in this report;
- Environment Bay of Plenty consider groundwater allocation limits on groundwater allocation as a proportion of groundwater available for allocation;
- risks of salt water intrusion are assessed when setting groundwater allocation limits.

Groundwater resource information is very important to sustainable management of the groundwater resource. Recommendations in this report include improvement to groundwater resource information including:

- water balance estimates of baseflow in streams are improved with a programme of low-flow stream measurements in summer with the aim of improving estimates of groundwater recharge;
- wells at risk from salt water intrusion are assessed with field measurements of well location, ground elevation, groundwater depth and also sampling for relevant water quality variables (e.g., chlorides);
- owners of wells at risk from salt water intrusion are informed about the issues of salt water intrusion to groundwater;
- Environment Bay of Plenty collect well depth information and groundwater allocation

data for consents where this information appears to be missing from the Environment Bay of Plenty groundwater allocation database;

- Environment Bay of Plenty should consider further groundwater investigations in catchments where allocation is large and is a large proportion of estimated groundwater available for allocation to improve knowledge of groundwater recharge and groundwater use. For example the groundwater allocation in the Lower Kaituna catchment is greater than groundwater available for allocation, and estimated use is a large proportion of groundwater available for allocation; groundwater resources in this area may be at risk if groundwater use increases to the rate of allocation.

1.0 INTRODUCTION

Water resources in the Western Bay of Plenty area are coming under growing pressure as both population and agricultural activity increase. For example, an assessment of surface water allocation in the late-1990s showed 16 catchments in the Western Bay of Plenty area, and 3 in the Te Puke area, were under usage pressure (Environment Bay of Plenty, 1999). Pressures on surface water resources in the area were recognised by the Bay of Plenty Catchment Commission as early as 1979 (Beca Carter Hollings and Ferner Limited, 1979).

Groundwater use in the Western Bay of Plenty area is increasing. The potential for excessive use of groundwater was recognised for the Mt Maunganui area by the Bay of Plenty Catchment Commission as early as 1981 (Beca Carter Hollings and Ferner Limited, 1981). Recent increase of groundwater use is shown by Western Bay District Council who now use groundwater for domestic water supply.

However, development of groundwater resources has been without regional estimates of groundwater availability. To avoid inadvertent over-allocation, Environment Bay of Plenty (EBOP) commissioned GNS Science (GNS) (Appendix 1) to complete a 'first-cut' assessment of groundwater availability in the Western Bay of Plenty area (Figure 1.1). This assessment is completed with a synthesis of geological information and hydrological data to estimate groundwater storage volumes and groundwater flows.

Groundwater availability is assessed in the following steps:

- identify geological units important to groundwater flow and model these units;
- estimate rainfall on catchments;
- estimate rainfall recharge on catchments;
- estimate baseflow discharge from catchments via streams;
- estimate 'shallow' groundwater recharge;
- estimate 'deep' groundwater recharge;
- estimate groundwater storage volumes;
- identify wells at risk from salt water intrusion.

Groundwater availability for use is not estimated in this report because decisions on allocation policy are required by EBOP before groundwater availability for use is established. This report estimates groundwater available for allocation in Western Bay of Plenty catchments of 13.7 m^3/s; these estimates should be a useful guide for groundwater allocation policies in the Western Bay of Plenty area. Current groundwater allocation is approximately 3.4 m^3/s or 25% of groundwater available for allocation, and estimated use is approximately 2.1 m^3/s or 15% of groundwater available for allocation, in the Western Bay of Plenty area. This report analyses groundwater levels and groundwater chemistry to assess salt water intrusion risk as this is a constraint on groundwater allocation. The report also recommends policy considerations for groundwater allocation.

2.0 GEOLOGY

2.1 Overview

The Western Bay of Plenty area consists of late Pliocene to Pleistocene sequence of volcanic rocks and volcanogenic sediments (Figure 2.1) derived from the southern Coromandel Volcanic Zone (CVZ) and the Taupo Volcanic Zone (TVZ). The oldest rocks in the stratigraphic sequence are andesite and dacite lavas of the Kaimai Subgroup, which are exposed in a restricted part of the area. The dacitic Aongatete Ignimbrite Formation was erupted after formation of the Kaimai subgroup.

Younger andesitic lavas and volcanic breccias known as the Otawa Volcanics were erupted during late Pliocene. Numerous isolated rhyolitic lava domes (termed Minden Rhyolite) have been extruded through this andesite. These domes are found scattered throughout the Western Bay of Plenty area.

Overtopping and flowing around the older Minden Domes are ignimbrites of the Waiteariki Ignimbrite. Later rhyolitic or dacitic eruptions include, in younging sequence, the Papamoa Ignimbrite, the Ongatiti Ignimbrite, the Te Puna Ignimbrite and the Te Ranga Ignimbrite and are termed the OTP Ignimbrites. These ignimbrites are mostly limited to isolated outcrops of small volume.

Later eruptions, in the early Pleistocene period, formed the Waimakariri Ignimbrite and then the Mamaku Ignimbrite. Throughout most of the Western Bay of Plenty area, these ignimbrites have been eroded, leaving the stratigraphically older Waiteariki Ignimbrite at the ground surface.

Tauranga Group Sediments consist of series of silts, sands, gravels and intercalated rhyolitic ashes and overlie older ignimbrites in the coastal margin.

The coastal part of the study area is dominated by coastal and alluvial sediments of Late Pleistocene to Holocene age.

A simplified summary of the stratigraphy of the study area is given in Table 2.1. This summary is derived from a compilation of published geological map boundaries held by Environment Bay of Plenty (Meilhac 2009). The names for stratigraphic units used in this report are those from published references. GNS Science has GIS project that is revising the geological maps of New Zealand. The revised geological map which includes the Tauranga area (Leonard and Begg in prep.) uses new formation names for some formations. Therefore some formation names used in this report will be revised in geological map of Leonard and Begg (in prep.).

Stratigraphic units of volcanic origin are described, in the following sections, from oldest to youngest. Thicknesses of stratigraphic units, or depth to stratigraphic unit, are estimated in Figure 2.2 to Figure 2.9. Thicknesses (isopachs) and depths to units are estimated from available information and this information is commonly sketchy. Therefore thicknesses and depths are estimated in a general way. Tauranga Group Sediments have a wide range of age and these will be described last.

Table 2.1 Simplified stratigraphy of the Western Bay of Plenty area.

	Stratigraphic unit		**Age**
	Tauranga Group Sediments	Modern Beach	Modern
		Holocene Sediments	Holocene
		Pleistocene Sediments (Matua Subgroup)	Pleistocene 0.22-2.18 Ma[4]
	Rotoiti Ignimbrite		Pleistocene 61 ka
	Mamaku Ignimbrite		Pleistocene 0.24 Ma[5]
	Waimakariri Ignimbrite[1]		Pleistocene 0.27 Ma[5]
	OTP Ignimbrite	Te Ranga Ignimbrite[2]	Pleistocene 0.27 Ma
		Te Puna Ignimbrite[3]	Pleistocene 0.93 Ma
		Ongatiti Ignimbrite	Pleistocene 1.34 Ma
		Papamoa Ignimbrite	Pliocene 1.90-2.40 Ma
	Waiteariki Ignimbrite		Pliocene 2.09 Ma
	Kopuairua Dacite		Pliocene 2.2 Ma[6]
	Minden subgroup rhyolite		Pliocene 1.95-2.89 Ma
	Otawa Volcanics		Pliocene 2.54-2.95 Ma
	Aongatete Ignimbrite		Pliocene 3.55-3.93 Ma
	Kaimai Subgroup		Pliocene 4.0-5.6 Ma

[1] Also termed Pokai formation ignimbrite by Karhunen (1993).

[2] Also termed Chimp formation ignimbrite by Karhunen (1993).

[3] Also termed Raepahu formation ignimbrite by Edbrooke (2005).

[4] Wilson et al. (2007).

[5] Gravely et al. (2007).

[6] Briggs et al. (2005).

2.2 Kaimai Subgroup

The Kaimai Subgroup occurs west and northwest of Tauranga Harbour and is part of the Coromandel Group that was first described by Skinner (1967). Houghton and Cuthbertson (1989) further define the Kaimai Subgroup as the Miocene – Pliocene, basaltic to dacitic, volcanic and volcaniclastic strata of the Kaimai Range.

The andesite and dacite lavas of the Kaimai Subgroup occur in a small area in the northwest of the area (Figure 2.1). The Kaimai Subgroup consists of several formations; three of which are present in the Tauranga catchment geology model - namely Waipupu, Uretara and Pukepenga. Each formation primarily consists of intermediate composition lavas (i.e. andesite to dacite) and associated pyroclastic deposits (Houghton and Cuthbertson, 1989). In the Kaimai Range, these lavas, pyroclastics and sediments are tilted to the east at approximately 20°-30° (Houghton and Cuthbertson, 1989). The tilting is a consequence of upthrust and extension along the Hauraki Fault on the western side of the Kaimai Range since ~1.34-2.09 Ma (Briggs et al., 2005). As a result of this upthrust, the oldest Kaimai Subgroup rocks exposed at the surface are located on the western side of the range.

The Kaimai Subgroup is inferred to have formed as part of an active terrestrial volcanic arc. The age of the Kaimai Subgroup has an age of 4.0 to 5.6 Ma. The subgroup is a deposit of the Coromandel Volcanic Zone.

Thickness data for the Kaimai Subgroup are estimated based on geophysical measurements that indicate the contact between the volcanic strata and the Mesozoic greywacke basement at approximately 1400 m below the western Kaimai Range. The slope of the top of the Kaimai Subgroup is assumed to be similar to its slope at the ground surface (20°-30°) and is extrapolated (Figure 2.2) beneath the overlying ignimbrites and sediments in the Tauranga basin.

2.3 Aongatete Ignimbrites

Due to the limited exposure of the Aongatete Ignimbrites, the primary interpretation of this deposit has come from drill holes. During the investigative drilling for the Kaimai Tunnel, a series of cores were taken to examine the geotechnical and lithological aspects of the country rock. One drill hole (ES 100) penetrated 290 m of the Aongatete Ignimbrites and did not reach the base of the sequence (Houghton and Cuthbertson, 1989). The lithology of the deposit in this drill hole is a sequence of non-welded to densely welded (lenticulite) units indicating the presence of at least 3 separate ignimbrite flow units. The Aongatete Ignimbrites are dacitic and contain common andesite lava accessory lithics in the ignimbrite matrix.

Recent $^{40}Ar/^{39}Ar$ age data for the Aongatete Ignimbrites have significantly adjusted the age of the deposit to 3.55 to 3.93 Ma (Briggs et al., 2005) from the previous age of ~0.9 Ma (Kohn, 1973). This new date range for the deposit confirms the interpretation of Houghton and Cuthbertson (1989) that the ignimbrite sequence was erupted over a long period of time (based on the presence of paleosol development and interbedded sedimentary deposits) and is therefore a composite of several distinct pyroclastic flow units.

Cross sections through the Kaimai Tunnel project by Houghton and Cuthbertson (1989) and data from a drillhole to the east suggest the Aongatete Ignimbrites thicken to the east towards Tauranga (Healy, 1969; Houghton and Cuthbertson, 1989). An isopach map (Figure 2.3) for Aongatete Ignimbrite assumes the location of the eruption that produced this unit is in the southern CVZ.

A source for the ignimbrite is very difficult to identify because the unit has limited exposure. However, based on the abundance of andesite lava lithics that are petrographically similar to Kaimai Subgroup lavas, the source of the ignimbrite sequence was probably in the Kaimai area of the southern CVZ (Houghton and Cuthbertson, 1989; Briggs et al., 2005).

2.4 Otawa Volcanics

The Otawa Volcanics is a collective term for the predominantly andesite unit exposed at the ground surface on the lava complex of the Papamoa Range to the southeast of Tauranga Harbour. The lava and volcanic breccias of these rocks are hornblende and biotite-bearing, porphyritic basaltic andesite to andesite (with minor dacite) (Briggs et al., 1996). Originally, these rocks were mapped as the Beeson’s Island Volcanics by Healy et al. (1964) which were later incorporated into the Coromandel Group (Skinner, 1967; 1986) of Miocene age. However these rocks are too young to be included in the Miocene (24-5 Ma) and could not be included in the Coromandel Group. Therefore, Briggs et al. (1996) reassigned the name Otawa Volcanics after the name of the trig station within the Papamoa Ranges. The Otawa Volcanics are younger than the Aongatete Ignimbrites and stratigraphically older than Minden Rhyolite and occur over most of the Western Bay of Plenty area.

The age of the Otawa Volcanics was determined by K-Ar ages by Stipp (1968) as between 2.54-2.95 Ma. The andesite complex is likely to be formed by a series of overlapping and coalescing lavas and pyroclastics. An andesite cone probably occupied a much larger area than the present outcrop suggests; this cone has been overtopped by successive pyroclastic flows and has been dissected by significant erosion. The depth to Otawa Volcanics (Figure 2.4) is estimated assuming a symmetrical andesite cone in the subsurface.

Information on the depth to the Otawa Volcanics is poor. We estimate the likely thickness of the andesite lava pile to be no more than 2 km based on experience gained from recent geothermal drilling in andesite lavas in the TVZ and using modern analogues e.g. Mt Ruapehu. Andesite lava flows probably reached as far east as Te Puke and as far west as Maungatapu. These lava flows have been buried since deposition by younger ignimbrites derived from TVZ, Kaimai and Tauranga.

2.5 Minden Rhyolite

Minden Rhyolite is a collective term for all rhyolite lava domes in the Coromandel/Bay of Plenty region with a mineral assemblage of hypersthene, hornblende and biotite (Houghton and Cuthbertson, 1989). These lavas are of late Miocene to Pliocene age and occur as isolated, steep-sided topographic highs on the Whakamarama and Mamaku plateaus (Adams et al., 1994). These lavas range from medium to high-silica rhyolites.

Minden Rhyolites have been heavily eroded and incised and exhibit a range of lava flow textures. These lavas are commonly flow-banded and spherulitic, and have retained some portions of the weak, pumiceous carapace e.g. Mangatawa, Upuhue and Mt Misery domes (Briggs et al., 1996).

The age of the Minden Rhyolites ranges from 1.95 Ma to 2.89 Ma and are thought to unconformably overlie the Aongatete Ignimbrites throughout the Western Bay of Plenty area. In this study, the base of each lava dome is interpreted to rest on a surface developed on Aongatete Ignimbrite. Note there is a long time between the age of the youngest Aongatete Ignimbrite and the age of the oldest Minden Rhyolite. The location of the Minden Rhyolites may be related to basement faults as there is a general NNE trend in the alignment of the eastern domes (Healy et al., 1964). There are no surface traces of basement faults, but there are numerous basement faults mapped by seismic reflection profiles offshore in Bay of Plenty (Davey et al., 1995).

The surface outcrop of the Minden Rhyolites has been modified by erosion and subsequent pyroclastic flow burial. A complete distribution of each lava flow/dome is difficult to determine, furthermore a significant amount of smaller lava flows/domes have probably been buried by later pyroclastic flows derived from Tauranga, Kaimai and northern TVZ.

The depth to Minden Rhyolites is estimated assuming a youthful dome shape in the subsurface (Figure 2.4). The extent of the proposed rhyolite domes is drawn to extend the lateral extent of each dome so that the dome has a flat base on the Aongatete Ignimbrites surface.

2.6 Waiteariki Ignimbrite

The Waiteariki Ignimbrite is a non-welded to densely welded ignimbrite consisting of 3 primary subunits with an estimated age of 2.09 Ma (Briggs et al., 2005). The lower and upper subunits of the ignimbrite are predominantly non-welded, with a moderate to very densely welded (lenticular) middle subunit. The upper subunit is biotite-bearing and is extensively vapour phase altered (Briggs et al., 1996). The source of the Waiteariki Ignimbrite is considered to be the southern CVZ (Briggs et al., 2005).

Surface outcrop of the Waiteariki Ignimbrite is uncommon despite Waiteariki Ignimbrite lying immediately beneath the surface over a wide area (Houghton and Cuthbertson 1989). Borehole data within the Western Bay of Plenty area is used to construct an isopach map (Figure 2.5) of the ignimbrite in the study area. Data has been compiled from boreholes in New Zealand map sheet T14 (Kaimai) where Houghton and Cuthbertson (1989) describe the distribution of the Waiteariki Ignimbrite in the area. They describe two boreholes on each side of the Hauraki Fault where the Waiteariki Ignimbrite is approximately 225 m thick on the western side and 180 m thick on the eastern side. Therefore the ignimbrite flowed into the Hauraki Plains. The Waiteariki Ignimbrite has been downfaulted beneath the Hauraki Plains in the west and uplifted and tilted (3°-5°) east of the Hauraki Fault to form the Whakamarama Plateau (Briggs et al., 1996).

Cross sections drawn by Harmsworth (1983), based on data from Healy et al., (1964) and Healy (1967), show a tilted surface of the ignimbrite that extends into the Tauranga basin. Flows of the ignimbrite are shown to have overtopped and flowed around the older Minden Domes (Briggs et al., 2005).

Harmsworth (1983) analysed borelogs where the Waiteariki Ignimbrite was intersected and on a regional scale map, providing thickness data for the ignimbrite in the Western Bay of Plenty area. These data points are used in construction of the isopach map (Figure 2.5).

The distribution of the ignimbrite is drawn assuming a Kaimai source area (Briggs et al. 2005) with local thinning on and around older volcanic centres e.g. the Otawa Volcanics.

2.7 OTP Ignimbrites

The Papamoa Ignimbrite was first described by Healy et al. (1964), but was later redefined in more detail by Hughes (1993). Originally mapped as one unit, Hughes (1993) divided the Papamoa Ignimbrite into upper and lower units. Lower Papamoa Ignimbrite contains a variety of juvenile components including basalt to rhyolite scoria and pumice in a fine ash matrix. Upper Papamoa Ignimbrite contains only a single pumice type (rhyodacite) set in a cream to grey, ash matrix. The boundary between the upper and lower ignimbrites is gradational (Hall, 1994).

Geochemically, the composition of the ignimbrite spans a wide range in SiO_2, K_2O and Zr content. However, in a broad sense, the ignimbrite has a close geochemical affinity with rhyolite and dacite domes of the Mangatawa Group (Briggs et al., 2005)

The composite Papamoa Ignimbrite is confined to the foothills and valleys of the Papamoa Ranges. This ignimbrite generally forms prominent bluffs that have a gentle dip and thin to the north (Briggs et al., 1996); it overlies the Papamoa Ranges, and onlaps the Kopukairua Dacite dome. It has an age of 1.90-2.40 Ma (Briggs et al. 2005) and its geochemical affinity to the neighbouring rhyolite domes of the Mangatawa Group domes suggests local derivation; it was probably moderately widespread prior to extensive erosion.

Due to the limited distribution of the ignimbrite in the Tauranga Catchment and the absence of drillhole evidence for the ignimbrite in the subsurface, an isopach map (Figure 2.6) is compiled based solely on the outcrop locations. The ignimbrite is estimated to be less than 100 m thick with a gradual thinning to the margins of the flow units.

2.8 Waimakariri Ignimbrite

The source of the Waimakariri Ignimbrite is assigned to the location of a gravity anomaly beneath the Mamaku Plateau to the north of Mamaku township (Lynch-Blosse, in prep).

The Waimakariri Ignimbrite has large volume (up to 100 km^3; Houghton et al., 1995) and is widely distributed in the northern TVZ. The Waimakariri Ignimbrite is partially welded and stratigraphically overlies the Whakamaru Ignimbrites in the western Mamaku plateau, the Waiteariki and Te Ranga Ignimbrites in the Tauranga basin and directly underlies the Mamaku Ignimbrite. The surface outcrop of the Waimakariri Ignimbrite, and inferred distribution, is similar to that of the Mamaku Ignimbrite.

The valley currently occupied by the Wairoa River was infilled by Mamaku and Waimakariri ignimbrites. As a consequence both the Waimakariri and Mamaku ignimbrites have been eroded by the current river system.

Throughout most of the Western Bay of Plenty area, the Waimakariri and Mamaku ignimbrites have been eroded leaving the stratigraphically older Waiteariki Ignimbrite at the surface.

The Waimakariri Ignimbrite is thickest in the area of McLaren Falls and Pyes Pa Rd (Briggs et al., 1996). In this area, the ignimbrite is in excess of 40 m thick and locally up to 50 m thick.

A map of Waimakariri Ignimbrite thickness (Figure 2.7) is drawn from unit thicknesses measured on surface exposures at outcrops. The distribution of the Waimakariri Ignimbrite is drawn assuming a similar distribution as the Mamaku Ignimbrite, with flows around the Otawa Volcanic complex (Briggs et al., 1996).

2.9 Mamaku Ignimbrite

The Mamaku Ignimbrite is a large volume (145 km^3), widely distributed, ignimbrite in the northern TVZ (Milner et al., 2002) erupted from the Rotorua Caldera. The Mamaku Ignimbrite is non-welded to densely welded, stratigraphically overlies Waimakariri Ignimbrite. Overlying the ignimbrite is a series of thin, Okataina and Taupo volcano-derived tephras. The surface outcrop of the Mamaku Ignimbrite has been dissected by recent stream development into the non-welded and unconsolidated upper subunit.

The Mamaku Ignimbrite has been studied in detail by Milner (2001). However neither Milner et al. (2002), nor previous authors, attempted to compile an isopach map for the Mamaku Ignimbrite. Therefore it was necessary to use data from published ignimbrite-producing eruptions e.g. the 26.5 ka Oruanui Ignimbrite (Wilson, 2001) as a proxy for the distribution of the Mamaku Ignimbrite. An isopach map (Figure 2.8) is compiled for the composite ignimbrite deposit incorporating recent published data on borelogs along with a series of seismic reflection profiles (Lamarche, 1992).

The Mamaku Ignimbrite is very thick in the Rotorua catchment due to the proximity to the Rotorua source caldera. Rogan (1982) analysed an airborne gravity survey of the TVZ and in turn Rotorua Caldera, and concluded a maximum thickness of Mamaku Ignimbrite of greater than 1 km immediately north of Rotorua City. Assuming a maximum 1 km thickness of ignimbrite occupying the primary caldera depression, the thickness of the ignimbrite is estimated to logarithmically decay with distance from the source. This assumption forms the basis of the isopach map.

2.10 Rotoiti Pyroclastics

The Rotoiti pyroclastics include a diverse range of pyroclastic fall and flow deposits. The Rotoiti Breccia Formation, also referred to as the Rotoiti Ignimbrite, the underlying and mantling Rotoehu Ash Member and the Matahi Basalt Tephra member comprise the Rotoiti Tephra Formation of Froggatt and Lowe (1990).

The major part of the volume of the eruption with a volume of greater than 50 km^3 (Nairn, 1981; Froggatt and Lowe, 1990) is represented by Rotoiti Ignimbrite. The distribution of the Rotoiti pyroclastics suggests that they were erupted from a vent lineament in the northern part of Haroharo Caldera from vents that are now concealed by younger lavas and pyroclastic deposits (Schmitz and Smith, 2004). The age for the Rotoiti eruption is 61 ± 4 ka (Wilson et al., 2007).

2.11 Tauranga Group Sediments

Tauranga Group Sediments consist of alluvial and estuarine sediments, tephra, postglacial sand dunes, estuarine deposits and alluvial fans, which fill the Tauranga basin. Various subgroups and formations within the Tauranga Group Sediments range in age from Pleistocene to recent (2.18 Ma to modern day, Houghton and Cuthbertson, 1989).

The oldest subgroup is the Matua Subgroup. Defined by Houghton and Cuthbertson (1989), the Matua Subgroup consists of alluvial gravel, sand, silty clay, and peat; estuarine silt and mud; and minor marine beach sand with shell fragments, interbedded with ignimbrite and tephra erupted from the Taupo Volcanic Zone. The sediments are composed of reworked pumiceous ignimbrite and ash, and clasts of local rhyolite and andesite (Houghton and Cuthbertson, 1989).

Matua Subgroup occurs in the coastal section of the study area, where it overlies Waiteariki Ignimbrite, andesite and buried domes of Minden Rhyolite. It has a wide range in age and is defined as all the sedimentary deposits that post-date the Waiteariki Ignimbrite and pre-date the Mamaku Ignimbrite (Houghton et al., 1995). The Matua Subgroup is classified as Pleistocene Sediments in Figure 2.1.

Much of the Matua Subgroup was deposited in an ephemeral braided river environment. Episodes of fluvial erosion and deposition commonly followed emplacement of pyroclastic flow and airfall deposits, indicating strong volcanic control on sedimentation. Glacio-eustatic sea level changes during Pleistocene also influenced sedimentation; for example by creating variations in the areal extent of pyroclastic deposits available for erosion (Brathwaite and Christie, 1996).

Matua Subgroup is directly overlain by a thick sequence of postglacial tephra beds, often 3-5 m of ash and tephras derived from the Taupo Volcanic Zone. These are followed by sedimentary deposits originating from the erosion and reworking of pyroclastic deposits.

Coastal and alluvial sedimentation formed low terraces, coastal sand dune complexes, barrier islands and tombolos which now part of the landscape. Modern dunes and beach sand (e.g. Kear and Waterhouse, 1961) have developed on present-day beach berms and on Matakana Island (Shepherd et al., 2000). The sediment consists mainly of well sorted and rounded fine sand derived mainly from erosion of rhyolitic pyroclastic deposits. These are referred as Modern Beach in Figure 2.1.

An isopach map for Tauranga Group Sediments (Figure 2.9) is compiled from borelogs referenced in Table 2.2 located at: Waihi Beach, Athenree Quarry, Katikati, Omokoroa and Te Puke areas. Other references relevant to Tauranga Group Sediments include: Schofield (1958), Bay of Plenty Catchment Board and Regional Water Board (undated), Carryer (1978), Groundwater Consultants New Zealand Limited (1984) and Groundwater Consultants New Zealand Limited (1985a). There is considerable lateral variation in thickness of these sediments. Most of the sediment is considered to have been derived from erosion of distal ignimbrites interbedded within Tauranga Group Sediments (Houghton and Cuthbertson, 1989). An isopach map of Tauranga Group Sediments is compiled and then related to relative elevation based on stratigraphy and surface outcrop (Figure 2.9).

Tauranga Group Sediments are thickest at the coast. For example these sediments under Matakana Island are estimated to exceed 300 m thickness.

Table 2.2 Summary of borelogs describing the Tauranga Group Sediments.

Bore Name	Location	Depth[1] (mbgl)	Lithologies	Reference
various	Athenree	0 - 220	Sediments	Groundwater Consultants New Zealand Limited (1987)
New North Well	Athenree Quarry	0 - 112	Interlayered/mixed rhyolite, andesite (boulders), pumice and silt; varying hardness; varying degrees of weathering	CH2M Beca Ltd January (2003)
WSZ6	Baker Road, Wharawhara	15 - 115	Interlayered Conglomerate and Ignimbrite	CH2M Beca Ltd December (2004)
WSZ3	Rea Road, Katikati	0 - 85	Interlayered clay, silt, sand, siltstone, sandstone, conglomerate (with fine sandy matrix) and ignimbrite	CH2M Beca Ltd November (2002)
WSZ4	Rea Road, Katikati	0 - 123	Interlayered clay, silt, sand, siltstone, sandstone, conglomerate (with fine sandy matrix) and ignimbrite	CH2M Beca Ltd November (2002)
Aongatete Bore	Omokoroa	0 - 16		CH2M Beca Ltd November (2000)
Omokoroa Bore	Omokoroa	0 - 15	Interlayered clays and silts, rare siltstone	CH2M Beca Ltd November (2000)
Ohourere Bore	Ohourere	0 - 5	Clay, silt and sand	CH2M Beca Ltd November (2000)
Te Puke Bore	Te Puke	0 - 169	Alluvium. Layered Tephra and alluvium.	CH2M Beca Ltd October (1999)
Bayliss Bore	Te Puke	0 - 25	Weathered Tephra	CH2M Beca Ltd May (2001)
ESZ8	Pongakawa	0 - 84	Residual Soils. Interbedded Terrace Alluvium, Ignimbrite and Airfall Tephra.	CH2M Beca Ltd March (2005a)
ESZ3	Te Puke	103	Wash-drilled, no recovery (into sediments?)	CH2M Beca Ltd March (2005b)
ESZ4	Te Puke	100	Wash-drilled, no recovery (into sediments?)	CH2M Beca Ltd March (2005b)
ESZ5	Te Puke	100	Wash-drilled, no recovery (into sediments?)	CH2M Beca Ltd March (2005b)
ESZ6	Te Puke	15	Residual Soils	CH2M Beca Ltd March (2005b)
Obs-ESZ9	Te Puke	80	Wash-drilled, no recovery (into sediments?)	CH2M Beca Ltd March (2005b)
various	Te Puke	120 - 140	Pumiceous Terraces	CH2M Beca Ltd July (1999)

[1] Depths are in metres below ground level (mbgl).

2.12 Other ignimbrite units

Three ignimbrite units are not included in the model of regional-scale geology. Observations of the Ongatiti, Te Ranga and Te Puna ignimbrites are quite limited in surface outcrop. Therefore it is difficult to determine the subsurface extent of the deposits.

The 1.34 Ma Ongatiti Ignimbrite is the product of a caldera-forming eruption of the Mangakino Volcanic Centre (Wilson et al., 1984; Briggs et al., 2005). This rhyolitic ignimbrite is one of the most voluminous eruptive units in the TVZ. In general, the ignimbrite is partially to densely welded and is crystal-rich. In the Bay of Plenty region, the Ongatiti Ignimbrite has been found in only one location: in the middle reaches of the Wairoa River north of McLaren Falls. At this location, the ignimbrite forms columnar jointed cliffs over a small area.

The Te Ranga Ignimbrite is a locally-derived, small volume (<5 km^3) ignimbrite that is 0.27 million years old (Briggs et al., 1996; 2005). This dacite/rhyolite ignimbrite is light grey, non-welded, crystal-poor with a sandy texture. The deposition of this ignimbrite occurs in valleys. The ignimbrite ponded in valleys and flowed over high points and only a thin deposit remains.

The outcrop area of the Te Ranga Ignimbrite is centred around a possibly paleo-river valley where the present Wairoa River is located. This ignimbrite is approximately 30 km^2 in area with a thickness in excess of 5-10 m (Briggs et al., 1996). The Te Ranga Ignimbrite has not been described outside of the Tauranga basin and therefore a local source has been suggested.

The Te Puna Ignimbrite is a small volume (<5 km^3) non-welded to partially welded, buff brown ignimbrite that is 0.93 million years old (Briggs et al., 1996; 2005). This rhyolitic ignimbrite contains white to grey fibrous pumice and common rhyolite lava lithics with a groundmass of cuspate, lunate and y-shaped glass shards set in a yellowish matrix. The distribution of the Te Puna Ignimbrite is limited to isolated outcrops near the mouth to the Waiora River, on Te Puna Station Road and in coastal sections in Tauranga Harbour. The outcrops are generally less than 20 m thick and do not form obvious topographic highs.

3.0 HYDROGEOLOGY

3.1 Review of hydrogeological investigations that include pump test data

3.1.2 The Waihi – Omokoroa area

Waihi Test Production Well (Groundwater Consultants, 1989)

Location
The investigation is located immediately west of Waihi Beach township, on Waihi Beach Road.

Scope
The purpose of the drilling programme was to install a 200 mm diameter test production well (WB4) and two multilevel piezometers (WB5 and WB6) and to evaluate the test production well.

This report provides construction details, geological logs, pump test results and groundwater quality measurements (Table 3.1).

Table 3.1 Investigations undertaken at Waihi, Athenree and Athenree Quarry.

Investigations		Availability	Report
Waihi Beach			
Geology	Borehole logs	YES	Groundwater Consultants, 1989
	Particle size analyses	NO	Groundwater Consultants, 1989
Hydrogeology	Historic records	NO	Groundwater Consultants, 1989
	Pump test: airlift	YES	Groundwater Consultants, 1989
	Pump test: stepped rate & recovery	YES	Groundwater Consultants, 1989
	Pump test: constant rate & recovery	YES	Groundwater Consultants, 1989
Geochemistry	Water quality	YES	Groundwater Consultants, 1989
	Water age testing	NO	Groundwater Consultants, 1989
Modelling	Groundwater flow	NO	Groundwater Consultants, 1989
Athenree township			
Geology	Borehole logs	YES	Groundwater Consultants, 1985b
	Particle size analyses	NO	Groundwater Consultants, 1985b
Hydrogeology	Historic records	NO	Groundwater Consultants, 1985b
	Pump test: airlift	NO	Groundwater Consultants, 1985b
	Pump test: stepped rate & recovery	YES	Groundwater Consultants, 1985b
	Pump test: constant rate & recovery	YES	Groundwater Consultants, 1985b
Geochemistry	Water quality	NO	Groundwater Consultants, 1985b
	Water age testing	NO	Groundwater Consultants, 1985b
Modelling	Groundwater flow	NO	Groundwater Consultants, 1985b
Athenree Quarry			
Geology	Borehole logs	YES	Woodward-Clyde (1991)
	Particle size analyses	NO	Woodward-Clyde (1991)
Hydrogeology	Historic records	NO	Woodward-Clyde (1991)
	Pump test: airlift	NO	Woodward-Clyde (1991)
	Pump test: stepped rate & recovery	YES	Woodward-Clyde (1991)
	Pump test: constant rate & recovery	YES	Woodward-Clyde (1991)
Geochemistry	Water quality	NO	Woodward-Clyde (1991)
	Water age testing	NO	Woodward-Clyde (1991)
Modelling	Groundwater flow	NO	Woodward-Clyde (1991)
Athenree Quarry			
Geology	Borehole logs	YES	CH2M Beca Ltd (January 2003)
	Particle size analyses	NO	CH2M Beca Ltd (January 2003)
Hydrogeology	Historic records	NO	CH2M Beca Ltd (January 2003)
	Pump test: falling head	YES	CH2M Beca Ltd (January 2003)
	Pump test: stepped rate & recovery	YES	CH2M Beca Ltd (January 2003)
	Pump test: constant rate & recovery	YES	CH2M Beca Ltd (January 2003)
Geochemistry	Water quality	YES	CH2M Beca Ltd (January 2003)
	Water age testing	NO	CH2M Beca Ltd (January 2003)
Modelling	Groundwater flow	YES	CH2M Beca Ltd (January 2003)

Significant Results

Geology:

- fractured rhyolite (aquifer) between 56.5 and 105 mbgl, overlain by sediments.

Hydrogeology:

- static water level (SWL): approximately 10 mbgl;
- transmissivity: 1.6 x 10^{-2} m^2/s (pumping test: stepped rate and constant rate);
- well yield 2000 m^3/day is estimated as sustainable for up to two months.

Geochemistry:

- water quality parameters within health guidelines except pH;
- taste, odour and colour absent from groundwater.

Conclusions

The production aquifer is in fractured rhyolite:

- transmissivity is estimated at 1400 m^2/day;
- well yield 2000 m^3/day is estimated as sustainable for two months but long-term sustainable yield is likely to be less than this;
- water quality is excellent.

Athenree town water supply (Groundwater Consultants, 1985b)

Location

The investigation is located in the Athenree township area and is associated with a reduction in yield from the existing town supply well.

Scope

The purpose of the project is to assess the fractured rhyolite aquifer, assess a reduction in yield from the existing town supply well, and investigate sites for a new bore to supply the town.

This report provides a summary of the geological setting, descriptions of pump tests, results from a resistivity survey, construction details, geological logs, pump test results and groundwater quality measurements (Table 3.1).

Significant Results

Geology:

- fractured rhyolite (aquifer) between 132 and 196 mbgl, overlain by sediments and rhyolite.

Hydrogeology:

- static water level (SWL): unknown;
- transmissivity: 1×10^{-3} to 1.54×10^{-3} m^2/s (pumping test: stepped rate and constant rate);
- maximum well yield 785 m^3/day is estimated;
- new, properly constructed, well may yield 1500 m^3/day.

Conclusions

The production aquifer is in fractured rhyolite:

- transmissivity is estimated at 1400 m^2/day;
- well yield maximum 785 m^3/day is estimated.

Athenree Quarry wells – assessment of yields (Woodward-Clyde 1991)

Location

The investigation is in Athenree Quarry, adjacent to State Highway 2.

Scope
The report described the results of pumping tests carried out on two production wells to evaluate production.

This report provides construction details, geological logs and pump test results (Table 3.1).

Significant Results
Geology:
- fractured rhyolite (aquifer) and ignimbrite between 3 and 277 mbgl overlain by clay.

Hydrogeology:
- static water level (SWL): 31 – 35 mbgl;
- transmissivity: 4.6 x 10^{-3} to 5.3 x 10^{-3} m^2/s, or 400 to 460 m^2/day (pumping test: stepped rate and constant rate);
- storativity: 2 x 10^{-4} to 7 x 10^{-4} m^2/s;
- drawdown in pumped wells is significant;
- well yield up to a maximum of 1920 m^3/day in well 1 and up to a maximum of 3600 m^3/day in well 2;
- the existing wells were not capable of pumping at these maximum rates.

Conclusions
The production aquifer is in fractured rhyolite:
- transmissivity is estimated as up to 460 m^2/day;
- well yield up to a maximum of 1920 m^3/day in well 1 and up to a maximum of 3600 m^3/day in well 2.

Athenree Quarry Production Well Completion Report (CH2M Beca Ltd, January 2003)

Location
The investigation bore is located at Athenree Quarry on the north edge of the Tauranga Harbour.

Scope
An existing well was lowered to test the possibility of increasing yields and therefore cope future water demand in the area.

This report provides construction details, results of pumping testing and updated 3D modelling of the new north well at the quarry, Table 3.1.

Significant Results
Geology:
- fractured rhyolite (aquifer) between 112 and 260.3 mbgl, overlain by interlayered/mixed rhyolite, andesite (boulders), pumice and silt.

Hydrogeology:
- static water level (SWL): 40 mbgl;
- hydraulic conductivity: 1 x 10^{-6} m/s (falling head), 8 x 10^{-6} m/s (pumping test: stepped rate), 9 x 10^{-6} m/s (pumping test: constant rate);
- transmissivity: 1 x 10^{-3} m/s (pumping test: stepped rate), 1.54 x 10^{-3} m^2/s (pumping test: constant rate);

- storativity: 2.3 x 10^{-4} (pumping test: constant rate);
- well yield 42 L/s ('present abstraction rate').

Geochemistry:
- standards met, except for turbidity, total iron, total manganese and faecal coliform. Contaminations from drilling/testing and possibly from surface water are considered.

Modelling:
- the new North well has a greater production capability than the well it replaced. Modelling indicates that constant discharge rates of 35 L/s from the New North Well and 20 L/s from the South Well should be sustainable over the long term.

Conclusions

The storativity value indicates the aquifer is confined. According to CH2M Beca (January 2003):
- flows in the quarry are highly dependent on vertical or near vertical fractures, which have a small degree of connectivity;
- flow between fractures appears to be severely limited;
- recharge to the aquifer is most likely horizontal flow via fractures from the central, thicker part of the aquifer and not vertical leakage from overlying material and surface waters.

Wharawhara Road Production Wells Completion Report (CH2M Beca Ltd, December 2004)

Location

The investigations described in this report were located on Wharawhara Road (see also CH2M Beca Ltd, October 2000), close to Katikati on the NW edge of the Tauranga harbour.

Scope

Investigations were conducted into the ignimbrite and andesite aquifers of the area: four observation bores (Ob-WSZ6, Ob-WSZ7, Ob-WSZ8, Ob-WSZ9) and three production bores (WSZ7, WSZ9, WSZ10) were drilled. This report provides a description of fieldwork, testing, analysis and design of the bores undertaken over the period October 2003 – July 2004 in the Western Water Supply Zone, Table 3.2.

Table 3.2 Investigations undertaken, Wharawhara Rd production wells.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	5 logs
	Particle size analyses	YES	
Hydrogeology	Historic records	NO	
	Pump test: falling head	YES	
	Pump test: stepped rate & recovery	YES	
	Pump test: constant rate & recovery	YES	15 days
Geochemistry	Water quality	YES	
	Water age testing	YES	
Modelling	Groundwater flow	YES	Updated

Significant Results

Geology:

- volcanic deposits dominated by ignimbrite and andesite lava flows with interlayered andesite flow and breccia.

Hydrogeology:

- hydraulic conductivity:
  Ignimbrites: 6×10^{-7} m/s (falling head pump test);
  Andesite: 1.4×10^{-5} m/s (falling head pump test), 8.8×10^{-5} to 1.9×10^{-4} m/s (constant rate pump test);
- transmissivity:
  Andesite: 3.9×10^{-3} m^2/s to 8.8×10^{-3} to 1.9×10^{-4} m/s (pumping test: constant rate);
- storativity:
  Andesite: 2.1×10^{-5} to 5×10^{-2} (pumping test: constant rate)

Geochemistry:

- compliance of all analysis with the 2000 drinking water standards, except sulphide during long term pump test (>0.05mg/l).

Conclusions

No significant water-bearing horizons were identified in the ignimbrite sequence by CH2M Beca (2004). Two separate andesite flow sequences (40-80m depth and 90-120m depth) were identified as potential aquifers for extraction of water for public water supply. Analyses suggest that little interference exists between the different bores intercepting the same andesitic aquifer (CH2M Beca, 2004).

Tahawai Production Well (Western Supply Zone). Contract No.03/1017 - Completion Report (CH2M Beca Ltd, November 2003)

Location

The investigations described in this report concern bores located at Tahawai.

Scope

This report presents the construction and testing of a temporary test well and the subsequent completion as a production well. These investigations (Table 3.3) are the first stages at evaluating the aquifer productivity in the region.

Table 3.3 Investigations undertaken, Tahawai production well.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	1 log
	Particle size analyses	YES	
Hydrogeology	Historic records	NO	
	Pump test: falling head	YES	
	Pump test: stepped rate & recovery	YES	10 hours
	Pump test: constant rate & recovery	YES	15 days
Geochemistry	Water quality	YES	
	Water age testing	NO	
Modelling	Groundwater flow	YES	

Significant Results

Geology:

- the area is dominated by ignimbrites. A limited aquifer was encountered from 43 to 99 mbgl and an aquifer suitable for further testing was encountered at 125 mbgl.

Hydrogeology:

- hydraulic conductivity: 2.5 x 10^{-6} to 3 x 10^{-6} m/s (falling head), 1 x 10^{-5} m/s (pumping test: stepped rate), 3 x 10^{-6} m/s (pumping test: constant rate);
- transmissivity: 7 x 10^{-4} m^2/s (pumping test: stepped rate), 2.2 x 10^{-4} m^2/s (pumping test: constant rate);
- storativity: 6 x 10^{-5} (pumping test: constant rate).

Geochemistry:

- all parameters comply with the 2000 drinking water standards.

Modelling:

- a groundwater flow model was constructed to assess aquifer resources and sustainable discharge rates.

Conclusions

Short term and long-term sustainable aquifer yield were assessed by modelling (CH2M Beca Ltd, November 2003).

Central Supply Zone Production Wells (Contract No.55/556) - Completion Report (CH2M Beca Ltd, July 2003)

Location

Two of the wells described in this report are located at Omokoroa and one at Ohourere, on Matakana Island.

Scope

Three new production wells are drilled on Matakana Island in the Central Water Supply Zone (CSZ). This report provides a record of the construction and testing of three production wells for water supply to the CSZ, Table 3.4.

Table 3.4 Investigations undertaken, Central Supply Zone production wells.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	3 logs
	Particle size analyses	NO	
Hydrogeology	Historic records	NO	
	Pump test: falling head	YES	
	Pump test: stepped rate & recovery	YES	
	Pump test: constant rate & recovery	YES	
Geochemistry	Water quality	YES	
	Water age testing	NO	
Modelling	Groundwater flow	YES	

Significant Results

Geology:

- strong, fractured, flow-banded rhyolite.

Hydrogeology:

- hydraulic conductivity: 1×10^{-6} m/s to 6×10^{-7} m/s (falling head), 7.4×10^{-6} m/s to 8.2×10^{-6} m/s (pumping test: constant rate);
- transmissivity: 1.5×10^{-3} m^2/s to 1.7×10^{-3} m^2/s (pumping test: constant rate);
- storativity: 6×10^{-5} to 1.7×10^{-3} (pumping test: constant rate).

Geochemistry:

- all parameters other than turbidity, total iron and total manganese are below limits. Faecal coliforms exceeded limits in two bores.

Modelling:

- the 3D groundwater model developed in Stage 3 was updated to incorporate new data from the pumping test.

Conclusions

Omokoroa wells are likely to reach good production yield, while the Ohourere well is likely to reach small yields (less than 10 L/s or less than 5 L/s). However, all sites are suitable for groundwater production according to CH2M Beca Ltd (July 2003).

Modelling allowed testing the sustainable production yields for the two Omokoroa wells over time and predicting drawdowns.

The location for new wells is discussed in order to optimise discharge from the aquifer.

Groundwater Options for Water Supply Stage 4: Rea Road - Report (CH2M Beca Ltd, November 2002)

Location

Investigations are conducted at Rea Road, Katikati.

Scope

Two sites (WSZ3, WSZ4) are investigated to identify suitability for groundwater abstractions, Table 3.5.

Table 3.5 Investigations undertaken, Rea Road.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	2 logs
	Particle size analyses	NO	
Hydrogeology	Historic records	NO	
	Pump test: falling head	YES	
	Pump test: stepped rate & recovery	YES	Only in ignimbrite aquifer
	Pump test: constant rate & recovery	YES	Only in ignimbrite aquifer
Geochemistry	Water quality	YES	
	Water age testing	NO	
Modelling	Groundwater flow	NO	

Significant Results

Geology:

- Ignimbrite and andesite aquifers.

Hydrogeology:

- hydraulic conductivity:
  Ignimbrite: 1.03×10^{-6} m/s to 3.48×10^{-6} m/s (falling head), 4.93×10^{-6} m/s (pumping test: stepped rate), 1.54×10^{-6} m/s (pumping test: constant rate);
  Andesite: 4.16×10^{-6} m/s to 3.85×10^{-7} m/s (falling head);
- transmissivity: ignimbrite 4.24×10^{-4} m^2/s (pumping test: stepped rate), 1.52×10^{-4} m^2/s (pumping test: constant rate);
- storativity:
  Ignimbrite: 1.03×10^{-6} (pumping test: stepped rate), 9.96×10^{-4} (pumping test: constant rate).

Geochemistry:

- all parameters, other than total iron and faecal coliforms, complied with the 2000 drinking water standards.

Conclusions

Full investigations of these aquifers were not possible, but CH2M Beca Ltd (November 2002) indicate that the two sites are likely to prove a viable source of water for public water supply.

Water quality appears suitable for public water supply with minimal treatment.

3.1.2 The Te Puke – Maketu area

Pongakawa Production Well - Completion Report (CH2M Beca Ltd, March 2005a)

Location

This report presents the establishment of two production wells and one observation borehole (back-filled) along Maniatutu Road, Pongakawa.

Scope

A series of deep pumping wells are investigated throughout the region to replace existing surface water supplies with groundwater for public water supply. This report presents the drilling, testing and implementation of one production well (Table 3.6).

Table 3.6 Investigations undertaken, Pongakawa production well.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	3 logs
	Particle size analyses	YES	
Hydrogeology	Historic records	NO	
	Pump tests (falling head & 24h pumping)	YES	
	Pump test: stepped rate & recovery	YES	10 hours
	Pump test: constant rate & recovery	YES	14 days
Geochemistry	Water quality	YES	6 days pumped WQ test
	Water age testing	YES	
Modelling	Groundwater flow	YES	

Significant Results

Geology:

- terrace alluvium overlying ignimbrite and airfall tephra, overlying ignimbrite (Mamaku Ignimbrite?). Two aquifers have been identified: an alluvial aquifer (60-100 mbgl) and an ignimbrite aquifer (>100 mbgl).

Hydrogeology:

- pump test of well. Well ESZ8 screened in tephra/alluvium/ignimbrite. Alluvium predominates in the screened section;
- hydraulic conductivity: 1 x 10^{-5} m/s (24h pumping), 3 x 10^{-5} m/s (pumping test: constant rate);
- transmissivity: 1 x 10^{-3} m^2/s (24h pumping), 3 x 10^{-3} m^2/s (pumping test: constant rate);
- storativity: 1 x 10^{-3} (pumping test: constant rate).

Geochemistry:

- all parameters other than total iron and manganese comply with the 2000 drinking water standards. Manganese is of concern only in the deep ignimbrite aquifer.

Modelling:

- a groundwater flow model was used to assess the effects of pumping on groundwaters and identify a long-term sustainable pumping rate.

Conclusions

CH2M Beca (2005b) assess short term and long-term sustainable aquifer yield by modelling.

Mutton's Production Wells - Completion Report (CH2M Beca Ltd, March 2005b)

Location

This report presents the establishment of three production wells and four observation bores constructed along No 1 Rd, Te Puke, in the vicinity of the Mutton's Farm Water Treatment Plant.

Scope

A series of deep pumping wells are investigated throughout the region to replace existing surface water supplies with groundwater for public water supply. Three boreholes were completed (ESZ3, ESZ6, ESZ9) as production wells and four as observation wells (ObESZ3, ObESZ4, ObESZ5, ObESZ9), Table 3.7.

Table 3.7 Investigations undertaken, Mutton's production wells.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	5 logs
	Particle size analyses	NO	
Hydrogeology	Historic records	NO	
	Pump tests (falling head & 24h pumping)	YES	
	Pump test: stepped rate & recovery	YES	5 hours
	Pump test: constant rate & recovery	YES	15 days
Geochemistry	Water quality	YES	
	Water age testing	YES	
Modelling	Groundwater flow	YES	Updated

Significant Results

Geology:

- sequence of non-welded ignimbrites interlayered with ash and alluvial horizons. A marine siltstone occurs beneath the aquifer system at a depth of approximately 220m.

Hydrogeology:

- pump tests of wells ESZ3, ESZ6 and ESZ9. Wells are screened in non-welded ignimbrite (predominantly) including sands, and also welded ignimbrite in the depth range 118 m to 205 m below ground surface;
- hydraulic conductivity: 1 x 10^{-6} m/s to 8 x 10^{-8} m/s (falling head pump test), 1 x 10^{-5} m/s to 5 x 10^{-6} m/s (24h pumping), 1 x 10^{-6} m/s to 1 x 10^{-5} m/s (pumping test: stepped rate), 4 x 10^{-6} m/s to 2 x 10^{-5} m/s (pumping test: constant rate);
- transmissivity: 2 x 10^{-3} m^2/s to 4 x 10^{-4} m^2/s (24h pumping), 3 x 10^{-4} to 5 x 10^{-3} m^2/s (pumping test: stepped rate), 3 x 10^{-4} m^2/s to 1.5 x 10^{-3} m^2/s (pumping test: constant rate);
- storativity: 1 x 10^{-3} (24h pumping).

Geochemistry:

- all parameters other than total iron, manganese, sulphide and faecal coliform comply with the 2000 drinking water standards.

Modelling:

- the 3D model of groundwater flow developed previously has been updated with new data information collected during this investigation campaign.

Conclusions

CH2M Beca (March 2005b) use a groundwater flow model to predict short-term (104 L/s) and long term production capacity (85 L/s). They also observe interference between boreholes.

Groundwater Options for Water Supply – Maketu Bore (CH2M Beca Ltd, June 2001)

Location

The investigated bore is located at Maketu (bore no.626).

Scope

An existing hole (79 mbgl) was investigated and lowered to 102.7 mbgl to reach a lower aquifer sought to be more suitable for public water supply (Table 3.8).

Table 3.8 Investigations undertaken, Maketu bore.

Investigations		Availability	Remarks
Geology	Borehole logs	YES	1 log
	Particle size analyses	NO	
Hydrogeology	Historic records	NO	
	Pump test: falling head	NO	
	Pump test: stepped rate & recovery	NO	
	Pump test: constant rate & recovery	NO	
Geochemistry	Water quality	YES	
	Water age testing	NO	
Modelling	Groundwater flow	NO	

Significant Results

Geology:

- permeable materials (alluvial sands, silts and gravels) without confining layer suitable to provide aquifer protection.

Hydrogeology:

- static Water level (SWL) was recorded at 57.9m bgl;
- maximum discharge: 1.2 L/s from the existing bore and 3 L/s from the new bore (lower aquifer).

Geochemistry:

- water quality of the upper aquifer is acceptable, although iron concentrations exceed guideline values. The lower aquifer appears contaminated by saline water and was therefore sealed.

Conclusions

Well yield in the upper aquifer is low. An increased yield could be obtained in the lower aquifer, which is however subject to seawater intrusion. CH2M Beca Ltd (June 2001) therefore recommended that Maketu bore remain unused at this stage.

3.2 Hydraulic properties

Six potentially important groundwater-bearing formations have been identified in the Western Bay of Plenty. These are (from oldest to youngest):

- Aongatete Ignimbrite;
- Minden Rhyolite;
- Waiteariki Ignimbrite;
- OTP Ignimbrites;
- Mamaku Ignimbrite;
- Tauranga Group Sediments.

A summary of hydraulic properties described in the literature is presented in Table 3.9. Transmissivities of the identified materials near wells in various aquifers are quite variable, with 10 to 850 m^2/d for sediments, up to 800 m^2/d for ignimbrite rocks and up to 1400 m^2/d for rhyolite.

Table 3.9 Summary of aquifer hydraulic properties.

Unit name	Transmissivity (m^2/d)	Storativity	Reference
Aongatete Ignimbrite	10 to 100	2.5×10^{-4} to 4.5×10^{-4}	Gordon, 2001
Aongatete Ignimbrite	19 to 61	6×10^{-5}	CH2M Beca Ltd, November 2003
Aongatete Ignimbrite	8.6 to 173	1×10^{-3}	CH2M Beca Ltd, March 2005b
Aongatete Ignimbrite	13 to 86	1.03×10^{-6} to 9.96×10^{-4}	CH2M Beca Ltd, November 2002
Minden Rhyolite	500 to 1400	2×10^{-4} to 7×10^{-4}	Gordon, 2001
Minden Rhyolite	130 to 150	6×10^{-5} to 1.7×10^{-3}	CH2M Beca Ltd, July 2003
Waiteariki Ignimbrite	10 to 100	no data	Gordon, 2001
OTP Ignimbrites	350 to 800	2.5×10^{-3} to 7.5×10^{-4}	Gordon, 2001
Mamaku Ignimbrite	up to 700	no data	Gordon, 2001
Tauranga Group Sediments	850	4.5×10^{-2}	KRTA (1982), mean from pump test
Tauranga Group Sediments	10 to 100	no data	Gordon, 2001
Tauranga Group Sediments	86 to 260	1×10^{-3}	CH2M Beca Ltd, March 2005a

3.3 Groundwater levels

Groundwater level data for wells in the Western Bay of Plenty area are available in several EBOP records. In many cases, such data are limited to only one or a few observations for each well at different times. In contrast, EBOP conducts routine water level monitoring in 54 wells in the Western Bay of Plenty as a part of its Natural Environmental Regional Monitoring Network (NERMN). NERMN data are used to evaluate groundwater levels in the Western Bay of Plenty area because of the quality of the record. The locations of these 54 wells are indicated in Figure 3.1. A summary of relevant information about these wells and the results of statistical analysis of data from them is provided in Appendix 2. In five cases involving a total of 15 wells, from between two and four wells are installed in nests at the same location but with open intervals or screens at different depths.

Water level measurements are made in the NERM wells on a quarterly basis. For most of the wells, measurements commenced in the mid-1980s (1984 through 1987) or 1990 but in one case (a well near the coast at Mt. Maunganui) data go back to 1975. Additionally, data loggers collecting daily water level measurements are installed in four of these wells.

Relevant information on each well provided in Appendix 2 includes the EBOP well number, New Zealand map grid (NZMG) coordinates, the number of water level measurements available as of early-2006, and the time frame for those measurements. Water level data are statistically analyzed using the Excel computer program to calculate the minimum, median, mean, and maximum water levels for the data from each well. These results are tabulated in Appendix 2. In general, there were outliers in the data for many of the wells. Because of this, median values provide the best indication of central tendency. The data were also plotted using the computer program Grapher. Graphical plots were visually assessed and quantitatively assessed using linear regression to determine indications of trends in water levels. In most cases (43 of the 54 wells or 80 percent), there was no indication of a trend for the time frame involved (i.e., the trend is classified as “horizontal”). For the other eleven wells, indications of rising or falling water level trends are nearly evenly split with five falling and six rising.

Ground elevations for each well are determined from GNS’s digital terrain model (DTM) of the Western Bay of Plenty area using well location coordinates. Assuming water level measurement reference points are similar to ground elevations, an assumption that is considered generally satisfactory for the scale involved, representative groundwater elevations are calculated by subtracting median groundwater levels. Well depth information is available for 53 of the 54 wells (it was not available for EBOP well number 3020 near the coast at Papamoa). Taking these data into consideration and using the DTM and other geologic information, these 53 wells are categorized as being within one of the following geologic units (in order from youngest to oldest):

- Tauranga Group Sediments;
- Waiteariki ignimbrite; and
- Aongatete ignimbrite.

The locations of wells in each geologic unit are indicated in Figure 3.1. Median groundwater elevation data from wells in each of these three units is contoured using Version 8 of the computer software Surfer and the kriging method assuming a linear variogram.

Groundwater levels are below, or close to, sea level in 19 wells (Table 3.10 and Figure 3.2). Therefore some wells may be at risk from salt water intrusion to groundwater. However, the accuracy of ground-level estimates cannot be assessed. For example ground level estimates used for calculating groundwater elevations derived from a DTM are dependent on:

- accurate horizontal locations;
- accurate conversions of topo map contours, estimated at a 20 m interval, into a regularised grid of topographic estimates.

It is therefore recommended that ground elevations and groundwater depths be checked with an accurate survey before conclusions are drawn about the risk of salt water intrusion to groundwater in the Western Bay of Plenty area. (A cross-check of the level and time trend of relevant water quality variables would also be useful).

Median groundwater levels in Tauranga Group Sediments wells and the contours from them (Figure 3.3) show that the direction of groundwater flow is generally to the north or northeast (with the exception of the northwest part of the area) and towards the coast. Groundwater elevations in some wells in the Tauranga Group Sediments are below sea level (EBOP well numbers 1520 and 1686, Table 3.10).

Groundwater elevation contours for wells in the Waiteariki Ignimbrite (Figure 3.4) are broadly similar to those for the overlying Tauranga sediment wells and also indicate that the direction of groundwater flow is to the north or northeast (with the exception of the northwest part of the area) and towards the coast in this unit. Since groundwater elevations may be below sea level near the coast (e.g., EBOP well numbers 2393 and 2838, Table 3.10), some wells in this unit may be at risk from salt water intrusion.

Groundwater elevation contours for wells in the Aongatete Ignimbrite (Figure 3.5) are broadly similar to those in the overlying two units. The direction of groundwater flow in the Aongatete Ignimbrite is to the north or northeast (with the exception of the northwest part of the area) and towards the coast. Groundwater elevations may be below sea level (e.g., EBOP well number 90, Table 3.10) and some wells in the Aongatete Ignimbrite near the coast may be at risk from salt water intrusion.

Table 3.10 Wells with groundwater levels below sea level or potentially below sea level.

EBOP well number	NZMG Easting	NZMG Northing	Median GW depth mBTOC	Ground elevation[1] mAMSL	Median GW elevation mAMSL	Assessment of median GW elevation	Comments	Geological Unit
90	2771660	6412750	30.28	30	-0.28	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
307	2788990	6383800	21.52	16-20	-5.52 to -1.52	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite
410	2811100	6367000	35.99	35	-0.99	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
1386	2788310	6382990	31.76	20-30	-11.76 to -1.76	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite
1468	2785130	6388070	14.71	0-10	-14.71 to -4.71	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
1520	2814780	6374110	26.77	20	-6.77	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
1566	2773640	6390110	31.92	30	-1.92	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite
1686	2777300	6391190	5.36	0-5	-5.36 to -0.36	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2303	2770200	6399200	3.33	0-10	-3.33 to 6.67	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite
2328	2766400	6396600	32.96	20	-12.96	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite

EBOP well number	NZMG Easting	NZMG Northing	Median GW depth mBTOC	Ground elevation[1] mAMSL	Median GW elevation mAMSL	Assessment of median GW elevation	Comments	Geological Unit
2330	2772920	6405440	30.17	20-36	-10.17 to 5.83	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2393	2784480	6385120	27.81	20-30	-7.81 to 2.19	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite
2707	2807520	6379440	4.49	2-10	-2.49 to 5.51	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2829	2770650	6414140	23.8	20-30	-3.8 to 6.2	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
2838	2772680	6396970	3.65	0-10	-3.65 to 6.35	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
2843	2791390	6390910	6.56	0-5	-6.56 to -1.56	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2847	2792370	6387990	1.91	0-10	-1.91 to 8.09	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
3020	2799920	6384300	2.00	0-5	-2.00	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
3462	2785220	6388230	8.39	2-5	-6.39	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Unknown (no bore depth)
3465	2787030	6388460	19.12	18-20	-1.12	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Unknown (no bore depth)
3467	2788830	6387550	0.53	0	-0.53	below sea level	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Waiteariki Ignimbrite

EBOP well number	NZMG Easting	NZMG Northing	Median GW depth mBTOC	Ground elevation[1] mAMSL	Median GW elevation mAMSL	Assessment of median GW elevation	Comments	Geological Unit
2522-1	2769740	6401600	3.28	0-10	-3.28 to 6.72	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Aongatete Ignimbrite
2522-2	2769740	6401600	6.67	0-10	-6.67 to 3.33	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2522-3	2769740	6401600	6.66	0-10	-6.66 to 3.34	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments
2522-4	2769740	6401600	6.75	0-10	-6.75 to 3.25	*below or possibly above sea level*	median groundwater elevation calculated by subtracting median groundwater depth to ground elevation determined from 1:50,000 map	Tauranga Group Sediments

[1] ground elevation determined from 1:50,000 topographic map

3.4 Groundwater quality

Groundwater quality data is assembled from three data sources to identify 171 wells in the Western Bay of Plenty area with groundwater chemistry suitable for interpretation:

- EBOP 'Wells' database data mostly collected by the former Bay of Plenty Catchment Commission;
- National Groundwater Monitoring Program (NGMP) wells;
- EBOP Natural Environmental Regional Monitoring Network (NERMN) database.

EBOP provided GNS with groundwater quality data mostly collected by the former Bay of Plenty Catchment Commission (Gordon, pers. comm.) specific to the Western Bay of Plenty area including several wells in close proximity to the Western Bay of Plenty boundary. These data were collected by well drillers (Gordon, pers. comm.) and supplied to EBOP with the drillers log, or as part of the water permitting process, by the former Bay of Plenty Catchment Commission. These data have been entered into EBOP's 'Wells' database along with drillers logs. Most of the samples were taken in the 1980s and, with the exception of one sample taken in September 1998, all were taken in, or before, April 1992. The data does not include analyses of all samples taken by drillers since April 1992 and many wells have been drilled in the area since April 1992. This database is unusual with regard to the variables for which samples were analysed. Reported analysis for the rare element tantalum in samples from most wells is a striking feature of this data. There is no evident reason why analysis for tantalum would be requested in groundwater samples. A check of the original data in one of the Bay of Plenty Catchment Commission water permit files shows that data currently entered as tantalum were measured as alkalinity (Gordon pers. comm.). The dataset has no data entries for alkalinity. Therefore it appears the dataset field for alkalinity has become corrupted as result of database changes over the years (Gordon pers. comm.). Bay of Plenty Catchment Commission 'Wells' database groundwater chemistry data 'tantalum' entries are not used in the analysis of groundwater chemistry data.

The analysis of Bay of Plenty Catchment Commission 'Wells' database groundwater chemistry data excludes wells for which there are only minimal data. Wells not considered in the analysis include wells with: 1) only field measurements for temperature, dissolved oxygen (DO), or pH; and 2) wells for which only one or two variables were recorded. These most often involve the variable chloride (the data have a column heading of "chlorine" which was assumed to actually mean chloride), but occasionally it was iron and/or manganese.

A total of 146 wells in the Bay of Plenty Catchment Commission 'Wells' database data set are considered to have data that is suitable for interpretation. For example wells with multiple analytes such as major anions and cations are suitable for interpretation. One hundred of these wells have only single samples and 46 of these wells have multiple samples.

Groundwater chemistry analyses from two National Groundwater Monitoring Program (NGMP) wells within the Western Bay of Plenty area (Daughney and Reeves, 2006) are included in the analysis of groundwater chemistry.

EBOP provided GNS with its Natural Environmental Regional Monitoring Network (NERMN) database (Zemansky, 2006). The NERMN database started in 1990 and covers all routinely monitored wells within the entire EBOP region. The NERMN database includes 35 wells in the Western Bay of Plenty area (i.e., classified by EBOP as within the Tauranga basin, the Te Puke-Maketu area, or the Coastal Plain); 10 of these wells have some chemistry measurements in the Bay of Plenty Catchment Commission 'Wells' database data set and the two NGMP wells are included in the database. The NERMN database includes data for the time period 1990 through 2005.

The combined dataset includes groundwater chemistry in 171 wells (Appendix 3). The wells in the groundwater chemistry dataset are given unique identification (ID) numbers so that plots of well locations are easier to read; EBOP identification numbers are four digit numbers and plots of four digit well identification numbers are more difficult to read.

Locations of these 171 wells are shown in Figure 3.6. Figure 3.6 also indicates the geologic unit from which each well draws water. The three units involved, from youngest to oldest, are:

- Tauranga Group Sediments;
- Waiteariki Ignimbrite;
- Aongatete Ignimbrite.

Altogether, there are 583 samples in the database for these 171 wells. However, only single samples are available for 100 of these wells. Multiple samples (i.e. two or more samples on different dates) are available for 71 wells. The greatest number of samples is 36 from well ID 159 (EBOP well number 3045, an NGMP well at Te Puke). NGMP wells have the most samples although there have been some missed sampling dates for these wells. The NGMP well ID 159, (EBOP well number 3045) has been sampled on a quarterly basis over the period 1991 through 2005. The NGMP well ID 168, (EBOP well number 4364) has been sampled on a quarterly basis over the period 1996 through 2005. The wells having the next-most samples are EBOP NERMN wells. Most of EBOP NERMN wells were sampled on an annual basis during the 1991 through 2005 period although some sampling dates are missing for these wells.

All groundwater quality data are organized into three groups. These are presented as "Field and Miscellaneous Data" and "Nutrients" in Appendix 3, "Major Cations" and "Major Anions" in Appendix 4, and "Other Elements" in Appendix 5. For those 71 wells with multiple samples, median values were calculated and it is these that are listed in Appendices 8, 9, and 10. Also shown in those appendices are: well ID, the EBOP well number, New Zealand map grid (NZMG) easting and northing coordinates (calculated from map references), the number of samples involved ("Sam"), and the date of sampling or date range for wells with multiple samples for each well.

Complete major ion data are available for only 47 of the 171 wells (27 percent). Locations of these 47 wells are indicated in Figure 3.7. Values for these (median values for wells having multiple samples) are separately listed in Appendix 6. In addition, charge balance errors (CBE) and water type based on single or median values, as appropriate, are also presented. CBEs show a small predominance of anions. Despite the use of median values, the mean CBE is a relatively small and acceptable –1.27. The predominant water type is the combination of sodium bicarbonate (eight wells, or 17% of the 47 wells) and sodium bicarbonate-chloride (21 wells, or 45% of the 47 wells).

Groundwater quality data are evaluated in several ways. First of all, median concentrations are contoured in an effort to look for distributional patterns. This contouring is performed using Version 8 of the computer program Surfer. As noted above, the geographic distribution of wells provides reasonable coverage of the Western Bay of Plenty area where data are available for most or all of the wells; however, in some cases of more limited data this may not have been the case (e.g., nitrate-nitrogen, sulfate, and bicarbonate where data were only available for less than 50 percent of all wells). Secondly, for the 47 wells with complete major ion data (see Appendix 6 and Figure 3.7), Piper and pie map plots are produced. These are prepared using Version 5 of the computer program AquaChem. Additionally, grouping the wells by the three geologic units (i.e., Tauranga, Waiteariki, and Aongatete), median unit values are calculated for each variable.

The most noticeable pattern in the contours for water quality variables is the indication of relatively low concentrations inland with concentrations increasing for wells closer to the coast. This is particularly evident for conductivity (see contoured conductivity data as presented in Figures 3.8, 3.9, and 3.10 for the Tauranga, Waiteariki, and Aongatete units, respectively) and is consistent with what might be expected given the proximity of coastal wells to the Pacific Ocean. The wells with the highest conductivity, sodium, and chloride levels are all close to the coast (well IDs 44, 96, 101, 122, 158, 160, and 162 or EBOP well numbers 1123, 2093, 2323, 2459, 3044, 3272, and 3460, respectively). Well ID 160 (EBOP well number 3272) in particular has sufficiently high conductivity, sodium, and chloride concentrations that geothermal influence and/or seawater intrusion are virtually certain (i.e., conductivity of 27,300 uS/cm and sodium and chloride concentrations of several thousands of mg/L). This value for conductivity is so high relative to values for other wells that it distorts the next-closest contours in the Waiteariki unit, as presented in Figure 3.9, tending to mask low conductivity levels in the Waiteariki unit. Conductivity in the Waiteariki unit is generally less than conductivity in the Tauranga Formation and Aongatete Ignimbrite. The temperature of water from this well is also elevated (i.e. a median of 35.9 ^{o}C).

As noted above, data from the 47 wells for which there are all major ions, are evaluated with a Piper plot and with pie mapping. Data tend to be similarly lumped without distinct groupings as can be seen in the Piper plots of Figures 3.11, 3.12, and 3.13 for Aongatete, Tauranga, and Waiteariki units and Figure 3.14 for those wells which could not be classified by geologic unit; although there are a few exceptions like well 144 (EBOP well number 2707). The sample from EBOP well number 2707 indicates more of a calcium chloride type water than a sodium bicarbonate one. This is consistent with the water type classifications as assigned by Aquachem and listed in Appendix 6. With few exceptions, the wells have water in which sodium and bicarbonate ions are the dominant constituents. There is only one exception in the case of cations (i.e., for a well where calcium is the dominant cation and sodium is secondary). There are several exceptions in the case of anions. These include wells near the coast having the highest conductivity, sodium, and chloride levels. There are also several other cases where chloride is the dominant anion and bicarbonate the secondary one. All of these cases are in close proximity to the coast. For example, the data from the sample for EBOP well number 2707 mentioned above as an exception show a water type that is dominated more by calcium and chloride than sodium and bicarbonate (EBOP well number 2707 is a shallow well in the Tauranga unit located close to the coast). This is also evident in the pie map (Figure 3.15).

Water quality data grouped by geologic unit are presented in Appendix 7. These data indicate that for most variables the quality of groundwater in the Tauranga unit is more related to the quality of groundwater in the Aongatete unit than to the quality of groundwater in the Waiteariki unit in between them. This is evident when median values for many of the variables in Appendix 7 are compared. For example, median chloride concentrations were 24 and 25 mg/L for the Tauranga and Aongatete unit wells, respectively, and 13 mg/L for Waiteariki unit wells and median concentrations of nitrate-nitrogen were 0.035 and 0.036 for the Tauranga and Aongatete unit wells, respectively, and 0.099 mg/L for Waiteariki unit wells. This circumstance was confirmed by hierarchical cluster analysis of nutrients (forms of nitrogen and phosphorus), several general water quality variables (e.g., conductivity, pH, and temperature), and major ions using Version 5.1 of the computer software StatGraphics Plus.

Two checks of data quality are available with the information on hand. These are calculated CBEs and comparison of calculated with analytically determined total dissolved solids (TDS) concentrations. Both of these checks were performed using median values. As noted above, despite the use of median values, CBE calculations generally appear to support data quality. The mean CBE was – 1.27 percent and in only 10 of the 47 wells (21 percent) did the CBE exceed a criterion of plus or minus 5 percent. The situation with regard to TDS is less favourable. There are only 12 cases where analytically determined TDS values were available and in only three of these (25 percent) was the calculated TDS closely comparable.

3.4.1 Groundwater quality trends

Time series data are plotted and linear lines of best fit calculated to evaluate trends in groundwater quality over time. In general, the available time-series water quality data indicates that water quality has remained basically unchanged over time. Based on the data, slope of the linear line of best fit, and coefficient of determination (r^2), there are only two wells having water quality variables with increasing trends and only two with decreasing trends in the Western Bay of Plenty area. These are as follows:

	EBOP well number	**Location**	**Variable**
1.	Increasing trends -		
	a. 1393	Katikati	HCO_3, PO_4-P, TP (high r^2)
	b. 2707	Papamoa	Conductivity, Ca, Mg, K, Na, Cl, SO_4 (high r^2)
2.	Decreasing trends –		
	a. 2303	Katikati	Temp, TP
	b. 4364	Tauranga	Na, HCO3, Cl, SO4, Mn (slight or very slight)

Because of its proximity to the coast, shallow depth, relatively cold temperatures, and the constant increase in multiple variables such as sodium and chloride over the period involved, the situation for EBOP well number 2707 suggests sea water intrusion. There are no obvious causes for the indicated trends with regard to the other three wells.

3.5 Groundwater temperature

Warm groundwater in the Western Bay of Plenty is used by private wells, public hot pools, glasshouses and swimming pools (Gordon 2001). Warm water bores and springs occur from

Little Waihi to Katikati with temperatures including: 30°C (Little Waihi, White 2001), 40°C-45°C (Maketu, Gordon 2001), 20°C-55°C (Tauranga City, Gordon 2001) and 39°C (Sapphire Springs, White 2001). Simpson and Stewart (1987) found no evidence that the warm waters have ever encountered high-temperature geothermal conditions. Simpson and Stewart (1987) suggest groundwater flows from high elevation recharge locations to depth, where heat is gained, and rises near the coast. Rhyolitic host rocks are identified by the groundwater chemistry of warm groundwaters (Simpson and Stewart 1987) and the aquifer is confined by Tauranga Formation sediments (Simpson and Stewart 1987).

Groundwater temperatures measured in wells may indicate groundwater flow patterns. Therefore EBOP records of groundwater temperature are modelled in three dimensions to identify the locations and extents of warm water areas and to identify groundwater flow patterns.

3.5.1 Groundwater temperature data

EBOP records groundwater temperature data in two forms: (1) temperatures reported with other water quality data for 42 wells; and (2) temperature versus depth profiles for 17 wells and, in addition, discrete depth temperatures for 9 other wells. In total, this provides a database of 68 wells for which there are groundwater temperature data (Appendix 8, Table A8.1). Well locations as NZMG easting and northing coordinates are calculated from map references and ground levels are determined from a digital terrain model.

Most of the temperature observations (Appendix 8) are between sea level and 400m below sea level.

The deepest temperature measurements are at Waihi Beach where temperature measurements to 754m below sea level are measured in well 10545. This well has temperature gradients of approximately 2.5°C per 100m of depth, i.e.

- estimated temperature at the ground surface = 15°C;
- measured temperature at 754 m depth is 34°C;
- therefore temperature gradient is (34°C-15°C)/7.54 °C/100m or approximately 2.5 °C/100m.

Temperature gradients in the Tauranga City area are greater than at Waihi. For example the vertical temperature gradient in well 3467 is approximately 12 °C/100m, i.e.

- estimated temperature at the ground surface = 15°C;
- measured temperature at 325m depth is 53°C;
- therefore temperature gradient is (53-15)/3.25 °C/100m or approximately 12°C/100m.

Relatively high groundwater temperatures (Environment Bay of Plenty 1996a), and relatively high geothermal gradients, are common in the Tauranga City area and presumably reflect ancient geothermal activity.

3.5.2 Model of temperature measurements

Observed temperatures in the Western Bay of Plenty area are modelled using the EarthVision software. The processing steps in this model are:

- generate a 30 grid model with cell size 1000m by 1000m by 20m in the elevation range ground surface to 400m below sea level;
- generate a 'faces' file and clip to the x and y extents of the data.

The model estimates that groundwater temperatures in the Tauranga City area are typically elevated consistent with observations of thermal waters in the area (Stewart et al. 1984). For example a plot of temperatures in the range 45°C to 55°C (Figure 3.16) indicates a 'dome-like' feature of elevated temperatures which, at about 300m below sea level, seems to occupy the area including Tauranga City centre, Sulphur Point, part of Otumoetai, and the Tauranga airport area (Figure 3.17). The shape of the area with a temperature of 45°C to 55°C is almost circular in plan view (Figure 3.17). However no temperature observations occur to the north-west (i.e. Matakana Island) to constrain the boundaries of the 45°C to 55°C volume. The 45°C to 55°C zone is presumably due to warm water moving upwards from depth and therefore probably corresponds to a zone of relatively high hydraulic conductivity. Elevated temperatures occur in the approximate depth interval -160 m to – 340 m.

Temperatures in the 45°C to 55°C are estimated, at around 300 m below sea level, in the Te Puna-Omokoroa area (Figure 3.17). Relatively warm temperatures in the Te Puna-Omokoroa area are possibly associated with Minden Rhyolite (Figure 2.4) of Minden Hill.

A relatively low temperature, and low temperature gradient, zone separates warm groundwater in Te Puna-Omokoroa from Tauranga City. This zone follows approximately the path of the Wairoa River. A zone of relatively high hydraulic conductivity following approximately the path of the Wairoa River may allow vertical downwards groundwater flow, or lateral groundwater flow, acting to depress temperatures at depth.

3.5.3 Temperatures and geology in the Tauranga City area

Elevated temperatures occur in the Tauranga harbour area, in the approximate depth interval -160m to -340m, i.e. below the Tauranga Group Sediments. The location of high temperature areas are identified in Otumoetai and Welcome Bay as red crosses in Figure 3.18. Elevated temperatures suggest either a good vertical permeability zone or a local heat source, such as a buried rhyolite dome or a buried caldera-like feature. Simpson and Stewart (1987) proposed a buried rhyolite dome in the Tauranga City area. Relatively low temperatures are identified as red dots in Figure 3.18 to the southwest of Otumoetai and southwest of Welcome Bay.

Evidence for dome, or caldera features, under Tauranga City is investigated here using well logs from the EBOP database and from literature (CH2M Beca Ltd, November 2000; Groundwater Consultants Ltd., 1984).

The EBOP database indicates that deep wells (greater than 250m) in the Tauranga City area are more common than in the rest of the Western Bay of Plenty. As identified with the 3D geological model, most of the wells in the Tauranga City area take water from the Waiteariki Ignimbrite and the Aongatete Ignimbrite.

A total of 346 wells, with detailed geological logs, located within 10 km of Tauranga City, are identified in the EBOP database. Individual lithological descriptions are assigned codes based on the occurrence or non-occurrence of undifferentiated volcanic rocks (including ignimbrite, rhyolite, and andesite). Sedimentary rocks of the Tauranga Group Sediments are assumed to occur where undifferentiated volcanic rocks are not observed.

Lithology codes are assigned to all well logs in the database using Excel functions to search for key words and predefined combinations of key words. The process identified that about 10% of the wells have no geological logs or incomplete geological logs. An additional five wells with detailed geological logs are compiled from the literature (wells named “Ohourere”, “N”, “64”, “52” and “56”). Estimated depths to the interface between Tauranga Group Sediments and undifferentiated volcanics are listed in Appendix 8, Table A8.2.

Observations of depths to the undifferentiated volcanics are contoured using ArcMap 9.2 and SURFER Version 8.04. Contours of the depth to the top of undifferentiated volcanics, in metres below ground level (mbgl), are presented in Figure 3.18. Figure 3.19 is a colour-coded representation of the same interface.

Undifferentiated volcanics (Figure 3.18) deepen towards the coast in the Tauranga City area, from 50 mbgl in the hills to 250 mbgl south of the Tauranga airport. Some differences between Figure 3.18 and the regional isopach map of Tauranga Group Sediments (Figure 2.9) are observed, for example:

- lithological descriptions coded as “sedimentary” are identified south of the 0 metre thickness contour in Figure 2.9 which is probably due to the presence of sediments deposited in river valleys, for example the Wairoa River valley, and/or to the erroneous assignment of ambiguous descriptions such as altered volcanic sand to the “sedimentary” code;
- depths to undifferentiated volcanic rocks of 100 to 200 m near Mt Maunganui and Omanu Beach (Figure 3.18), while the regional isopach map (Figure 2.9) indicate thicknesses of Tauranga Group Sediments between 200 and 300 metres at these locations. The regional isopach map for Tauranga Group Sediments may be adjusted following careful review of well log descriptions in the area.

Relatively high temperatures identified in the 3D temperature model (red crosses) are located on relative highs in undifferentiated volcanics (i.e. areas where Tauranga Group Sediments are relatively thin) as identified by Figure 3.18.

Relatively low temperatures at Otumoetai are located in a relative basement low. The modelled temperature low associated with Welcome Bay is located on a relative basement high as interpreted from the geological logs.

Interpretations of the surface representing the top of undifferentiated volcanics (Figure 3.18) include:

- the apparent deep structure with maximum depth around 200 m under Tauranga City,

centred at approximately Eleventh Avenue, could be interpreted as a caldera shape with the modelled highs located on the rims of the caldera;
- relative basement highs surrounded by relative basement lows may represent faulting in the undifferentiated volcanics. For example faulting in the Wairoa River valley may cause the relatively large depth to undifferentiated volcanics in the valley.

Further assessment of these interpretations, could include:

- review of geophysical data available for the area;
- check geological coding with EBOP well log descriptions of some key wells with additional descriptions available from the literature;
- model the top of undifferentiated volcanics as elevation.

4.0 WESTERN BAY OF PLENTY GEOLOGICAL MODEL

A geological model of the Western Bay of Plenty area aims to represent formations important to groundwater flows (Figure 4.1) as three-dimensional surfaces and volumes.

4.1 Model construction

Seven geological units are represented on the model:

- Tauranga Group Sediments;
- Mamaku Ignimbrite;
- Waimakariri Ignimbrite;
- Waiteariki Ignimbrite;
- Aongatete Ignimbrite;
- Minden Rhyolite;
- Kaimai Subgroup.

Estimates of formation thickness or depth (Section 2) are converted to a three-dimensional dataset describing the geology of the area using the following process:

- estimate ground elevation (Appendix 9);
- estimate formation thickness with a grid of formation thickness estimates (Appendix 10.1);
- define lateral extent of formations with boundary polygons (Appendix 10.2);
- estimate elevation of the top of each formation (Appendix 10.3);
- combine two-dimensional grids of elevation estimations and define boundary type (erosional, unconformity) (Appendix 10.4);
- convert the 500 m-grid model (Appendix 10) to a 100 m-grid model (Appendix 11).

This model development follows a similar process to a geological model development in the Lake Rotorua catchment (White et al. 2007).

4.2 Features of the geological model

The geological model (Figure 4.2) is represented as a chronology of unit emplacement from oldest unit to youngest unit.

Basement andesites (etc) of the Kaimai Subgroup (4.0 – 5.6 million years ago), are represented above an elevation of -1000 m in Figure 4.3.

Aongatete Ignimbrite (Figure 4.4) occupies the apparent basin of the basement.
Otawa Volcanics and Minden Rhyolite (Figure 4.5) are modelled as near-vertically-sided 'plugs' with geographic extents the same as the extents of surface exposure of these units. These units sit unconformably on Aongatete Ignimbrite.

Waiteariki Ignimbrite (Figure 4.6) sourced from near Kaimai Range 'flooded' much of the Western Bay of Plenty area. Deposition of some of the Tauranga Group Sediments (Figure 4.7) occurred after the Waiteariki Ignimbrite eruption. Eruptions from near Lake Rotorua deposited the Waimakariri Ignimbrite (Figure 4.8) and then the Mamaku Ignimbrite (Figure 4.9). The Waimakariri Ignimbrite and Mamaku Ignimbrite 'flooded' much of the Wairoa River Valley and much of the Kaituna River Valley (Figure 4.10).

4.3 Geological cross sections

Five cross sections (Figure 4.11) are generated from the geological model (Appendix 12). Lava feeder dikes, likely buried lavas, and intrusions not shown in these sections.

These sections are:

- Waihi Beach (Figure 4.12);
- Katikati (Figure 4.13);
- Omokoroa (Figure 4.14);
- Tauranga (Figure 4.15);
- Te Puke (Figure 4.16).

Generally, these sections show:

- Aongatete Ignimbrite is generally the formation with the greatest thickness above basement in each of the cross sections;
- the top surface of the Aongatete Ignimbrite is modelled as an unconformity (Figure 4.15 and Figure 4.16) so that Otawa Volcanics and Minden Rhyolite domes sit on this unconformity;
- the base of the Tauranga Group Sediments is modelled as deepening off the coast.

4.4 Volume calculations

The geological model is used to estimate the volume of rock (Section 4.4.1) in the Western Bay of Plenty area by catchment and by geological unit. Estimates of saturated rock volume are made (Section 4.4.2) from grids (Appendix 11) and groundwater level maps. Groundwater volume is estimated (Section 4.4.3) using saturated rock volume estimates and aquifer storativity estimates.

4.4.1 Rock volume

Volume estimates are made with two-dimensional grids representing layer boundaries and polygons representing surface shapes, as listed in Appendix 12.

Layer volumes are summarised in Table 4.1 as km^3 of rock. Aongatete Ignimbrite has the largest volume of rock in the region and Waiteariki Ignimbrite has the second-largest volume of rock in the region.

Table 4.1 Rock volume estimates.

Surface catchment (or zone) polygon	Rock volume (km^3), rounded					
	Sediments	Mamaku Ignimbrite	Waimakariri Ignimbrite	Waiteariki Ignimbrite	Otawa Volcanics and Rhyolite Domes	Aongatete Ignimbrite
Aongatete catchment	0.7	0	0	6.3	0	10
Apata catchment	0.4	0	0	1.8	0	12
Kaitemako catchment	0.1	0	0	1.7	0.7	14
Lower Kaituna catchment	23	8.7	13	34	11	245
Katikati catchment	1.9	0	0	0	0	4.7
Kopurererua catchment	0.6	0.8	4.7	16	0.1	64
Maketu catchment	1.2	0	0	0.1	0	1.2
Mangapapa catchment	0	3.5	22	40	0.4	49
Mangorewa catchment	0.1	12	38	19	0	32
Matakana catchment	22	0	0	1.3	0	67
Maungatawa catchment	7.8	0	0	4.0	2.5	51
Omanawa catchment	0	1.9	12	16	7.7	49
Ongare catchment	3.7	0	0	0	0	6.3
Otumoetai catchment	3.7	0	0	1.8	0	19
Oturu catchment	0.4	0	0	1.0	0.5	11
Tahawai catchment	0.6	0	0	0	0	1.8
Tauranga catchment	1.2	0	0	0.8	0	7.4
Te Mania catchment	0.4	0	0	0.4	0	2.8
Te Puna area catchment	0.7	0	0	0.3	0	4.2
Te Puna catchment	0.3	0	0	4.7	2.0	32
Te Rereatukahia catchment	0.3	0	0	0.3	0	1.8
Tuapiro catchment	0.4	0	0	0	0	1.3
Uretara catchment	1.0	0	0	0.4	0	4.8
Waiau catchment	1.0	0	0	0	0	1.4
Waihi catchment	1.1	0	0	0	0.2	1.5
Waimapu catchment	0.2	0.7	2.1	17	4.9	101
Wainui catchment	0.8	0	0	9.3	0	25
Waione catchment	1.5	0	0	0.4	0	5.8
Waiora – Ngawahine catchment	0	0	0.6	31	5.4	62
Waiora – Ohourere catchment	0	0	0	5.2	3.3	31
Waiora – Waiora catchment	0.7	0.2	1.4	16	1.7	70
Waipapa catchment	0.6	0	0	9.9	0.2	45
Waitao catchment	0.1	0	0	0.8	5.6	36
Waitekohe catchment	0.7	0	0	0.9	0	4.0
Welcome catchment	0	0	0	1.4	1.2	16
Whatako catchment	0.3	0	0	6.6	0	14
Mamaku 1 zone	0	32	107	104	14	283
Minden-Otawa domes (14) zone	0	0	0	0	44	155
Otawa 1 zone	0	0	0	0	18	98
Waimak 2 zone	0	29	110	120	14	313
Waimak Outcrop zone	0	0	3.3	20	0	57
Waite outcrop zone	0	0	0	82	9.0	229

Volume estimates greater than 0.1 km^3 are included and these estimates are rounded to the nearest 0.1 km^3 (volume estimates less than 10 km^3) or nearest 1 km^3 (volume estimates greater than 10 km^3).

4.4.2 Saturated rock volume

The volume of rock that is saturated with water will be less than the total rock volume where the water table is below ground level.

Estimates of water table elevation for six geological units in the Western Bay of Plenty area are described in Appendix 12 and summarised as follows:

- Tauranga Group Sediments. An elevation 0 m is assumed at the coast and water table elevation is assumed as in Figure 3.3 (extrapolated) over the surface area of the unit;
- Mamaku Ignimbrite. No wells with water levels in this unit occur in the Western Bay of Plenty area (Figure 3.1). Therefore groundwater levels are estimated using ground elevation and groundwater level data in the Lake Rotorua catchment (Appendix 12.3) where:
  Groundwater elevation = 0.98 ground elevation -65;
- Waimakariri Ignimbrite. No wells with water levels in this unit occur in the Western Bay of Plenty area (Figure 3.1). Therefore the water table elevation of the Waiteariki Ignimbrite (Figure 3.4, extrapolated) is assumed where Waimakariri Ignimbrite is exposed at the ground surface. The unit is assumed to be fully saturated where it is not exposed at the ground surface.
- Waiteariki Ignimbrite. An elevation of 0 m is assumed at the coast and water table elevation is assumed as in Figure 3.4 (extrapolated) where the unit is exposed at the ground surface. The unit is assumed to be fully saturated where it is not exposed at the ground surface.
- Otawa Volcanics and rhyolite domes. No wells with water levels in this unit occur in the Western Bay of Plenty area (Figure 3.1). Therefore the water table elevation of the Waiteariki Ignimbrite (Figure 3.4, extrapolated) is assumed where Otawa Volcanics and rhyolite domes are exposed at the ground surface.
- Aongatete Ignimbrite. This unit is assumed to be fully saturated.

Estimated saturated rock volumes (Appendix 12.4) are listed in Table 4.2.

Table 4.2 Saturated rock volume estimates.

Surface catchment (or zone) polygon	Saturated rock volume (km^3), rounded					
	Sediments	Mamaku Ignimbrite	Waimakariri Ignimbrite	Waiteariki Ignimbrite	Otawa Volcanics and Rhyolite Domes	Aongatete Ignimbrite
Aongatete catchment	0.7	0	0	1.3	0	10
Apata catchment	0.4	0	0	1.4	0	12
Kaitemako catchment	0	0	0	1.5	0.3	14
Lower Kaituna catchment	22	1.0	13	30	1.8	245
Katikati catchment	2.0	0	0	0	0	4.7
Kopurererua catchment	0.4	0	2	15	0	64
Maketu catchment	1.1	0	0	0	0	1.2
Mangapapa catchment	0	0	9	33	0	49
Mangorewa catchment	0	1.2	38	19	0	32
Matakana catchment	21	0	0	1.3	0	67
Maungatawa catchment	7.7	0	0	4.0	1.5	51
Omanawa catchment	0	0	5.3	16	4.2	49
Ongare catchment	3.5	0	0	0	0	6.3
Otumoetai catchment	3.5	0	0	1.8	0	19
Oturu catchment	0.3	0	0	1.0	0.4	11
Tahawai catchment	0.6	0	0	0	0	1.8
Tauranga catchment	1.2	0	0	0.8	0	7.4
Te Mania catchment	0.5	0	0	0.3	0	2.8
Te Puna area catchment	0.7	0	0	0.3	0	4.2
Te Puna catchment	0.2	0	0	2.8	1.0	32
Te Rereatukahia catchment	0.2	0	0	0.1	0	1.8
Tuapiro catchment	0.3	0	0	0	0	1.3
Uretara catchment	0.8	0	0	0.2	0	4.8
Waiau catchment	0.9	0	0	0	0	1.4
Waihi catchment	1.0	0	0	0	0.2	1.5
Waimapu catchment	0	0	0.8	13	0.5	101
Wainui catchment	0.9	0	0	2.8	0	25
Waione catchment	1.7	0	0	0.4	0	62
Waiora – Ngawahine catchment	0	0	0.2	15	1.8	5.8
Waiora – Ohourere catchment	0	0	0	3.8	1.3	31
Waiora – Waiora catchment	0.5	0	0	16	1.1	70
Waipapa catchment	0.6	0	0	4.8	0	45
Waitao catchment	0	0	0	0.8	1.6	36
Waitekohe catchment	0.8	0	0	0.4	0	4.0
Welcome catchment	0	0	0	1.3	0.9	16
Whatako catchment	0.4	0	0	1.7	0	14
Mamaku 1 zone	0	3.0	107	93	47	283
Minden-Otawa domes (14) zone	0	0	0	0	14	155
Otawa 1 zone	0	0	0	0	4.7	98
Waimak 2 zone	0	2.6	110	109	4.7	313
Waimak Outcrop zone	0	0	3.3*	20	0	57
Waite outcrop zone	0	0	0	38	3.7	229

* The Waimakariri Ignimbrite is estimated to be fully saturated by the Waiteariki Ignimbrite piezometric map.

4.4.3 Groundwater volume

Available groundwater volumes (Table 4.3) are estimated as the product of storativity and saturated rock volume as follows:

groundwater volume = storativity * saturated rock volume

Storativity of geological units used in this calculation were as follows:

- Tauranga Group Sediments 4.5×10^{-2} (Table 3.9);
- Mamaku Ignimbrite. No pump tests of this unit are made in the Western Bay of Plenty area. Therefore a specific capacity of 4×10^{-3} is taken from the pump test of the Dibley bore (Reeves et al. 2005, pg 26). This pump test measures the specific capacity of the main water-bearing sub unit (an unwelded ignimbrite) in the Mamaku Ignimbrite in the Lake Rotorua catchment;
- Waimakariri Ignimbrite. No pump tests of this unit are made in Western Bay of Plenty area or the Lake Rotorua catchment. Therefore a storage coefficient of 4×10^{-3} is assigned to this unit, being the storage coefficient for the Mamaku Ignimbrite;
- Waiteariki Ignimbrite. No field estimates of storage coefficient are made in this unit. Therefore a storage coefficient of 3.5×10^{-4}, being the mid-range estimate of the storage coefficient for the Aongatete Ignimbrite (Table 3.9), is assigned to the Waiteariki Ignimbrite;
- Otawa Volcanics and Minden Rhyolites. A storage coefficient of 5×10^{-4} is assigned to these units, being the mid-point estimate (Table 3.9), rounded, from pump tests;
- Aongatete Ignimbrite. A storage coefficient of 3.5×10^{-4} is assigned, being the mid-point of estimates (Table 3.9) for this unit.

Groundwater volumes, as defined here, are the maximum volumes that may be withdrawn by pumping, i.e. the maximum reservoir of groundwater in the region potentially available to pumpage. Withdrawal of the maximum available groundwater volumes is not recommended because significant environmental effects (e.g. aquifer de-watering and reductions in stream baseflows) would result.

The total of estimated groundwater volume (Table 4.4) is summed by geological unit. Tauranga Group Sediments have the largest storage volume; Aongatete Ignimbrite has the largest storage volume of the ignimbrite units.

Table 4.3 Groundwater volume estimates.

Surface catchment (or zone) polygon	Groundwater volume (million m³), rounded					
	Sediments	**Mamaku Ignimbrite**	**Waimakariri Ignimbrite**	**Waiteariki Ignimbrite**	**Otawa Volcanics and Rhyolite Domes**	**Aongatete Ignimbrite**
Aongatete catchment	32	0	0	0.5	0	3.5
Apata catchment	18	0	0	0.5	0	4.2
Kaitemako catchment	0	0	0	0.5	0.2	4.9
Lower Kaituna catchment	990	4	52	11	0.9	86
Katikati catchment	90	0	0	0	0	1.6
Kopurererua catchment	18	0	8	5.3	0	22
Maketu catchment	50	0	0	0	0	0.4
Mangapapa catchment	0	0	45	12	0	17
Mangorewa catchment	0	4.8	152	6.7	0	11
Matakana catchment	945	0	0	0.5	0	23
Maungatawa catchment	357	0	0	1.4	0.8	18
Omanawa catchment	0	0	21	5.6	2.1	17
Ongare catchment	156	0	0	0	0	2.2
Otumoetai catchment	158	0	0	0.6	0	6.7
Oturu catchment	14	0	0	0.4	0.2	3.9
Tahawai catchment	27	0	0	0	0	0.6
Tauranga City catchment	54	0	0	0.3	0	2.6
Te Mania catchment	23	0	0	0.1	0	1.0
Te Puna area catchment	32	0	0	0.1	0	1.5
Te Puna catchment	9	0	0	1.0	0.5	11
Te Rereatukahia catchment	9	0	0	0.04	0	0.6
Tuapiro catchment	14	0	0	0	0	0.5
Uretara catchment	360	0	0	0.07	0	1.7
Waiau catchment	41	0	0	0	0	0.5
Waihi catchment	45	0	0	0	0.1	0.5
Waimapu catchment	0	0	3.2	4.6	0.3	35
Wainui catchment	41	0	0	1.0	0	8.8
Waione catchment	77	0	0	0.1	0	22
Waiora – Ngawahine catchment	0	0	0.8	5.3	0.9	2.0
Waiora – Ohourere catchment	0	0	0	1.3	0.7	11
Waiora – Waiora catchment	23	0	0	5.6	0.6	25
Waipapa catchment	27	0	0	1.7	0	16
Waitao catchment	0	0	0	0.3	0.8	13
Waitekohe catchment	36	0	0	0.1	0	1.4
Welcome catchment	0	0	0	0.5	0.5	5.6
Whatako catchment	18	0	0	0.6	0	4.9
Mamaku 1 zone	0	12	428	33	2.4	99
Minden-Otawa domes (14) zone	0	0	0	0	7	54
Otawa 1 zone	0	0	0	0	2.4	34
Waimak 2 zone	0	10	440	38	2.4	110
Waimak Outcrop zone	0	0	13	7	0	20
Waite outcrop zone	0	0	0	13	1.9	80

Table 4.4 Estimated groundwater volume by geological unit.

Geological Unit	Estimated groundwater volume (million m^3)
Tauranga Group Sediments	3664
Mamaku Ignimbrite	19
Waimakariri Ignimbrite	282
Waiteariki Ignimbrite	68
Otawa Volcanics and Minden rhyolite domes	9
Aongatete Ignimbrite	387
Total	4429

4.4.3.1 Groundwater volume and groundwater supply prospects

Groundwater-bearing potential is related to storage volumes and following observations are noted for each geological unit:

- Tauranga Group Sediments are mostly saturated indicating good opportunities for groundwater supplies, however most wells in this unit yield low rates of groundwater flow (up to 13 L/s, White 2005);
- Mamaku Ignimbrite is mostly dry in the Western Bay of Plenty area. For example the rock volume of Mamaku Ignimbrite (Table 4.1, 'Mamaku 1 zone') is estimated as 32 km^3 yet the saturated volume is estimated as 3 km^3 (Table 4.2). Therefore the Mamaku Ignimbrite, particularly off the Mamaku Plateau, is an unlikely target for groundwater supply;
- Waimakariri Ignimbrite is unexplored in the Western Bay of Plenty area. This unit has large water storage volumes and has the potential to supply groundwater;
- Otawa Volcanics and Minden Rhyolite domes have relatively low storage volumes and substantial portion of dry volume. The flanks of these units, particularly where the rhyolites are saturated (e.g. underlying Tauranga Group Sediments), represent reasonable opportunities for groundwater supply.
- Waiteariki Ignimbrite. The unit has good storage volumes and produces reasonable flows from wells (up to 20 L/s, White 2005) and so has potential for groundwater supply.
- Aongatete Ignimbrite. The unit has good storage volumes and yields of around 10 – 20 L/s are common. Drawdown is commonly quite large. For example (CH2M Beca, November 2003) report 63 m of drawdown after 30 hours pumping at 15 - 20 L/s.

5.0 HYDROLOGY

5.1 Rainfall in the Western Bay of Plenty

5.1.1 Observations

EBOP holds records of rainfall at 21 rainfall recording sites and NIWA holds records of 20 sites in the area (Appendix 13, Appendix 14 and Appendix 15).

The range of mean annual rainfall at the EBOP sites (Table 5.1) is:

- minimum 1232 mm/yr, site 766101 (Tauranga City);
- maximum 2142 mm/yr, site 769302 (Kaharoa).

The standard deviation of mean annual rainfall is in the range 13% to 36% of the mean annual rainfall at each site. The standard deviation is an average of 18% of the mean indicating significant annual variability in rainfall.

5.1.2 NIWA rainfall model

NIWA have produced a model of mean annual rainfall in the area (rainfall model: annual_0050p created by Mike Ladd, 20 September 2005). This model has annual mean rainfall on a 500m by 500m grid for the Bay of Plenty region.

Table 5.1 Comparison of measured rainfall with the NIWA rainfall model.

EBOP rain gauge site	Type	Location		Mean annual rainfall observed (mm)	NIWA model annual rainfall (mm)	Altitude (m)
755903	manual	2769240	6405090	1592	1513	25
758905	"	2772570	6369970	2231	2139	274
766101	"	2789300	6387300	1232	1184	5
767201	"	2797100	6384500	1285	1277	10
767304	"	2801650	6376550	1413	1475	15
768002	"	2777850	6373350	1953	1894	95
768003	"	2780300	6366500	2076	2020	300
768103	"	2790300	6372800	2059	2044	310
768307	"	2802950	6363950	2009	1856	150
769203	"	2793500	6361400	2133	2353	380
769302	"	2801200	6354400	2142	2160	270
860303	"	2803900	6348400	1903	1861	280
861302	"	2803300	6330650	1535	1534	360
755811	automatic	2766100	6405700	1893	1778	30
757901	"	2773700	6382400	2022	2173	240
766002	"	2779200	6389000	1287	1408	10
768301	"	2806000	6373600	1288	1458	10
768310	"	2804300	6363300	1756	1851	100
769402	"	2816400	6360300	1405	1581	55
860205	"	2797100	6349300	1786	2007	420
861204	"	2796500	6333200	1430	1503	300

Annual rainfall is estimated at the locations of rain gauge sites (Table 5.1) by interpolation of the NIWA model. The difference between the observed and NIWA model-estimated annual rainfall is at most 12.3% (site 860205); the mean absolute difference between observed and estimated is 5%.

Features of the rainfall map (Figure 5.1) include:

- rainfall is approximately 1200 - 1500 mm/year at the coast;
- rainfall is generally related to elevation. For example rainfall is generally above 1800 mm/year where elevation is above around 200 m in the hills of the Western Bay of Plenty;
- rainfall is greater than 2400 mm/year on parts of the Mamaku Plateau;
- rainfall is lower in the Lake Rotorua basin than on the Mamaku Plateau but is still higher than at the coast.

5.1.3 Rainfall model error

The NIWA model provides reasonable estimates of observed annual rainfall. The error of rainfall estimate is assessed as follows:

- error of the NIWA model estimate is +/- 5%; plus
- error in mean annual rainfall is 18%, considering inter-annual rainfall variability, i.e. 1 standard deviation about the mean. A more scientifically robust analysis of errors in rainfall estimates is beyond the scope of this report.

For example, the error in a NIWA model estimated annual rainfall of 2000 mm/year is:

- +/- 460 mm/year, or +/- 23% of 2000 mm or a range of 1540 mm/year to 2460 mm/year.

The components of this error estimate are:

- +/- 100 mm/year to allow for the quality of the NIWA model i.e. 1900 mm to 2100 mm; plus
- +/- 360 mm/year to allow for inter-annual rainfall variability.

5.2 Surface Water

Surface water catchments in the region (Figure 5.2 and Figure 5.3) are mapped by EBOP in a GIS dataset.

5.2.1 Rainfall

The surface area of each catchment, and mean annual rainfall on each catchment with the NIWA rainfall model, are assessed using GIS ArcMap (Table 5.2). Mean annual rainfall is lowest in catchments near the coast (Figure 5.4 and Figure 5.5), for example the “Te Puna area” catchment has a mean annual rainfall of 1311 mm/yr. Mean annual rainfall is greatest in the hills; for example mean annual rainfall is 2256 in the Mangapapa/Opuiaki catchment.

Table 5.2 Surface water catchments, catchment areas and mean annual rainfall (mm and m^3/s).

No.	Catchment Name	Area (km^2)	Mean Annual Rainfall (mm/y)	Mean Annual Rainfall* (m^3/s)
1	Aongatete	46.0	1904.2	2.8
2	Apata	12.1	1738.0	0.7
3	Kaitemako	12.7	1576.2	0.6
4	Katikati Streams	8.7	1594.2	0.4
5	Kopurererua	74.1	1854.1	4.4
6	Lower Kaituna	398.8	1806.1	22.8
7	Maketu	2.1	1196.7	0.1
8	Mangapapa/Opuiaki	165.1	2255.8	11.8
9	Mangorewa	185.7	2193.6	12.9
10	Matakana Island	60.2	1235.1	2.4
11	Maungatawa area	46.8	1305.8	1.9
12	Omanawa	84.4	2129.2	5.7
13	Ongare/Tanners Point	14.1	1422.0	0.6
14	Otumoetai area	14.9	1254.1	0.6
15	Oturu	9.0	1484.6	0.4
16	Tahawai	11.7	1939.6	0.7
17	Tauranga City area	5.9	1218.2	0.2
18	Te Mania	13.1	2008.7	0.8
19	Te Puna	28.6	1870.3	1.7
20	Te Puna area	3.4	1310.8	0.1
21	Te Rereatukahia	18.6	2077.2	1.2
22	Tuapiro	52.2	1935.0	3.2
23	Uretara	32.9	2093.0	2.2
24	Waiau	33.3	1695.9	1.8
25	Waihi Beach	25.6	1611.5	1.3
26	Waimapu	111.7	1922.0	6.8
27	Wainui	38.5	2025.4	2.5
28	Waione	8.2	1689.4	0.4
29	Waipapa	45.3	1924.7	2.8
30	Wairoa_Ngamawahine	112.7	2154.6	7.7
31	Wairoa_Ohourere	30.2	2017.6	1.9
32	Wairoa_Wairoa	70.3	1754.7	3.9
33	Waitao area	37.3	1768.8	2.1
34	Waitekohe	21.8	1860.2	1.3
35	Welcome Bay area	14.5	1432.2	0.7
36	Whatakao	28.9	1966.4	1.8

* This value has meaning only with regard to the catchment for which it was calculated.

5.2.2 Surface water flow measurements

The EBOP gauging database holds many records of river flows (Figure 5.6). River flow is currently monitored continuously at 19 sites in the study region (Environment Bay of Plenty 2001) plus the Kaituna River catchment (Table 5.3); 13 of these sites are in the study region (Figure 5.7). Some statistics on flow rates are presented in Table 5.3. The number of flow measurement sites (continuous flow measurements and gaugings, Table 5.4) total 483 in the Western Bay of Plenty. Standard deviations of flow estimates are commonly a significant portion of mean, or median, flows. For example the standard deviation of flow at site 13309, Kauri Point, is 85 L/s and the mean and median flows at Kauri Point are 56 and 32 L/s, respectively. This indicates that considerable percentage error may be reasonably attached to estimates of stream flow central tendency. Mean flows exceed median flows in nearly all cases indicating the influence of extreme events in the distribution and indicating that median values are likely a better indicator of central tendency.

Table 5.3 Continuous flow recording sites in the study region plus the Kaituna River catchment: mean flow, standard deviation and median flow calculated from Environment Bay of Plenty data.

Site	Name	Mean Flow*	Standard Deviation*	Median Flow*
13309	Kauri Point	56 L/s	85 L/s	32 L/s
13310	Tuapiro	1862 L/s	3379 L/s	1012 L/s
13805	Waipapa	486 L/s	1045 L/s	237 L/s
13901	Mangawhai	69 L/s	115 L/s	40 L/s
14130	Wairoa (Ruahihi)	3840 L/s	14623 L/s	695 L/s
14132	Wairoa (Power Station) (TIDEDA Item 3)	11921 L/s	8852 L/s	11130 L/s
14302	Kopurererua	1874 L/s	804 L/s	1713 L/s
14410	Waimapu	2121 L/s	2633 L/s	1444 L/s
1114651	Raparapahoe	1844 L/s	2319 L/s	1277 L/s
14627	Waiari	4035 L/s	1534 L/s	3816 L/s
14628	Mangorewa	6165 L/s	5712 L/s	5217 L/s
14614	Kaitura (Te Matai)	35.7 m^3/s	10.5 m^3/s	34.2 m^3/s
1114609	Kaituna (Taaheke)	20.9 m^3/s	6.5 m^3/s	19.7 m^3/s
1014641	Ngongotaha	1760 L/s	1117 L/s	1579 L/s
14610	Utuhina	1969 L/s	1024 L/s	1732 L/s
14625	Puarenga (FRI)	1775 L/s	982 L/s	1561 L/s
1114613	Puarenga (Hemo Gorge)	1608 L/s	937 L/s	1391 L/s
1114610	Tamaheke	28.0 L/s	14.3 L/s	27.3 L/s
1114615	Te Kokonga	22.9 L/s	8 L/s	23.3 L/s

*Statistics from TIDEDA process "PSUMMARY".

These statistics are calculated from the full period of record to November – December 2005.

Table 5.4 Continuous flow measurement sites and gauging sites in each catchment.

Catchment number	Catchment	Number of continuous flow measurement sites	Number of gauging sites
1	Aongatete	0	16
2	Apata	0	1
3	Kaitemako	0	14
4	Katikati Streams	0	1
5	Kopurererua	1	18
6	Lower Kaituna	4	57
7	Maketu	0	1
8	Mangapapa/Opuiaki	0	14
9	Mangorewa	1	3
10	Matakana Island	0	0
11	Maungatawa area	0	7
12	Omanawa	0	5
13	Ongare/Tanners Point	1	11
14	Otumoetai area	0	2
15	Oturu	0	9
16	Tahawai	0	13
17	Tauranga City area	0	0
18	Te Mania	0	11
19	Te Puna	0	18
20	Te Puna area	0	0
21	Te Rereatukahia	0	24
22	Tuapiro	1	18
23	Uretara	0	27
24	Waiau	0	8
25	Waihi Beach	0	1
26	Waimapu	1	47
27	Wainui	0	11
28	Waione	0	2
29	Waipapa	2	44
30	Wairoa_Ngamawahine	0	21
31	Wairoa_Ohourere	0	21
32	Wairoa_Wairoa	2	21
33	Waitao area	0	3
34	Waitekohe	0	22
35	Welcome Bay area	0	4
36	Whatakao	0	8
	TOTAL	**13**	**483**

5.3 Groundwater flow budget and groundwater available for allocation

A simple groundwater flow budget is used to estimate groundwater available for allocation.

$$F_R = G_S + G_D$$

where

F_R rainfall recharge to groundwater
G_S 'shallow' groundwater recharge
G_D 'deep' groundwater recharge

- 'shallow' groundwater recharge is assumed as discharging to streams supporting baseflow in streams. Observed baseflow in streams (S_S) is therefore taken as the 'shallow' groundwater recharge;
- 'deep' groundwater recharge is assumed as discharging into deeper aquifers and discharging through the coastal boundary.

Baseflow in streams is taken as median surface water discharge as calculated from flow recorder sites and gaugings. An extensive analysis of baseflow is beyond the scope of this report and an analysis of errors in baseflow estimates is also beyond the scope of this report.

'Shallow' groundwater recharge supports baseflow in streams and abstraction of 'shallow' may impact stream flow. Therefore this report assumes 'shallow' groundwater recharge is not available for groundwater allocation.

This report assumes that 'deep' groundwater recharge is available for allocation. 'Deep' groundwater flow is estimated within each surface catchment boundary with:

$$G_D = F_R - S_S$$

Published assessments of relevant water balances and groundwater flows in the Western Bay of Plenty area include a water balance for the Te Puke – Maketu groundwater resource estimated by Bay of Plenty Regional Council (1990). They estimated rainfall minus potential evapotranspiration as:

- 414 mm per year, or 30% of rainfall at Tauranga;
- 108 mm per year, or 60% of rainfall at Kawerau.

Bay of Plenty Regional Council (1990) calculate surface specific discharge for streams in the Te Puke – Maketu area, for example:

- 24.7 $L/s/km^2$ for the Raparapahoe Stream;
- 272.2 $L/s/km^2$ for the Waiari Stream.

Bay of Plenty Regional Council (1990) estimate groundwater through-flow for their 25 km. wide study area as:

- approximately 5.8 m^3/s in the section above the spring zone, which is less than the much larger stream base flows;
- approximately 0.6 m^3/s at the coastal section.

Groundwater Consultants (1984) estimate 0.3 m^3/s of 'additional recharge' available for groundwater use in the 85 km^2 area of the unconfined aquifer between Athenree and Wairoa River.

Groundwater Consultants (1985a) use Darcy's law to estimate groundwater flow in the Kauri Point region as approximately 0.01 m^3/s. They estimate groundwater use as equivalent to 0.006 m^3/s.

Bay of Plenty Catchment Board and Regional Water Board (undated) use Darcy's law to estimate groundwater flow in the Kauri Point area as 0.03 m^3/s.

5.3.1 Estimates of rainfall recharge to groundwater (F_R)

Rainfall recharge to groundwater supports baseflow in streams ('shallow' groundwater recharge) and supports recharge of deeper aquifers ('deep' groundwater recharge). In this study rainfall recharge is assumed as either 30% of rainfall or 50% of rainfall (Figure 5.8). The bases for these assumptions are as follows:

- the 30% rainfall recharge area includes the sedimentary lithologies of the Tauranga Group Sediments;
- the 30% rainfall recharge area has relatively low annual rainfall;
- 30% rainfall recharge through sedimentary deposits is measured by White et al. (2003) in Canterbury;
- rainfall minus PET is 30% of rainfall at Tauranga (Bay of Plenty Regional Council 1990);
- the 50% rainfall recharge area includes the volcanic lithologies of the Coromandel Volcanic Zone and Taupo Volcanic Zone;
- approximately 50% rainfall recharge is measured for the Mamaku Plateau discharge through springs and stream around Putaruru (White et al., 2004);
- approximately 50% rainfall recharge is the maximum measured in two lysimeters located at Kaharoa, near Lake Rotorua, in volcanic lithologies (unpublished preliminary GNS Science data);
- rainfall minus PET is 60% of rainfall at Kawerau (Bay of Plenty Regional Council 1990).

Table 5.5 Estimates of rainfall recharge.

		50% Rainfall recharge area				30% Rainfall recharge area				Sum of mean groundwater recharge from rainfall (L/s)
No	**Catchment name**	**Area (km^2)**	**Mean rainfall (mm/y)**	**Mean rainfall recharge (mm/y)**	**Mean rainfall recharge (L/s)**	**Area (km^2)**	**Mean rainfall (mm/y)**	**Mean rainfall recharge (mm/y)**	**Mean rainfall recharge (L/s)**	
1	Aongatete	35.9	1917.9	958.9	1091	10.1	1855.7	556.7	178	1269
2	Apata	7.8	1792.8	896.4	222	4.3	1635.0	490.5	66	288
3	Kaitemako	10.2	1640.5	820.2	265	2.5	1320.7	396.2	32	297
4	Katikati Streams	*	*	*	*	8.7	1594.2	478.3	132	132
5	Kopurererua	74.0	1854.1	927.1	2175	**	**	**	**	2175
6	Lower Kaituna	270.8	1993.3	996.6	8558	127.9	1403.8	421.1	1708	10266
7	Maketu	*	*	*	*	2.1	1196.7	359.0	24	24
8	Mangapapa/Opuiaki	165.1	2255.8	1127.9	5905	**	**	**	**	5905
9	Mangorewa	184.6	2197.0	1098.5	6432	1.1	1557.3	467.2	16	6448
10	Matakana Island	*	*	*	*	60.2	1235.1	370.5	707	707
11	Maungatawa area	10.8	1535.8	767.9	264	35.9	1234.7	370.4	422	686
12	Omanawa	84.4	2129.2	1064.6	2848	**	**	**	**	2848
13	Ongare/Tanners Point	*	*	*	*	14.1	1422.0	426.6	190	190
14	Otumoetai area	4.2	1264.8	632.4	84	10.7	1250.6	375.2	127	211
15	Oturu	2.0	1640.6	820.3	51	7.0	1418.0	425.4	95	146
16	Tahawai	4.2	2096.2	1048.1	139	7.5	1795.5	538.7	129	268
17	Tauranga City area	1.9	1269.3	634.7	38	4.0	1192.6	357.8	46	84
18	Te Mania	4.8	1985.1	992.6	150	8.4	2022.0	606.6	161	311
19	Te Puna					28.6	1870.3	561.1	509	509
20	Te Puna area	20.4	2018.3	1009.2	652	8.3	1511.8	453.6	119	771
21	Te Rereatukahia	11.9	2055.3	1027.7	388	6.7	2132.3	639.7	135	523

		50% Rainfall recharge area				30% Rainfall recharge area				Sum of mean groundwater recharge from rainfall (L/s)
No	**Catchment name**	**Area (km^2)**	**Mean rainfall (mm/y)**	**Mean rainfall recharge (mm/y)**	**Mean rainfall recharge (L/s)**	**Area (km^2)**	**Mean rainfall (mm/y)**	**Mean rainfall recharge (mm/y)**	**Mean rainfall recharge (L/s)**	
22	Tuapiro	43.5	1995.4	997.7	1375	8.7	1682.1	504.6	139	1514
23	Uretara	17.3	2167.3	1083.6	595	15.6	2033.8	610.1	301	896
24	Waiau	23.2	1772.3	886.1	653	10.0	1545.7	463.7	147	800
25	Waihi Beach	12.0	1688.4	844.2	320	13.6	1564.1	469.2	203	523
26	Waimapu	110.6	1927.1	963.5	3380	1.0	1350.7	405.2	13	3393
27	Wainui	31.2	2100.4	1050.2	1039	7.3	1726.4	517.9	120	1159
28	Waione	*	*	*	*	8.2	1689.4	506.8	132	132
29	Waipapa	35.1	2051.1	1025.5	1142	10.2	1549.8	464.9	150	1292
30	Wairoa_Ngamawahine	112.7	2154.6	1077.3	3850	**	**	**	**	3850
31	Wairoa_Ohourere	30.2	2017.6	1008.8	965	**	**	**	**	965
32	Wairoa_Wairoa	59.4	1818.4	909.2	1712	11.0	1379.7	413.9	144	1856
33	Waitao area	34.8	1802.1	901.1	994	2.6	1351.1	405.3	33	1026
34	Waitekohe	12.6	1863.1	931.5	371	9.2	1881.3	564.4	165	536
35	Welcome Bay area	12.0	1451.2	725.6	277	2.5	1361.7	408.5	32	309
36	Whatakao	20.0	2022.5	1011.2	642	8.9	1851.4	555.4	156	798
									Total	53107

* Whole catchment is included in the 30% rainfall recharge area.

** Whole catchment is included in the 50% rainfall recharge area.

These assumptions may over estimate rainfall recharge in mountainous terrain, for example runoff in mountainous terrain (e.g. Kaimai Range and Otawa Hill) may be a much larger proportion of rainfall then in the relatively flat-lying ignimbrite and sedimentary areas.

Rainfall recharge estimates in each catchment (Table 5.5) in the "50%" and "30%" zones are summed.

Rainfall recharge to groundwater totals an estimated 53107 L/s, or approximately 53.1 m^3/s.

The error in rainfall estimates is estimated as +/- 20% from the rounded from the error (23%) in the rainfall model estimated in Section 5.1.3.

5.3.2 Estimates of baseflow in streams (S_S)

The EBOP gauging database and continuous flow records are assessed to estimate the discharge by baseflow from catchments. The process to estimate baseflow discharge from catchments is as follows:

- assign gauging sites and continuous flow sites to catchments;
- identify gauging sites and/or continuous flow sites that may represent stream flow at the bottom of catchments (Figure 5.9 and Figure 5.10). Surface water discharges from more than one stream in some catchments; therefore some catchments have discharge measurements from more than one stream;
- calculate mean flow and median flow for the site (Table 5.6).

Some median flow estimates are made from a small number of gaugings. For example median flow for the Waihi Beach catchment is estimated from only one gauging. A full analysis of the quality of the gauging data, and the errors in estimating median flows, is beyond the scope of this report.

The standard deviation of flow at continuous flow recording sites (Table 5.3) is commonly similar to, or larger than, median flow estimates. Therefore the errors in median catchment flow estimates are likely to be large so an error of +/- 100% is estimated. This large error is because all gauging measurements are included in the calculations without discrimination between low flow and flood events.

The approach to estimating baseflows used in this report differs from Environment Bay of Plenty (1996b) approach to estimating low flows. Environment Bay of Plenty (1996b) estimate low flows based on a statistical (regression or Gumbel) estimation of the Q_5 '7-day' flows but Environment Bay of Plenty (1996b) has reservations about the quality of the results: 'results are tentative at best' (Environment Bay of Plenty 1996b, page 29) when applied to gauged flows. Low flow estimates are 'tentative' partly because of the small number of gaugings at most sites.

Environment Bay of Plenty (1996b) low flow estimates compare only generally to median flows estimated in this report. For example:

- Te Mania Stream at SH2 Bridge, site 13505, has a low flow estimate of approximately

50 L/s – 78 L/s (Environment Bay of Plenty 1996b) and a median flow of 210 L/s (Table 5.6);

- Tahawai Stream at Willoughby Road Bridge, site 13406, has a low flow estimate of approximately 44 L/s – 49 L/s (Environment Bay of Plenty 1996b) and a median flow of 69 L/s (Table 5.6).

The flow estimates of Environment Bay of Plenty (1996b) are not used in this report because:

- reservations of Environment Bay of Plenty (1996b) about the quality of the estimated low flows; and
- Environment Bay of Plenty (1996b) does not estimate low flow at many of the gauging sites located at the bottom of the catchments.

Wilding (2003) estimates low flows at 17 locations in 14 streams in the Tauranga area as part of a low-flow stream habitat survey by Environment Bay of Plenty. Most of these sites have mid-catchment locations. Sites of Wilding (2003) that are near the bottom of catchment include:

- Whatakao – Wilding (2003) has a Q_5 7-day flow of 150 L/s and median flow (Table 5.6) is 266 L/s;
- Mangawhai – Wilding (2003) has a Q_5 7-day flow of 7 L/s and median flow (Table 5.6) is 40 L/s;
- Oturu – Wilding (2003) has a Q_5 7-day flow of 10 L/s and median flow (Table 5.6) is 30 L/s;
- Kopurererua – Wilding (2003) has a Q_5 7-day flow of 1335 L/s and median flow (Table 5.6) is 1713 L/s;
- Waitao – Wilding (2003) has a Q_5 7-day flow of 150 L/s and median flow (Table 5.6) is 202 L/s.

Therefore the low flow estimates of Wilding (2003) are generally similar to estimates of median flow used in this report.

Table 5.6 Base flow discharge estimates for catchments.

Catchment No.	Catchment	D/s site river name	D/s site name	D/s site number	G/F*	Number of gaugings	Mean flow (L/s)	Median flow (L/s)
1	Aongatete	Aongatete	S.H. 2 Br.	13607	G	40	862	583
2	Apata	Lowe Creek	Apata Station Rd.	13705	G	13	89	28
3	Kaitemako	Kaitemako	Welcome Bay Br.	14504	G	17	135	70
4	Katikati Streams	-	-	-	-	-	-	-
5	Kopurererua	Kopurereroa	S.H. 29 Br.	14302	F	-	1874	1713
6	Lower Kaituna (1)	Kaituna	Te Matai	14614	F	-	36,644[1]	35,535[1]
	Lower Kaituna (2)	Raparapahoe	U/S Drop Structure	1114651	F	-	1844	1277
	Lower Kaituna (3)	Waiari	Muttons	14627	F	-	4035	3816
7	Maketu	-	-	-	-	-	-	-
8	Mangapapa/Opuiaki (1)	Opuiaki	Ford	14122	G	3	4768	2543
	Mangapapa/Opuiaki (2)	Mangapapa	Above Dam	14127	G	1	177	177
9	Mangorewa	Mangorewa	Saunders Farm	14628	F	-	6165	5217
10	Matakana Island	-	-	-	-	-	-	-
11	Maungatawa area (1)	Mt. Maunganui	Totara St. Culvert	14202	G	11	15	9
	Maungatawa area (2)	Rocky Stream	Mangatawa Lane	14509	G	38	213	175
12	Omanawa	Omanawa	S.H. 29 Br.	14131	G	114	1461	1450
13	Ongare/Tanners Point	Kauri Point Stream	Tuapiro Rd. Br.	13307	G	3	23	15
14	Otumoetai area (1)	Carmichael's Disc	Bethlehem	-	G	1	966	966
	Otumoetai area (2)	Pond Outlet	Bethlehem	14212	G	2	207[2]	207
15	Oturu	Oturu Creek	Borrell Rd.	14002	G	22	63	30
16	Tahawai	Tahawai	Willoughby Rd. Br.	13406	G	24	106	69
17	Tauranga City area	-	-	-	-	-	-	-
18	Te Mania	Te Mania	S.H. 2 Br.	13505	G	95	299	210
19	Te Puna	Te Puna	S.H. 2 Br.	14004	G	13	643	641
20	Te Puna area	-	-	-	-	-	-	-

Catchment No.	Catchment	D/s site river name	D/s site name	D/s site number	G/F*	Number of gaugings	Mean flow (L/s)	Median flow (L/s)
21	Te Rereatukahia	Te Rereatukahia	S.H. 2 Br.	13503	G	24	300	220
22	Tuapiro	Tuapiro	Woodlands Rd.	13310	F	-	1862	1012
23	Uretara	Wharawhara	Henry Rd. Ford	13403	G	51	638	406
24	Waiau	Waiau	Waiau Rd Farm Br.	13201	G	50	380	321
25	Waihi Beach	Unnamed	Fergus Rd.	-	G	1	25	25
26	Waimapu	Waimapu	McCarrolls Farm	14410	F	-	2121	1444
27	Wainui	Wainui	S.H. 2 Br.	13708	G	24	1730	1753
28	Waione	Waione	S.H. 2 Br.	-	G	1	3	3
29	Waipapa (1)	Mangawhai	Omokoroa	13901	F	-	69	40
	Waipapa (2)	Waipapa	S.H. 2 Br.	13806	G	21	698	476
30	Wairoa_Ngamawahine	Ngamuwahine	S.H. 29 Br.	14129	G	34	1318	925
31	Wairoa_Ohourere	Ohourere	Crawfords Rd. Br.	14107	G	4	382	166
32	Wairoa_Wairoa (1)	Wairoa	above Ruahihi	14130	F	-	3840	695
	Wairoa_Wairoa (2)	Wairoa	Power station	14132	F	-	11921	11130
33	Waitao area	Waitao	Welcome Bay Rd.	-	G	1	202	202
34	Waitekohe	Waitekohe R/B Trib.	U/S Estuary	-	G	3	128	132
35	Welcome Bay area (1)	Waikite	Welcome Bay Rd.	14505	G	12	31	9
	Welcome Bay area (2)	Kawhia Creek	Welcome Bay Rd.	14512	G	11	50	32
	Welcome Bay area (3)	Ngapeke	Welcome Bay Rd. Br.	14506	G	1	8	8
36	Whatakao	Whatakao	Walford Rd. Br.	13602	G	24	300	266

* G: gauging site
* F: continuous flow measurement site (Environment Bay of Plenty, 2001)

[1] The Kaituna (Te Matai) mean and medium flow are taken for the period 21st October 1981 to 22 April 2005. This is to estimate outflows from the lower Kaituna catchment for the same period as inflows to the catchment from Lake Rotoiti (Kaituna River at the Taaheke recording site).

[2] Median flow from this catchment is taken as the median of the two measurements at pond outlet.

5.3.3 Wairoa River catchment and hydropower

The Wairoa River catchment includes a hydropower scheme with three power houses (Figure 5.11):

- Lower Mangapapa;
- McLaren Falls;
- Ruahihi.

Inter-catchment water transfers by the power scheme (Figure 5.11) impact on water balance estimates. Baseflow discharge at sites 14130, 14131 and 14132 (Figure 5.11) represents discharge from the following catchments:

- Opuiake;
- Tauwhakawhaka;
- Natuhoa;
- Awakatuko;
- Mangonui;
- Mangapapa;
- Ruakaka;
- Mangakaiwhiria;
- Ohanawa;
- Mangakarengorengo;
- Ngamawahine.

These catchments are represented by the following surface water catchments (Figure 5.2) in the water budget model:

- Mangapapa/Opuiaki;
- Wairoa-Ngamawahine;
- Omanawa;
- Wairoa-Wairoa (approximately 21 km^2 in area of this catchment).

The estimated water budget for these four catchments (Table 5.7) includes:

- groundwater recharge approximately 14.5 m^3/s including groundwater recharge on the full Wairoa-Wairoa catchment;
- baseflow discharge approximately 13.3 m^3/s from sites 14130, 14131 and 14132.
- groundwater discharge to the Lake Rotorua catchment estimated as 1.3 m^3/s (Section 5.3.5).

Therefore groundwater recharge (14.5 m^3/s) approximately balances water outflows (14.6 m^3/s i.e. 13.3 m^3/s + 1.3 m^3/s) for these catchments.

However the 14.5 m^3/s of groundwater recharge from rainfall includes recharge on the full area of the Wairoa-Wairoa catchment and the gauging sites do not represent recharge over the whole area of the four catchments because the gauging sites are not at the bottom of the Wairoa-Wairoa catchment. Therefore the water inflows of these four catchments may be less than water outflows when baseflow in the Wairoa-Wairoa catchment downstream of the hydropower scheme is considered.

Table 5.7 Catchment groundwater flow balance and estimated deep groundwater recharge.

Catchment number	Catchment name	Rainfall (L/s)	Rainfall Recharge to groundwater (L/s)	Surface water inflow to catchment (L/s)	Groundwater outflow to Lake Rotorua catchment (L/s)	Stream baseflow discharge (L/s)	Rainfall recharge plus surface water inflow minus groundwater outflow minus baseflow discharge (L/s)	Estimated deep groundwater recharge (L/s)
1	Aongatete	2776	1269	0	0	583	686	686
2	Apata	664	288	0	0	28	260	260
3	Kaitemako	636	297	0	0	70	227	227
4	Katikati Streams	442	132	0	0	0	132	132
5	Kopurererua	4353	2175	0	0	1713	462	462
6 (part), 9	Lower Kaituna (foothills) and Mangorewa	30035	15007	19700	1400	40628	-7321	-7321
6 (part)	Lower Kaituna (Plains)	5693	1708	0	0	0	1708	1708
7	Maketu	79	24	0	0	0	24	24
8	Mangapapa/Opuiaki (included in Wairoa Power Scheme)	-	-	-	-	-	-	-
8,12,30,32	Wairoa Power scheme	29121	14459	0	1300	13275	-116	-116
9	Mangorewa (included in Lower Kaituna, hills)	-	-	-	-	-	-	-
10	Matakana Island	2358	707	0	0	0	707	707
11	Maungatawa area	1936	686	0	0	184	502	502
12	Omanawa (included in Wairoa Power Scheme)	-	-	-	-	-	-	-
13	Ongare/Tanners Point	634	190	0	0	15	175	175
14	Otumoetai area	592	211	0	0	207	4	4
15	Oturu	424	146	0	0	30	116	116
16	Tahawai	722	268	0	0	69	199	199
17	Tauranga city area	229	84	0	0	0	84	84
18	Te Mania	837	311	0	0	210	101	101
19	Te Puna	1698	509	0	0	641	-132	-132
20	Te Puna area	139	771	0	0	0	771	771
21	Te Rereatukahia	1223	523	0	0	220	303	303
22	Tuapiro	3200	1514	0	0	1012	502	502
23	Uretara	2183	896	0	0	406	490	490
24	Waiau	1788	800	0	0	321	479	479
25	Waihi Beach	1309	523	0	0	25	498	498
26	Waimapu	6805	3393	0	0	1444	1949	1949
27	Wainui	2474	1159	0	0	1753	-594	-594
28	Waione	441	132	0	0	3	129	129
29	Waipapa	2764	1292	0	0	516	776	776
30	Wairoa_Ngamawahine (included in Wairoa Power Scheme)	-	-	-	-	-	-	-
31	Wairoa_Ohourere	1929	965	0	0	166	799	799
32	Wairoa_Wairoa (included in Wairoa Power Scheme)	-	-	-	-	-	-	-
33	Waitao area	2094	1026	0	0	202	824	824
34	Waitekohe	1285	536	0	0	132	404	404
35	Welcome Bay area	658	309	0	0	49	260	260
36	Whatakao	1801	798	0	0	266	532	532
	Sum (L/s)	113322	53108	19700	2700	64168	5940	5940
	Sum (m^3/s)	113.3	53.1	19.7	2.7	64.2	5.9	5.9

5.3.4 Lower Kaituna catchments

5.3.4.1 Lower Kaituna hills catchments and Mangorewa catchment

The water balance estimate for the Lower Kaituna hills catchments has outflows greater than inflows, i.e.

Water inflow $= 15.0\ m^3/s + 19.7\ m^3/s$
$= 34.7\ m^3/s$

Water outflow $= 40.6\ m^3/s + 1.4\ m^3/s$
$= 42.0\ m^3/s$

Groundwater recharge in the Lower Kaituna hills catchments is estimated as approximately 15.0 m^3/s for the:

- Mangorewa catchment 6448 L/s;
- Lower Kaituna hills catchment in the '50%' rainfall recharge zone (8559 L/s).

The Kaituna River flows at a median of 19.7 m^3/s from Lake Rotoiti (the Taaheke site, Table 5.3).

Baseflow discharge from the Lower Kaituna hills catchments (i.e. the hills to the west, south and south east of Te Puke) is represented by discharge at three sites:

- Kaituna at Te Matai, site 14614;
- Raparapahoe, site 1114651;
- Waiari at Muttons, site 14627.

Median flow at these sites totals approximately 40.6 m^3/s.

Groundwater probably flows from the Mangorewa catchment to the Lake Rotorua catchment. A flow from the Mangorewa catchment to the Lake Rotorua catchment of 1.4 m^3/s is assigned.

The significant difference in water inflows and water outflows may mean:

- data errors are significant;
- unaccounted water inflows occur.

Unaccounted water inflows may occur from the adjacent streams to the east of the Western Bay of Plenty area; this will be investigated in the future with a water balance model of the Paengaroa – Matata area.

Unaccounted inflows may also occur if groundwater recharge from rainfall is greater than 50% of rainfall.

Groundwater recharge from rainfall would total 22.3 m^3/s (from Table 5.5) if water inflows balance water outflows. This seems unreasonably large as it is approximately 74% of estimated rainfall on the combined Lower Kaituna (hills) and Mangorewa catchment.

5.3.4.2 Lower Kaituna Plains

Baseflow discharge from the Lower Kaituna Plains is unknown. Groundwater recharge from rainfall on the Plains is estimated as 1708 L/s, being the rainfall recharge in the '30%' area (Table 5.5).

5.3.5 Groundwater discharge to the Lake Rotorua catchment

Groundwater probably discharges from the Western Bay of Plenty area to the Lake Rotorua catchment (White et al. 2007). For example:

- estimated groundwater recharge in the Lake Rotorua surface catchment 13.1 m^3/s (from White et al. 2004, their Table 7.7);
- estimated water inflows from the catchment total 15.8 m^3/s.

Therefore 2.7 m^3/s of groundwater recharge to the Lake Rotorua catchment may flow from adjacent catchments to the Lake Rotorua catchment.

The water balance of two Western Bay of Plenty catchments is potentially impacted by groundwater discharge to the Lake Rotorua catchment:

- Mangapapa/Opuiaki;
- Mangorewa.

Groundwater discharges to the Lake Rotorua catchment of 1.3 m^3/s and 1.4 m^3/s, respectively, are assigned to these catchments arbitrarily.

5.3.6 Groundwater balance

Deep groundwater recharge (G_D) is estimated with a water balance equation:

Water inflow = water outflow

$$F_R + F_O = G_S + G_D + G_R$$

where

F_R rainfall recharge to groundwater
F_O surface water flow from outside the Western Bay of Plenty area
G_S shallow groundwater recharge which equals stream baseflow discharge
G_D 'deep' groundwater recharge
G_R groundwater discharge to the Lake Rotorua catchment from the Western Bay of Plenty area

Water inflows and outflows for the Western Bay of Plenty (Table 5.7) are estimated as:

- water inflows = 72.8 m^3/s including:
  - rainfall recharge to groundwater 53.1 m^3/s;
  - surface water flow in the Kaituna River at Taaheke 19.7 m^3/s.

- water outflows = 72.8 m^3/s including:
  - groundwater discharge to the Lake Rotorua catchment 2.7 m^3/s;
  - surface water baseflow 64.2 m^3/s;
  - deep groundwater recharge 5.9 m^3/s, estimated from the groundwater flow balance equation.

5.3.7 Adjustments to the groundwater balance

Deep groundwater recharge is adjusted where estimated deep groundwater recharge is less than zero (Table 5.7) in catchments:

- Te Puna;
- Wainui;
- Wairoa hydropower scheme catchments;
- Lower Kaituna (hills) and Mangorewa catchments.

Therefore deep groundwater recharge is assumed as zero for these catchments.

Deep groundwater recharge is less than zero (Table 5.7) for catchments in the Wairoa hydropower scheme, i.e. land upstream of the Ruahihi Power Station and the Omanawa catchment. Therefore deep groundwater recharge is adjusted to zero for the following catchments:

- Wairoa – Ngamawahine;
- Mangapapa/Opuiaki;
- Omanawa;
- part of the Wairoa – Wairoa catchment upstream of the Ruahihi Power Station.

The Wairoa – Wairoa catchment upstream of the Ruahihi Power Station is approximately 21 km^2 in area and the land area in the Wairoa – Wairoa catchment downstream of the power station is approximately 38.4 km^2. Rainfall recharge on the land area downstream of the Ruahihi Power Station is estimated as from:

$$G_{DR} = F_{RR}\, LB$$

G_{DR} deep groundwater discharge in the Wairoa – Wairoa catchment below the Ruahihi Power Station.

F_{RR} rainfall recharge on the Wairoa – Wairoa catchment (1856 L/s, Table 5.5).

L land area in the Wairoa – Wairoa catchment below Ruahihi Power Station (38.4 km^2) as a portion of total land area in the Wairoa – Wairoa catchment 59.4 km^2), i.e. 0.65.

B estimated deep groundwater flow in 12 catchments, like the Wairoa – Wairoa, between Wairoa – Ohourere and Taupiro as a portion rainfall recharge, i.e. 0.4
- rainfall recharge in 12 catchments 10040 L/s;
- estimated surface baseflow in 12 catchments 5974 L/s;
- estimated deep groundwater recharge in 12 catchments 4066 L/s.

Therefore deep groundwater recharge in the Wairoa – Wairoa catchment downstream of Ruahihi Power Station is estimated as:

$$G_{DR} = 1856.\ 0.65.\ 0.4$$
$$= 483 \text{ L/s}$$

Deep groundwater recharge is estimated as less than zero in Lower Kaituna hills catchments (Section 5.3.4). Therefore deep groundwater recharge in the Lower Kaituna hills catchments is assumed as zero.

Deep groundwater recharge in the Lower Kaituna Plains catchment of 1708 L/s (Table 5.7) is adjusted to estimate stream baseflow from Plains streams and drains as follows:

- revised deep groundwater recharge 854 L/s;
- estimated stream baseflow 854 L/s, i.e. stream baseflow equals deep groundwater recharge.

These adjustments give revised deep groundwater recharge estimates by surface catchment in Table 5.8. The total adjusted deep groundwater recharge is estimated as approximately 13.7 m^3/s (Table 5.8) which is larger than the unadjusted deep groundwater recharge of 5.9 m^3/s (Table 5.7). The major contribution to the difference between these two figures is approximately 7.3 m^3/s 'added' to balance flows in the Lower Kaituna (hills) and Mangorewa catchments. This flow balances Lower Kaituna (hills) and Mangorewa catchments outflows to inflows. Implicit in this estimate is that approximately 7.3 m^3/s is added to the Lower Kaituna (hills) catchment, possibly from the catchments to the east (e.g. Pokopoko Stream). A project on the groundwater balance of the Paengaroa-Matata area will assess possible groundwater discharge to the Lower Kaituna (hills) catchment.

Table 5.8 Deep groundwater recharge estimates in catchments.

Catchment number	Catchment name	Adjusted deep g/w recharge (L/s)
1	Aongatete	686
2	Apata	260
3	Kaitemako	227
4	Katikati Streams	132
5	Kopurererua	462
6 (part)	Lower Kaituna, (hills)	0
6 (part)	Lower Kaituna, Plains	854
7	Maketu	24
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	707
11	Maungatawa area	502
12	Omanawa	0
13	Ongare/Tanners Point	175
14	Otumoetai area	4
15	Oturu	116
16	Tahawai	199
17	Tauranga City area	84
18	Te Mania	101
19	Te Puna	0
20	Te Puna area	771
21	Te Rereatukahia	303
22	Tuapiro	502
23	Uretara	490
24	Waiau	479
25	Waihi Beach	498
26	Waimapu	1949
27	Wainui	0
28	Waione	129
29	Waipapa	776
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	799
32	Wairoa_Wairoa	408
33	Waitao area	824
34	Waitekohe	404
35	Welcome Bay area	260
36	Whatakao	532
	Sum (L/s)	13657
	Sum (m^3/s)	13.7

5.4 Western Bay of Plenty deep groundwater recharge

Deep groundwater recharge is estimated as a total of 13.7 m^3/s in the Western Bay of Plenty (Table 5.8) using adjustments, as listed in Section 5.3.7, to the water balance estimates.

Deep groundwater recharge is assumed as zero (Table 5.8), because estimated surface baseflow is larger than estimated groundwater recharge, for the following catchments:

- Te Puna;
- Wainui;
- Mangapapa/Opuiaki;
- Omanawa;
- Wairoa – Ngamawahine;
- Lower Kaituna foothills, including Mangorewa.

5.5 Estimates of deep groundwater recharge in geological units and in catchments

Estimated deep groundwater recharge in geological units (Table 5.9) of each catchment are listed in Appendix 17.

Deep groundwater recharge to each geological unit is estimated according to the likely hydraulic nature of the unit including: type (aquifer, aquitard), hydraulic properties, depth and thickness of the geological units. The hydraulic nature of geological units is represented by factors that represent:

- the relative proportion of a geological unit at the ground surface as estimated by ArcGIS;
- a ball-park estimate of relative sub-surface flows.

For example, deep groundwater recharge in the Aongatete catchment is apportioned between three geological units in the proportions:

- Tauranga Group Sediments 0.3;
- Waiteariki Ignimbrite 0.5;
- Aongatete Ignimbrite 0.2.

Therefore deep groundwater recharge in the Aongatete catchment (a total of 686 L/s, Table 5.8) is apportioned to geological units as:

- Tauranga Group Sediments 206 L/s (i.e. 0.3 x 686 L/s);
- Waiteariki Ignimbrite 343 L/s (i.e. 0.5 x 686 L/s);
- Aongatete Ignimbrite 137 L/s (i.e. 0.2 x 686 L/s).

The approach involves making many assumptions on groundwater flows in the geological units in the Western Bay of Plenty. This model of groundwater flows could be improved by using a finite difference, or finite element, groundwater flow model of the region. Such quantitative computer modelling is beyond the scope of this project.

The calculation of deep groundwater recharge is based on a calculation of estimated rainfall recharge minus estimated baseflow discharge. In some catchments there is no baseflow discharge. For example no stream flow measurements are made on Matakana Island and therefore all groundwater recharge is classified as ‘deep’. However, in the case of Matakana Island it is likely that all of this rainfall recharge will discharge laterally to the sea through the sand aquifer. Therefore this recharge will not be generally available to groundwater users taking from the Tauranga Group Sediments outside the geographic boundary of Matakana Island.

Many catchments with Tauranga Group Sediments are likely to be similar to Matakana Island, i.e. deep groundwater recharge is not available to groundwater users outside the boundaries of the catchment. For example:

- Waihi Beach rainfall recharge will probably discharge to the ocean or estuary through the sand aquifer;
- Ongare/Tanners Point includes Tanners Point and Kauri Point and therefore will have a significant coastline in the Tauranga estuary and it is likely that a significant portion of the deep rainfall recharge will discharge through this coastal boundary.

However, groundwater recharge to deeper aquifers (e.g. Waiteariki Ignimbrite) may be available to groundwater users outside the catchment boundary where the aquifer is continuous across a catchment boundary.

Median annual deep groundwater recharge is an estimated 13.7 m^3/s for the Western Bay of Plenty (Table 5.8). Estimated deep groundwater recharge is largest in the Tauranga Group Sediments (Table 5.9 and Table 5.10) at approximately 4.9 m^3/s.

Table 5.9 Estimated deep groundwater recharge by geological unit.

Geological unit	Estimated deep groundwater recharge (L/s)	Estimated deep groundwater recharge (m^3/s)
Tauranga Group Sediments	4858	4.9
Mamaku Ignimbrite	915	0.9
OTP Ignimbrite	649	0.6
Waiteariki Ignimbrite	4409	4.4
Minden Rhyolite	765	0.8
Aongatete Ignimbrite	2136	2.1
Sum (L/s)	13732	
Sum (m^3/s)		13.7

Table 5.10 Sum of estimated deep groundwater recharge in the Tauranga Group Sediments.

TAURANGA GROUP SEDIMENTS		Estimated deep groundwater recharge (L/s)
1	Aongatete	206
2	Apata	104
3	Kaitemako	45
4	Katikati Streams	66
5	Kopurererua	162
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	512
7	Maketu	14
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	495
11	Maungatawa area	251
12	Omanawa	0
13	Ongare/Tanners Point	158
14	Otumoetai area	2
15	Oturu	70
16	Tahawai	100
17	Tauranga City area	46
18	Te Mania	61
19	Te Puna	0
20	Te Puna area	463
21	Te Rereatukahia	212
22	Tuapiro	201
23	Uretara	245
24	Waiau	144
25	Waihi Beach	249
26	Waimapu	195
27	Wainui	0
28	Waione	90
29	Waipapa	155
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	0
32	Wairoa_Wairoa	48
33	Waitao area	165
34	Waitekohe	162
35	Welcome Bay area	52
36	Whatakao	186
	Sum (L/s)	4858
	Sum (m^3/s)	4.9

Groundwater flow estimated by the above approach can be checked with application of Darcy's law:

Q = KAH

Q flow in m^3/s;

K hydraulic conductivity taken as 2×10^{-6} m/s from the Rea Road investigation (Section 3.1) for Aongatete Ignimbrite and assumed for Waiteariki Ignimbrite equivalent of 850 m^2/day (Table 3.9) for Tauranga Group Sediments;

A cross-section area of formation (= width times thickness), estimated from Figures 2.3, 2.5 and 2.9;

w width of formation;

t thickness of formation;

H groundwater gradient, estimated from figures 3.3, 3.4 and 3.5.

Darcy's law applied to groundwater flow in three geological units gives:

- Tauranga Group Sediments estimated flow across the coast 3.1 m^3/s with K = 5×10^{-5} m/s, w = 62000 m, t = 250 m, H = 0.004;
- Waiteariki Ignimbrite estimated flow across the coast 0.03 m^3/s with K = 2×10^{-6} m/s, w = 46000 m, t = 80 m, H = 0.004;
- Aongatete Ignimbrite estimated flow across the coast 0.5 m^3/s with K = 2×10^{-6} m/s, w = 62000 m, t = 1000 m, H = 0.004.

Note that a considerable range in parameter values means that flow rate estimates provided by the Darcy equation have a considerable range for example:

- the transmissivity of the Aongatete Ignimbrite may range between 10 m^2/day and 100 m^2/day (Table 3.9), i.e.:
  - groundwater flow in the Aongatete Ignimbrite may range from 0.03 m^3/s to 0.3 m^3/s.

Groundwater flow in the Tauranga Group Sediments estimated by the Darcy equation (3.1 m^3/s) is similar to groundwater flow estimated by the baseflow model (4.9 m^3/s). Groundwater flow in the Waiteariki and Aongatete ignimbrites estimated by the Darcy equation is significantly less than groundwater flow estimated by the baseflow model. However, groundwater flow estimated by the Darcy equation may be similar to estimated deep groundwater flow with a reasonable range (e.g. a factor of 10) in hydraulic conductivity and a reasonable factor in unit thickness (e.g. a factor of 5).

The application of the Darcy equation here is a very simple approach that does not consider the many details of the actual coastal boundary, for example:

- the crenulated coastline of Tauranga Harbour has the capacity to discharge more groundwater across the coastal boundary than would be estimated with the above representation of the harbour boundary as a straight line;
- groundwater discharge from Matakana Island (partly to the sea and partly to the estuary) is not fully represented by the Darcy equation application above.

Use of the Darcy equation is quite a simple approach to the estimation of regional groundwater flows. Regional groundwater flow models provide estimates of regional groundwater flows because they incorporate groundwater recharge, flow and discharge characteristics; regional groundwater flow models are recommended (Section 7.8) for the next phase of groundwater allocation assessment in the Western Bay of Plenty area.

5.6 Discharge of deep groundwater

Deep groundwater flow will discharge to Tauranga Harbour, to the sea or to other geological units.

The locations of deep groundwater discharge is assumed as follows:

- the sea for groundwater flow in Tauranga Group Sediments;
- Waitaeriki Ignimbrite for groundwater flow in the Mamaku/Waimakariri Ignimbrite;
- Waitaeriki Ignimbrite for groundwater flow in the OTP Ignimbrite;
- the sea for groundwater flow in the Waitaeriki Ignimbrite;
- Waitaeriki Ignimbrite for groundwater flow in the Minden Rhyolite;
- the sea for groundwater flow in the Aongatete Ignimbrite.

Therefore the deep groundwater flow in three units (Mamaku, Waimakariri and OTP ignimbrites) may potentially increase the deep groundwater flow in the Waitaeriki Ignimbrite. For example deep groundwater flow in the Waitaeriki Ignimbrite may be 6.7 m^3/s made of:

- 4.4 m^3/s deep groundwater recharge to the Waitaeriki Ignimbrite (Table 5.9);
- 1.5 m^3/s deep groundwater recharge from the Mamaku and OTP ignimbrites (Table 5.9);
- 0.8 m^3/s deep groundwater recharge from the Minden Rhyolite (Table 5.9).

6.0 GROUNDWATER ALLOCATION

6.1 Groundwater allocation at January 2009

Groundwater allocation records are obtained from Environment Bay of Plenty for Tauranga City and the Western Bay of Plenty District (Appendix 18) and these records are termed 'January 2009' allocation.

A summary of consents in the Western Bay of Plenty model area (Table 6.1) has most consents with allocation data and with bore log numbers. Consents without allocation information, and without bore log number, are mostly earthworks.

Table 6.1 Summary of January 2009 consents.

<table>
<tr><th colspan="4">Consent numbers</th></tr>
<tr><td rowspan="3">Inside Western Bay of Plenty model area</td><td rowspan="3">545</td><td>Consents with allocation rate data</td><td>519</td></tr>
<tr><td>Consents with bore log number</td><td>426</td></tr>
<tr><td>Consents without allocation data and without bore log number</td><td>25</td></tr>
<tr><td>Outside Western Bay of Plenty model area</td><td>78</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Total</td><td>623</td></tr>
</table>

Groundwater allocation includes:

- cold groundwater consents (Figure 6.1);
- 'geothermal' consents (Figure 6.2) – these are groundwater takes where water temperature is greater than 30 °C.

Information recorded on consents includes: consent number, purpose, type (either cold groundwater or 'geothermal' status, property address, maximum abstraction, maximum daily allocation (m^3/d) maximum rate (L/s) and sometimes a bore log number. Some consents include allocation from multiple wells.

Table 6.2 summarises the distribution of EBOP groundwater consents by surface catchment. The number of consents is largest in the Lower Kaituna catchment; no groundwater allocation is assigned to Maketu and Mangapapa/Opuiaki catchments.

For each catchment, some statistics on allocation ('general', frost protection and irrigation) are summarised by surface catchment in Appendix 19.

Total groundwater allocation is estimated at approximately 291,829 m^3/day (or approximately 3.4 m^3/s) for the area (Table 6.2). Daily allocation is highest in the Lower Kaituna catchment, with a total of with about 49% of the total groundwater allocation in the Western Bay of Plenty area.

Allocation is assigned to geological units, where possible. However:

- only 352 consents specify a well that has a record of well depth;
- these consents represent only approximately 50% of the total groundwater allocation in the Western Bay of Plenty area (Appendix 20).

Groundwater allocation, by geological formation (Appendix 20) is summarised in Table 6.3 in two groupings of geological units coincident with suggested groundwater allocation zones (Section 6.2). Groundwater allocation is largest in the combined Waiteariki Ignimbrite and Aongatete Ignimbrite.

Table 6.2 Groundwater consents by surface catchment (Appendix 19).

Surface catchment number	Surface catchment name	Number of current EBOP groundwater consents	Total (m^3/day)
1	Aongatete	6	1285
2	Apata	7	1233
3	Kaitemako	3	185.4
4	Katikati Streams	8	1707
5	Kopurererua	21	8241.5
6	Lower Kaituna	123	143031.9
7	Maketu	0	0
8	Mangapapa/Opuiaki	0	0
9	Mangorewa	2	7584
10	Matakana Island	5	978
11	Maungatawa Area	40	18182.7
12	Omanawa	12	3326.6
13	Ongare/Tanners Point	31	9607.5
14	Otumoetai Area	30	2834.6
15	Oturu	16	4379
16	Tahawai	5	1553
17	Tauranga City Area	11	2366.7
18	Te Mania	6	1798
19	Te Puna	25	3416.3
20	Te Puna Area	1	118
21	Te Rereatukahia	6	1872
22	Tuapiro	6	2343
23	Uretara	5	940
24	Waiau	9	10957.4
25	Waihi Beach	8	3565
26	Waimapu	42	7606.15
27	Wainui	8	2190
28	Waione	22	5501.87
29	Waipapa	32	21495.1
30	Wairoa-Ngamawahine	2	46.7
31	Wairoa-Ohourere	1	12960
32	Wairoa-Wairoa	20	4953.5
33	Waitao Area	8	1136
34	Waitekohe	6	1083.6
35	Welcome Bay Area	13	2594
36	Whatakao	5	756
	Total	**545**	**291828.52**

Table 6.3 Groundwater allocation by geological formation in suggested groundwater allocation zones.

Surface catchment number	Groundwater allocation zone/surface catchment name	Sum of allocation for Tauranga Group Sediments, Waimakariri Ignimbrite and Minden/Otawa volcanics (m^3/day)
1	Aongatete	0
2	Apata	75
3	Kaitemako	0
4	Katikati Streams	707
5	Kopurererua	0
6	Lower Kaituna	26896
7	Maketu	0
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	978
11	Maungatawa Area	4311
12	Omanawa	0
13	Ongare/Tanners Point	5348
14	Otumoetai Area	918.5
15	Oturu	0
16	Tahawai	0
17	Tauranga City Area	0
18	Te Mania	0
19	Te Puna	0
20	Te Puna Area	0
21	Te Rereatukahia	150
22	Tuapiro	0
23	Uretara	240
24	Waiau	930
25	Waihi Beach	0
26	Waimapu	156
27	Wainui	182
28	Waione	586
29	Waipapa	172.5
30	Wairoa-Ngamawahine	0
31	Wairoa-Ohourere	0
32	Wairoa-Wairoa	573
33	Waitao Area	0
34	Waitekohe	55
35	Welcome Bay Area	91
36	Whatakao	0
	Sub-total	**42369**
	Groundwater allocation zone/'WAI' number	**Sum of allocation in Waiteariki Ignimbrite, Aongatete Ignimbrite and Coromandel volcanics (m^3/day)**
	WAI1	46649.5
	WAI2	23345.7
	WAI3	32386
	Sub-total	**102381.2**
	Sum of allocation with information on geological formation	**144750.2**

6.2 Suggested groundwater allocation zones

Groundwater allocation zones are useful for:

- assessment of groundwater availability;
- assessment of groundwater use;
- identifying a community of interest in water resource issues;
- linking groundwater use and potential locality-specific effects of groundwater use.

The authors suggest that allocation zones are existing surface catchment boundaries (Figure 5.2) where aquifers have a likely connection with surface catchments, i.e.:

- Tauranga Group Sediments;
- Mamaku Ignimbrite;
- Waimakariri Ignimbrite;
- Minden Rhyolites and Otawa Volcanics.

The authors suggest three allocation zones (Figure 6.3) are adopted for groundwater allocation from the Waiteariki Ignimbrite, Aongatete Ignimbrite and Coromandel volcanics, named 'WAI' zones, where allocation is unlikely to directly impinge on surface water flow. Suggested boundaries for these three allocation zones are coincident with some surface catchment boundaries as:

- allocation is conveniently summed by surface catchment;
- groundwater abstraction may affect surface flows in related catchments.

These three allocation zones are located:

- WAI zone 1 Waihi to Te Puna, including Matakana Island, from the coast to the Kaimai Range with boundaries based on surface catchment boundaries;
- WAI zone 2 Te Puna to Mt Otawa, from the coast to the Kaimai Range and Mamaku Plateau with boundaries based on surface catchment boundaries and the groundwater boundary of the Lake Rotorua catchment;
- WAI zone 3 from Mt Otawa to the eastern boundary of the Western Bay of Plenty area with boundaries based on surface catchment boundaries (Figure 6.3) and the groundwater boundary of Lake Rotorua catchment.

Groundwater boundaries of the Lake Rotorua catchment are not represented in Figure 6.3 as these boundaries are in review at the time of writing (January 2009).

6.3 Allocation policies

This report considers maximum 'groundwater available for allocation', i.e. the maximum potential groundwater allocation, based on available geological and water balance models. Actual allocation should be less than the maximum groundwater available for allocation.

Groundwater flow and storage may be available for allocation, subject to policies and rules for allocation in the regional plan.

EBOP's proposed Regional Water and Land Plan (summarised by White 2005) includes policies and objectives for groundwater allocation, e.g.:

- Objective 36, abstraction of groundwater should be sustainable;
- Policy 57, sustainable yield allocation;
- Method 125, 'instruments' to manage water takes;
- Method 126, address adverse effects of groundwater takes on surface water.

The authors suggest (Section 8.5) that allocation policy should further consider:

- maintenance of baseflow in streams;
- a conservative allocation of deep groundwater flow;
- experience of other regional councils' groundwater allocation policies, for example Environment Canterbury aims to allocate a maximum of 50% of deep groundwater recharge;
- proposed national policies on water allocation. For example the proposed National Policy on water allocation proposes a maximum allocation of 35% of groundwater flow, in lieu of regional policy statements;
- groundwater levels near the coast – ensuring that levels do not decline below sea level allowing the possibility of salt water intrusion as salt water intrusion may occur when the water table is below sea level;
- groundwater chemistry near the coast – ensuring that wells where indications show the potential for salt water intrusion are assessed;
- groundwater quality in key aquifers is protected from potential effects of agricultural intensification;
- allocation of groundwater from storage in emergency situations only.

Policy decisions on groundwater allocation are beyond the scope of this report.

6.4 Shallow groundwater recharge

Shallow groundwater recharge supports baseflow in streams.

An assessment of surface water allocation (EBOP 1999) showed that 22 catchments were under usage pressure in the Bay of Plenty region including approximately 16 Tauranga catchments and 3 catchments in the Te Puke area. Some streams are over allocated.

Use of shallow groundwater recharge (estimated by surface catchment in Table 3.7) will probably impact on stream baseflow and put surface waters under further pressure. Therefore it is recommended that rules be put around the allocation of shallow groundwater recharge based on assessments of local and cumulative effects.

This report assumes shallow groundwater recharge is not available for allocation.

6.5 Estimated groundwater available for allocation

A conservative approach to estimation of maximum groundwater available for allocation has:

- zero allocation where estimated deep rainfall recharge to groundwater is less than surface water baseflow;

- zero allocation of inter-aquifer deep groundwater flow (e.g. deep groundwater flow in the Minden Rhyolite probably flows to the Waiteariki Ignimbrite).

The sum of maximum groundwater available for allocation is approximately 13.7 m^3/s (Table 5.8).

Estimated groundwater available for allocation is assigned to two sets of geological units (Section 6.2):

- Tauranga Group Sediments, Mamaku Ignimbrite, Waimakariri Ignimbrite and Minden/Otawa volcanics within catchment boundaries (Table 6.4);
- Waiteariki Ignimbrite, Aongatete Ignimbrite and Coromandel volcanics within three broad zones (Table 6.5);

Table 6.4 Estimated groundwater available for allocation from Tauranga Group Sediments, Mamaku/Waimakariri Ignimbrite, Minden Rhyolite and Otawa Volcanics within catchment boundaries.

Shallow geology catchment number	Catchment Name	Estimated maximum groundwater allocation (L/s)
1	Aongatete	206
2	Apata	104
3	Kaitemako	91
4	Katikati Streams	66
5	Kopurererua	393
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	512
7	Maketu	14
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	495
11	Maungatawa area	351
12	Omanawa	0
13	Ongare/Tanners Point	158
14	Otumoetai area	3
15	Oturu	81
16	Tahawai	100
17	Tauranga City area	71
18	Te Mania	61
19	Te Puna	0
20	Te Puna area	463
21	Te Rereatukahia	212
22	Tuapiro	201
23	Uretara	245
24	Waiau	240
25	Waihi Beach	249
26	Waimapu	1169
27	Wainui	0
28	Waione	90
29	Waipapa	233
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	320
32	Wairoa_Wairoa	145
33	Waitao area	412
34	Waitekohe	162
35	Welcome Bay area	156
36	Whatakao	186
	Sum (L/s)	7187
	Sum (m^3/s)	7.2

Table 6.5 Estimated groundwater available for allocation from Waiteariki Ignimbrite and Aongatete Ignimbrite in three broad zones.

Zone	Estimated maximum groundwater allocation (L/s)
WAI 1	3711
WAI 2	2483
WAI 3	351
Sum (L/s)	6545
Sum (m^3/s)	6.5

Typically, the geology of the Waiteariki Ignimbrite and Aongatete Ignimbrite are difficult to distinguish whilst drilling and may be hydraulically connected. Therefore the groundwater flows available for allocation are combined in this table.

6.6 Existing groundwater allocation and estimated groundwater available for allocation

Current EBOP groundwater allocation for 'cold' groundwater and 'geothermal' groundwater are listed in Appendix 18. Current groundwater allocations and estimated deep groundwater recharge for each surface catchment are summarised by surface catchment in Table 6.6. Groundwater allocation (3.4 m^3/s) is an average of 25% of estimated deep groundwater flow (13.7 m^3/s).

Current allocation is not compared with estimated deep groundwater recharge in allocation zones, suggested in Section 6.2, as only about 50% of the consented groundwater allocation has information on well depth (Section 6.1).

Some catchments have current groundwater allocation that exceed the estimated deep groundwater recharge, for example:

- Otumoetai area: current groundwater allocation is 33 L/s, while estimated deep groundwater recharge is 4 L/s;
- Te Puna: current groundwater allocation is 40 L/s, while estimated deep groundwater recharge is 0 L/s;
- Wainui: current groundwater allocation is 25 L/s, while estimated deep groundwater recharge is 0 L/s;
- Lower Kaituna (plain): current groundwater allocation is 1246 L/s while groundwater available for allocation is 854 L/s.

Some catchments have current groundwater allocations that are a large proportion of estimated deep groundwater recharge:

- Ongare/Tanners Point: current groundwater allocation corresponds to 63% of estimated groundwater available for allocation;
- Waione: current groundwater allocation corresponds to 50% of estimated groundwater available for allocation;
- Tauranga City area: current groundwater allocation corresponds to 32% of estimated groundwater available for allocation.

Table 6.6 Groundwater available for allocation in Tauranga Group Sediments, Mamaku Ignimbrite, Waimakariri Ignimbrite, Minden Rhyolite and Otawa Volcanics geological units and existing groundwater allocation.

Catchment number	Catchment name	Deep groundwater recharge/groundwater available for allocation (L/s)	Current groundwater allocation (L/s)	Allocation/deep groundwater recharge %
1	Aongatete	686	15	2
2	Apata	260	14	5
3	Kaitemako	227	2	1
4	Katikati Streams	132	20	15
5	Kopurererua	462	95	21
6	Lower Kaituna (hills)	0	409	Excess allocation
6a	Lower Kaituna (Plain)	854	1246	Excess allocation
7	Maketu	24	0	0
8	Mangapapa/Opuiaki	0	0	Excess allocation
9	Mangorewa	0	88	Excess allocation
10	Matakana Island	707	11	2
11	Maungatawa area	502	210	42
12	Omanawa	0	39	Excess allocation
13	Ongare/Tanners Point	175	111	63
14	Otumoetai area	4	33	Excess allocation
15	Oturu	116	51	44
16	Tahawai	199	18	9
17	Tauranga City area	84	27	32
18	Te Mania	101	21	21
19	Te Puna	0	40	Excess allocation
20	Te Puna area	771	1	0
21	Te Rereatukahia	303	22	7
22	Tuapiro	502	27	5
23	Uretara	490	11	2
24	Waiau	479	127	27
25	Waihi Beach	498	41	8

Catchment number	Catchment name	Deep groundwater recharge/groundwater available for allocation (L/s)	Current groundwater allocation (L/s)	Allocation/deep groundwater recharge %
26	Waimapu	1949	88	5
27	Wainui	0	25	Excess allocation
28	Waione	129	64	50
29	Waipapa	776	249	32
30	Wairoa_Ngamawahine	0	1	Excess allocation
31	Wairoa_Ohourere	799	150	19
32	Wairoa_Wairoa	408	57	14
33	Waitao area	824	13	2
34	Waitekohe	404	13	3
35	Welcome Bay area	260	30	12
36	Whatakao	532	9	2
	Sum (L/s)	13657	3378	
	Sum (m^3/s)	13.7	3.4	

6.7 Estimate of groundwater use

Current groundwater use is estimated in three water use classes:

- ‘general’ allocation (Appendix 19), which includes municipal water use, for 365 days in the year at the daily allocated rate;
- frost protection water use for 30 days in the year at the allocated daily rate;
- irrigation water use for 5 months in the year at the allocated daily rate.

Annual groundwater use is estimated as an equivalent of 180,682 m^3/day (Table 6.7).

Estimated groundwater use by general (municipal) is largest of the three water use classes.

Table 6.7 Estimated use for existing groundwater consents.

Type of use	Estimated annual use (m^3/day equivalent)
General (municipal)	135,624
Frost protection	4,916
Irrigation	40,142
Total	180,682

6.8 Groundwater available for allocation and estimated groundwater use

Estimated groundwater use (Section 6.7) totals an equivalent of 180,682 m^3/day or approximately 2.1 m^3/s (Table 6.7 and Table 6.8). Estimated groundwater use is largest in the Kaituna catchment.

Estimated use is greater than estimated groundwater available for allocation in five catchments (Table 6.8):

- Omanawa;
- Otumoetai area;
- Te Puna;
- Wainui;
- Wairoa - Ngamawahine.

Table 6.8 Groundwater available for allocation and estimated groundwater use

Catchment number	Catchment name	Deep groundwater recharge/groundwater available for allocation (L/s)	Estimated groundwater use (L/s)	Allocation/deep groundwater recharge %
1	Aongatete	686	6	1
2	Apata	260	10	4
3	Kaitemako	227	2	1
4	Katikati Streams	132	15	11
5	Kopurererua	462	55	12
6	Lower Kaituna	854	819	96
7	Maketu	24	0	0
8	Mangapapa/Opuiaki	0	0	na
9	Mangorewa	0	36	excess
10	Matakana Island	707	6	1
11	Maungatawa area	502	175	35
12	Omanawa	0	21	excess
13	Ongare/Tanners Point	175	68	39
14	Otumoetai area	4	32	800
15	Oturu	116	25	22
16	Tahawai	199	11	6
17	Tauranga City area	84	27	32
18	Te Mania	101	17	17
19	Te Puna	0	26	excess
20	Te Puna area	771	1	0
21	Te Rereatukahia	303	20	7
22	Tuapiro	502	7	1
23	Uretara	490	8	2
24	Waiau	479	119	25
25	Waihi Beach	498	35	7

Catchment number	Catchment name	Deep groundwater recharge/groundwater available for allocation (L/s)	Estimated groundwater use (L/s)	Allocation/deep groundwater recharge %
26	Waimapu	1949	61	3
27	Wainui	0	12	excess
28	Waione	129	28	22
29	Waipapa	776	208	27
30	Wairoa_Ngamawahine	0	1	excess
31	Wairoa_Ohourere	799	150	19
32	Wairoa_Wairoa	408	46	11
33	Waitao area	824	8	1
34	Waitekohe	404	11	3
35	Welcome Bay area	260	25	10
36	Whatakao	532	4	1
	Sum (L/s)	13657	2091	
	Sum (m^3/s)	13.7	2.1	

6.9 Allocation of groundwater from storage

Allocation of groundwater from storage (as opposed to groundwater flux) is not good practice as this can lead to mining of the groundwater resource. However allocation of groundwater from storage may be reasonable in emergency situations (e.g. fire or failure of drinking water supplies in natural disasters). For example Gisborne City used groundwater as an emergency drinking water supply when its surface reservoirs were put out of action during Cyclone Bola (White, 1997).

Tauranga City may have 2.6 million m^3 of groundwater from the Aongatete Ignimbrite in the Tauranga City catchment (Table 4.3) potentially available for emergency use. It is recommended that EBOP consider rules for the use of groundwater in emergency situations and rules that define an emergency.

6.10 Uncertainty of estimates

Uncertainty in groundwater recharge estimates is large (Section 5.3.1 and Section 5.3.2). For example, the uncertainty in deep groundwater recharge estimate of 686 L/s for the Aongatete catchment may be $\pm$ 371 L/s (Appendix 21). Uncertainty in groundwater recharge estimates is commonly larger than +/- 100% (e.g. Maungatawa area, Otumoetai area, etc). These uncertainties are reason to be conservative with groundwater allocation.

7.0 RECOMMENDATIONS

7.1 Estimates of baseflow in streams

Environment Bay of Plenty holds records of low flow for many streams in the Western Bay of Plenty. However some low flow measurement sites are not located in the ideal position to measure baseflow discharge from groundwater; many streams have only one, or few, flow measurements.

Therefore it is recommended that Environment Bay of Plenty review its low-flow measurement programme in the Western Bay of Plenty area, with regard to:

- the location of flow gauging sites to measure baseflow discharge from groundwater;
- prioritisation for measurement;
- frequency of measurement.

It is also recommended that Environment Bay of Plenty:

- incorporate low-flow measurements in the Western Bay of Plenty area at priority sites in its summer gauging programme for the purpose of measuring baseflow discharge, and that:
- measurements of nutrients (nitrogen and phosphorous) be incorporated in the gauging programme to establish a dataset of nutrient discharge from the groundwater system to surface waters. This dataset will be very useful to assess the effects of land use on water quality.

7.2 Baseflow discharge estimates

Baseflow discharge is estimated as larger than, or very similar to, rainfall recharge in the following catchments (Section 5.3):

- Otumoetai;
- Te Puna;
- Wainui;
- Wairoa above Ruahihi Power Station;
- Lower Kaituna (hills).

It is recommended that a more in-depth analysis of baseflow be undertaken in these catchments to assess the potential for shallow (and deep) groundwater recharge.

This analyses could be supplemented with more gauging measurements to better estimate the location and rate of surface baseflow. The Lower Kaituna (hills) and Mangorewa catchments have surface water discharge larger than estimated recharge from rainfall. Therefore assessment of water balances from catchments to the east of the Lower Kaituna (hills) catchments is recommended to assess groundwater discharge to the Lower Kaituna (hills) catchments.

7.3 Groundwater level

Several dozen wells were identified (Section 3.3) where groundwater levels are close to, or below, sea level. These wells are at risk from salt water intrusion. However the quality of Environment Bay of Plenty data is unknown. Known-quality data over time are required to allow confident assessment of the risks of salt water intrusion. Collection of groundwater elevation data, pumping data and relevant aquifer properties (e.g., hydraulic conductivity) would also be helpful to assess the risks of salt water intrusion.

It is recommended that:

- these wells are located on the ground;
- ground elevations at the wells, and groundwater depths in the wells, be surveyed;
- groundwater elevation be calculated;
- wells where groundwater level is at, or below, sea level are considered at risk from salt water intrusion (other wells may also be at risk from salt water intrusion);
- drawdowns during pumping and groundwater levels after pumping should be considered in this analysis;
- Environment Bay of Plenty consult with well owners and discuss possible future actions;
- Environment Bay of Plenty review groundwater availability in catchments, and in geological units, if groundwater levels are shown to be below sea level.

7.4 Groundwater chemistry and temperature

Chemistry data collected by the Bay of Plenty Catchment Commission before April 1992 (Section 3.4) apparently contains database errors.

Therefore it is recommended that:

- groundwater chemistry data collected before April 1992 is reviewed by Environment Bay of Plenty. Original chemistry measurements should be compared with database entries and corrections to the database actioned.

Salt water intrusion is possibly identified in EBOP well number 2707, located at Papamoa (Section 3.4).

It is recommended that:

- historical trends of groundwater chemistry in EBOP well number 2707, with interpretation, be reported to the well owner;
- Environment Bay of Plenty consult with the owner of EBOP well number 2707 to discuss possible future actions if salt water intrusion is possible at this well;
- Environment Bay of Plenty continue to monitor groundwater quality at EBOP well number 2707;
- Environment Bay of Plenty continue to monitor groundwater quality at EBOP well numbers 1393, 2303 and 4364 more frequently if required;
- Environment Bay of Plenty report on the monitoring data in these wells to owners;
- Environment Bay of Plenty review the monitoring programme in these wells.

Trends (increasing or decreasing) in groundwater chemistry over time are identified in EBOP well numbers 1393, 2707, 2303 and 4364 (Section 3.4.1).

Potential stress on the thermal groundwater resource is indicated by:

- allocation in the Otumoetai catchment that is larger than estimated groundwater available for allocation;
- estimated use in the Tauranga City catchment that is a relatively large (27%) proportion of groundwater available for allocation.

It is recommended that:

- historical trends of temperature and groundwater level are assessed in wells taking thermal water;
- Environment Bay of Plenty continue to monitor water temperature and groundwater levels in wells taking thermal water.

7.5 Groundwater allocation data

The EBOP allocation dataset includes errors, including occasional incorrect definition of allocation units, and omissions, such as missing consent coordinates.

It is recommended that Environment Bay of Plenty complete a quality audit of its water allocation database as, for example:

- some consents on the database have duplicate entries (Appendix 18);
- some consents on the database do not have allocation information and do not have location information (Appendix 19).

Many wells in the EBOP groundwater allocation database set do not have depth information and therefore estimates of groundwater allocation by geological formation are incomplete (Appendix 20).

It is therefore recommended that EBOP attempt to measure the depth of wells with groundwater consents, where depth is currently unknown, to improve estimates of allocation by formation.

Many wells in the EBOP groundwater allocation dataset do not have a record of allocation (Table 6.1).

It is recommended that EBOP attempt to find allocation figures for these wells.

Groundwater use by municipal users is an important water use in the Western Bay of Plenty area. However the EBOP groundwater allocation dataset does not contain a 'municipal' water use class.

It is recommended that EBOP assign a 'municipal water' use class in the allocation dataset to relevant users.

7.6 Groundwater allocation policy

It is recommended that Environment Bay of Plenty consider allocation policies for:

- shallow groundwater, i.e. groundwater that supports baseflow in streams. Key policy issues include:
  - surface water use,
  - groundwater use and associated stream depletion,
  - land use in groundwater catchments affecting water availability,
  - land use in groundwater catchments affecting groundwater/surface water quality;
- deep groundwater. Key policy issues include:
  - allocation decisions (e.g. the proportion of groundwater recharge to allocate),
  - groundwater zone definition,
  - source protection;
- salt water intrusion. Key policy issues include:
  - definition of a 'set-back' distance for wells taking water from the Tauranga Group Sediments so that the potential for salt water intrusion is reduced in new wells,
  - Environment Bay of Plenty approach on existing wells where a potential for salt water intrusion is demonstrated;
- take into consideration well total depth, flow rate and hydraulic conductivity so that potential for salt water 'upconing' can be considered;
- groundwater allocation zones. An approach to the definition of groundwater zones is suggested in Section 6.5 where allocation zones are defined by surface catchments for the shallower aquifers and by three geological zones for the deeper aquifer;
- land use protection. Land use protection rules could be considered by Environment Bay of Plenty aiming to protect drinking water supplies. Groundwater systems provide the baseflow for drinking water supplies of Tauranga (White 2005) and Te Puke. Groundwater also supports directly the drinking water for Western Bay of Plenty. Land use in the catchments (surface water and groundwater) that supply drinking water is

mostly native forest and plantation forest. Forest conversions to intensive agriculture (e.g. dairy) are identified by White (2005) as an on-going land use change in the region. Intensification of agriculture commonly impacts on groundwater quality and surface water quality;

- allocation of groundwater from storage. Allocation of groundwater from storage (as opposed to groundwater flux) is not good practice as this can lead to mining of the groundwater resource. However allocation of groundwater from storage may be reasonable in emergency situations (e.g. fire or failure of drinking water supplies in natural disasters). Therefore stringent rules around allocation from storage in emergency situations, and rules that identify an emergency situation, could be considered by Environment Bay of Plenty.

7.7 Current groundwater allocation and estimated use

Potential stress on the groundwater resource is indicated by:

- groundwater allocation that is a relatively large proportion of estimated groundwater available for allocation;
- estimated groundwater use that is a relatively large proportion of estimated groundwater available for allocation;
- groundwater allocation and estimated groundwater use of thermal groundwater resources that are a relatively large proportion of estimated groundwater available for allocation;
- environmental measurements that indicate salt water intrusion, or declining availability of thermal groundwaters (Section 7.3 and Section 7.4).

Current groundwater allocation is generally less than estimated deep groundwater recharge (Table 6.6). However groundwater allocation is greater than 30% (Table 6.6) of estimated groundwater available for allocation in fourteen catchments in the Western Bay of Plenty area.

Estimated groundwater use is greater than estimated groundwater available for allocation in five catchments (Table 6.8) and greater than 50% of estimated groundwater available for allocation in the Lower Kaituna catchment.

Allocation, and use, in catchments with thermal resources such as Tauranga City and Otumoetai are a relatively high proportion of estimated groundwater available for allocation.

Environment Bay of Plenty should consider further groundwater investigations in catchments that have potential stress from allocation and use to improve knowledge of groundwater recharge and groundwater use and aim to assess, for example:

- effects of groundwater use on catchment groundwater levels at the catchment scale;
- any effects of groundwater pumping on stream flow;
- risks of depleting thermal resources;
- risk of salt water intrusion.

7.8 Model of groundwater recharge and flow

The model of groundwater recharge used in this report is quite simple but is appropriate as a first cut at estimating groundwater recharge in the Western Bay of Plenty area. Further analysis and geological unit modelling by catchment could provide more detailed information on groundwater flows and availability for allocation.

It is recommended that Environment Bay of Plenty consider a more sophisticated model to improve the confidence of flow estimates. A MODFLOW (or FEFLOW) groundwater flow would be the next logical step to assess groundwater resources in the area. This model could consider rainfall recharge, 'shallow' groundwater flow, 'deep' groundwater flow discharge, off-shore and inter-aquifer transfers.

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FIGURES

Figure 1.1 Topographic map with boundaries of the study area.

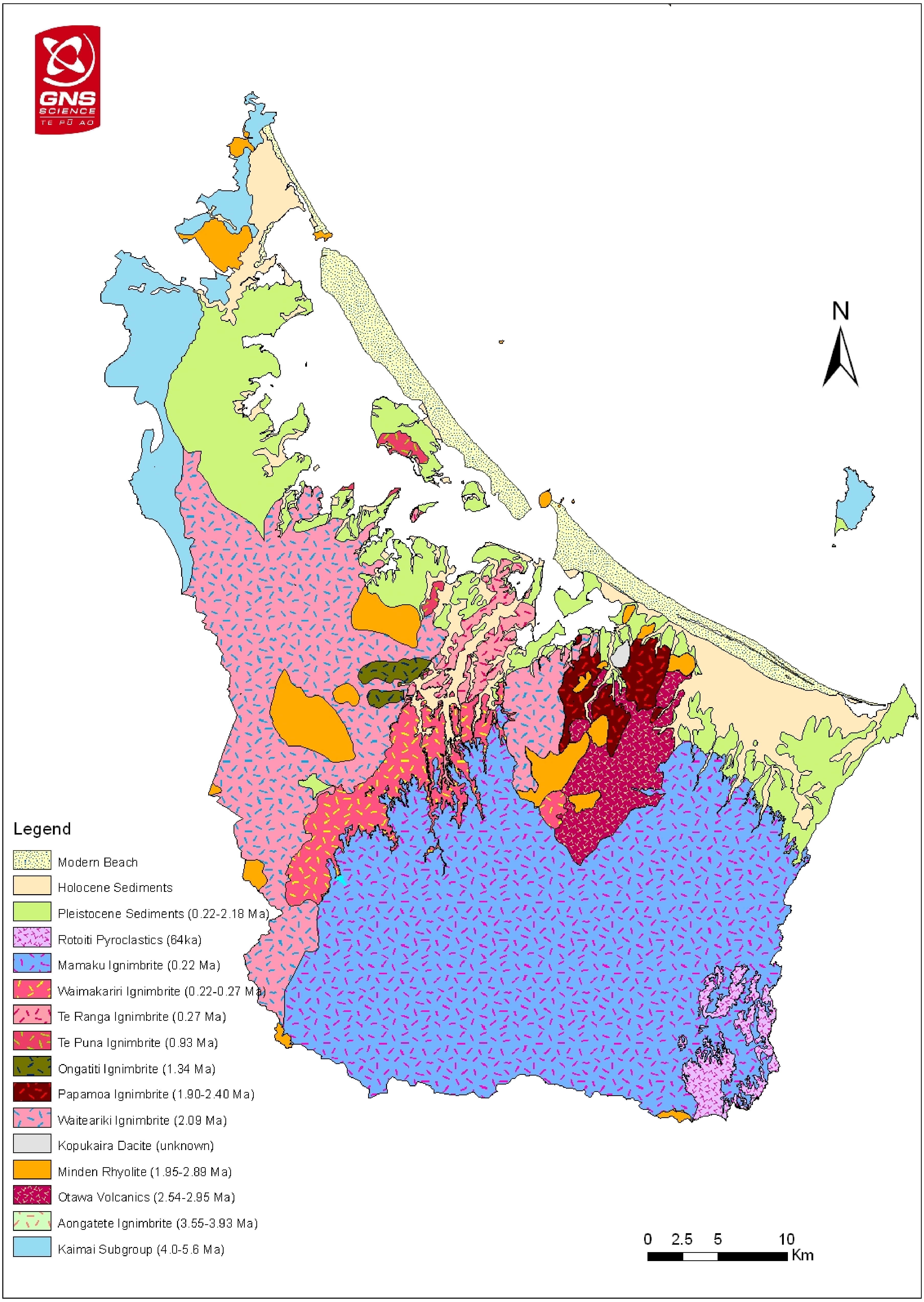


Figure 2.1 Geological map.

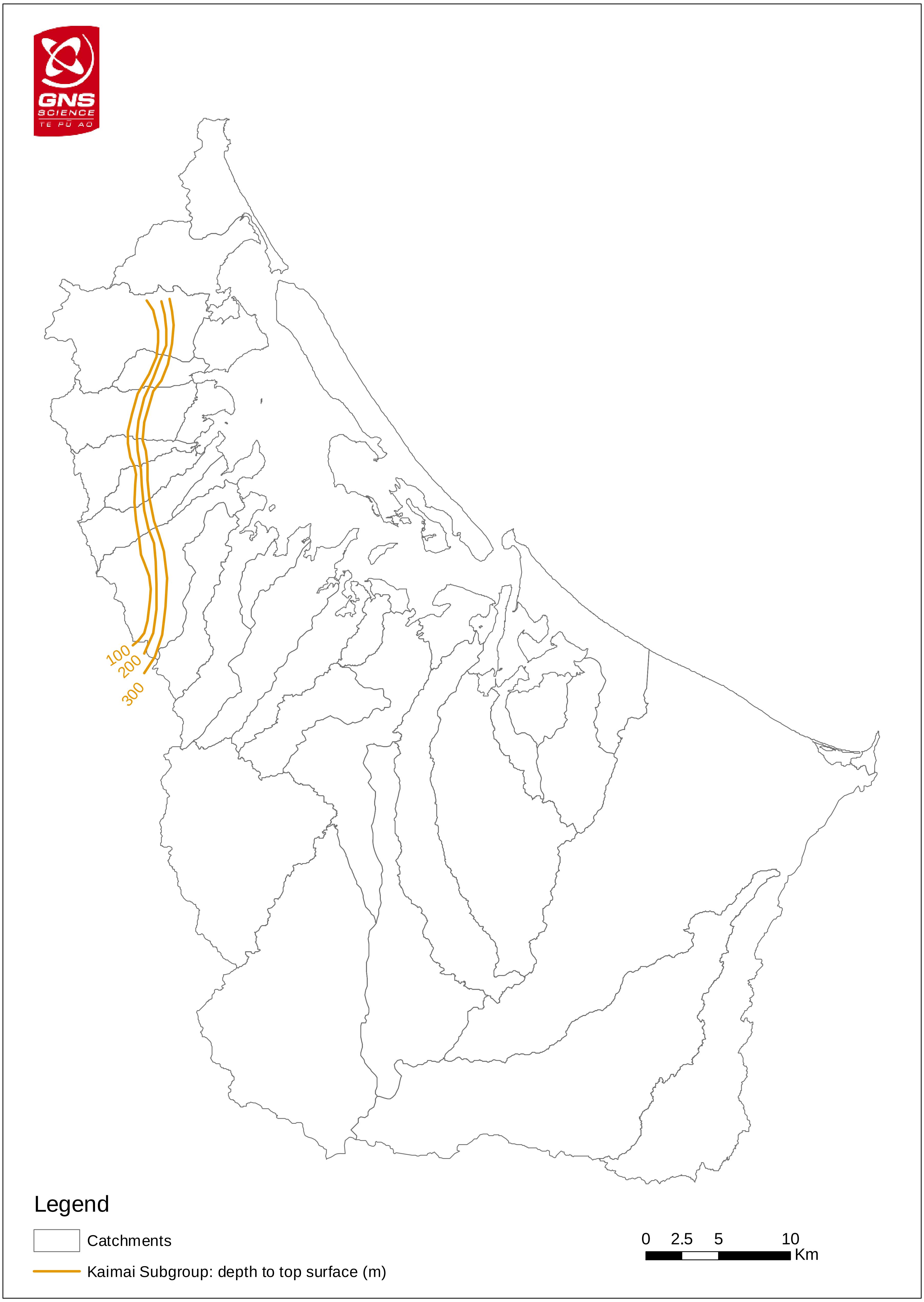


Figure 2.2 Estimated depth to the top of Kaimai Subgroup.

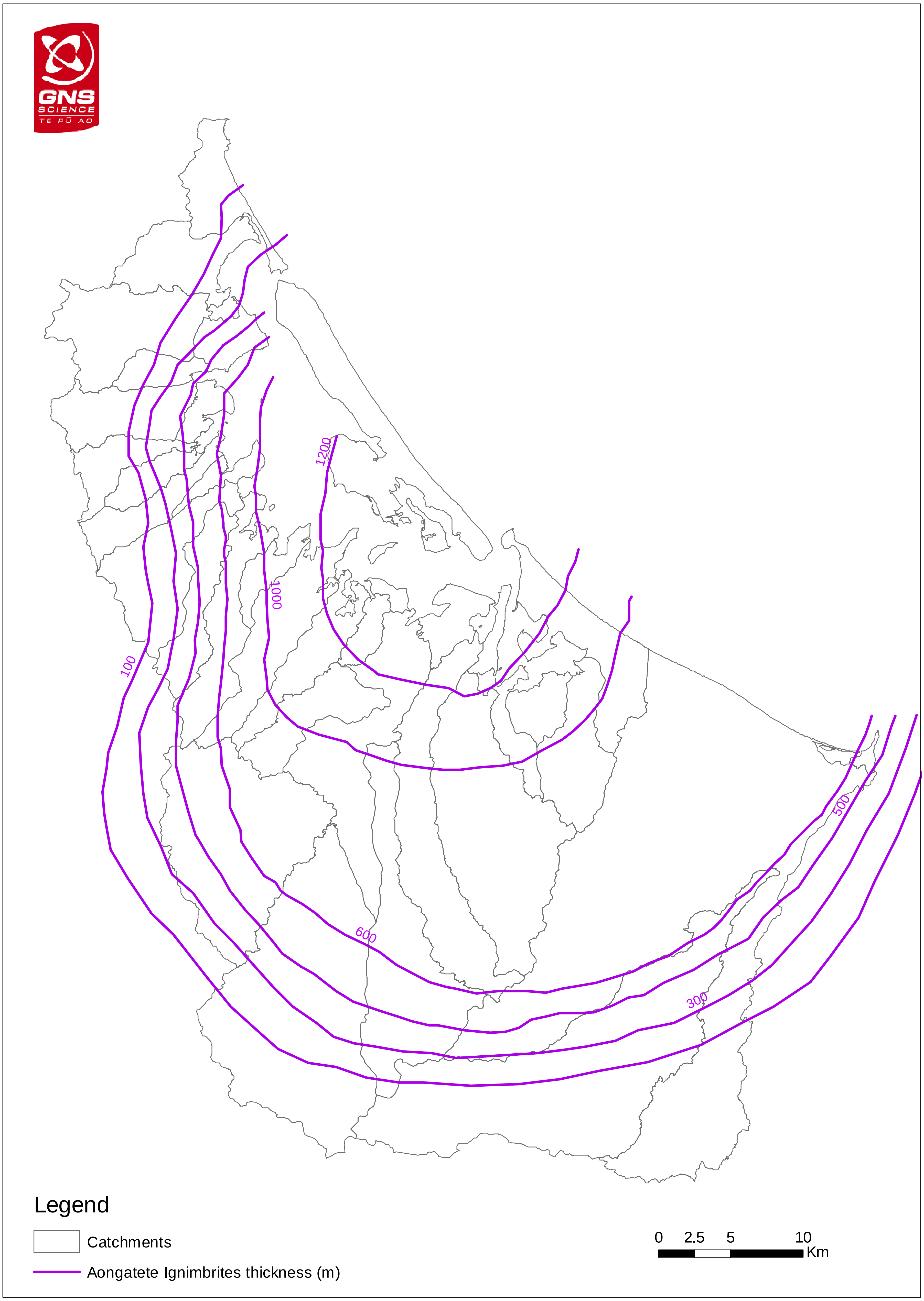


Figure 2.3 Isopach map – Aongatete Ignimbrites.

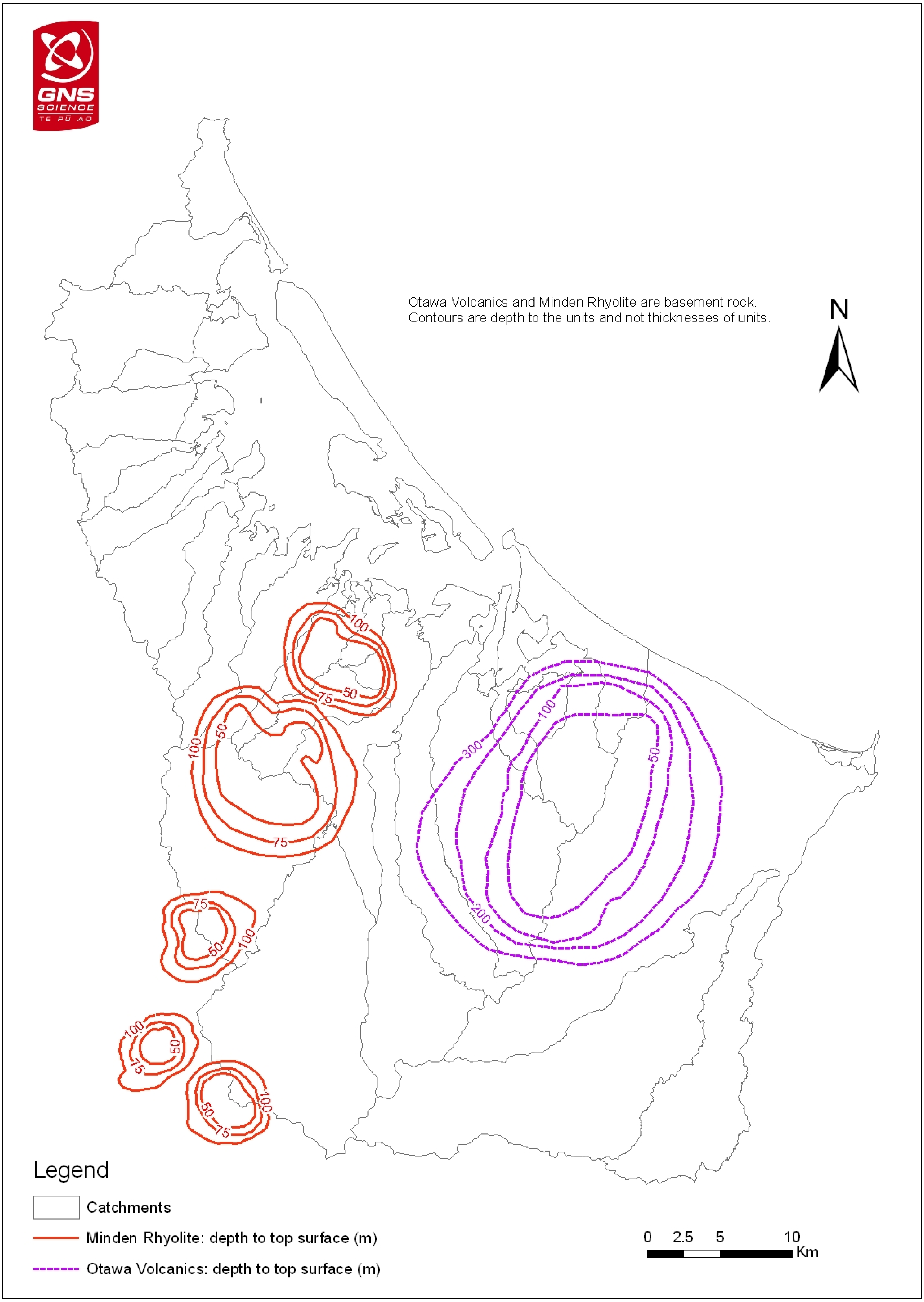


Figure 2.4 Otawa Volcanics and Minden Rhyolite.

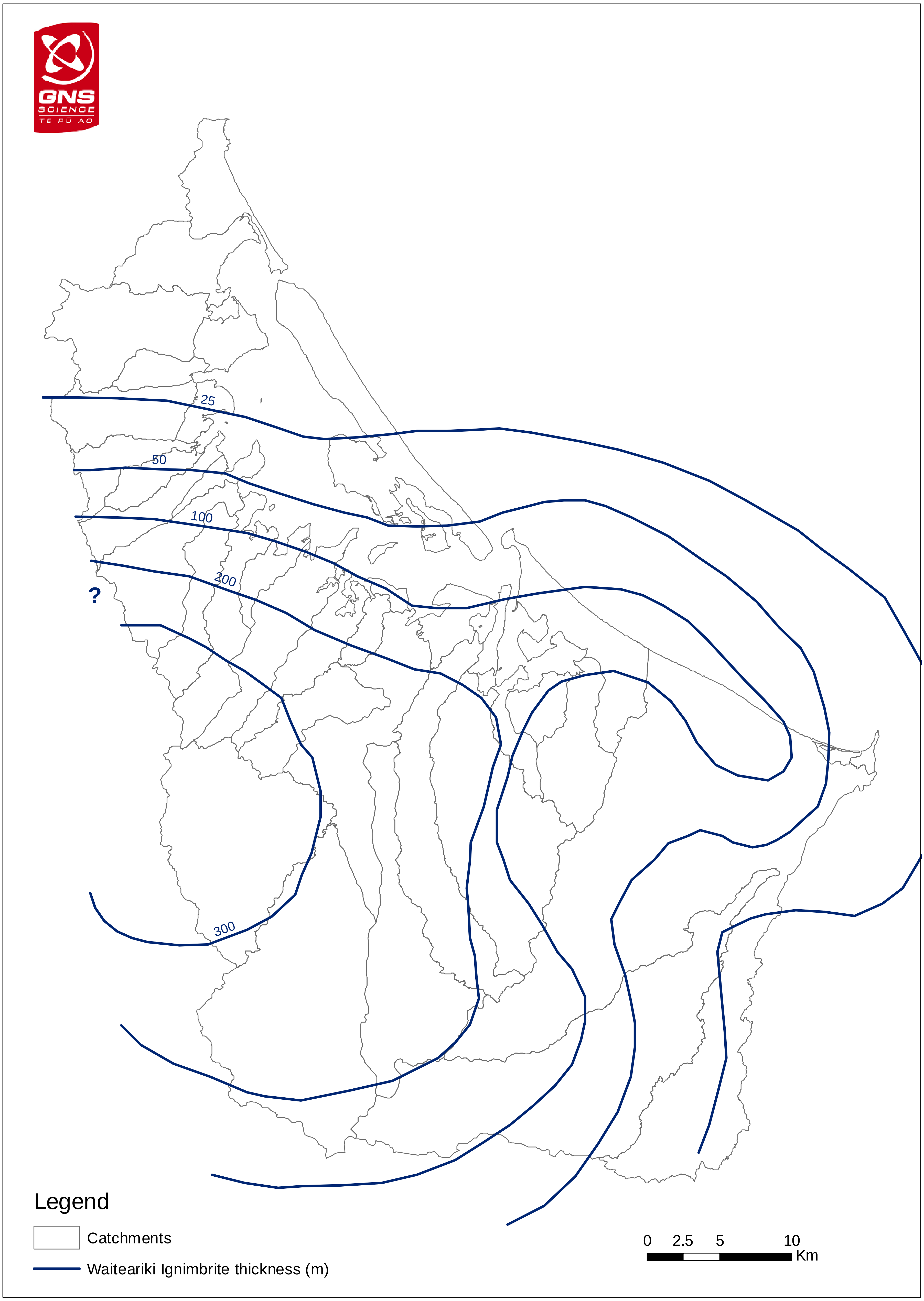


Figure 2.5 Isopach map – Waiteariki Ignimbrite.

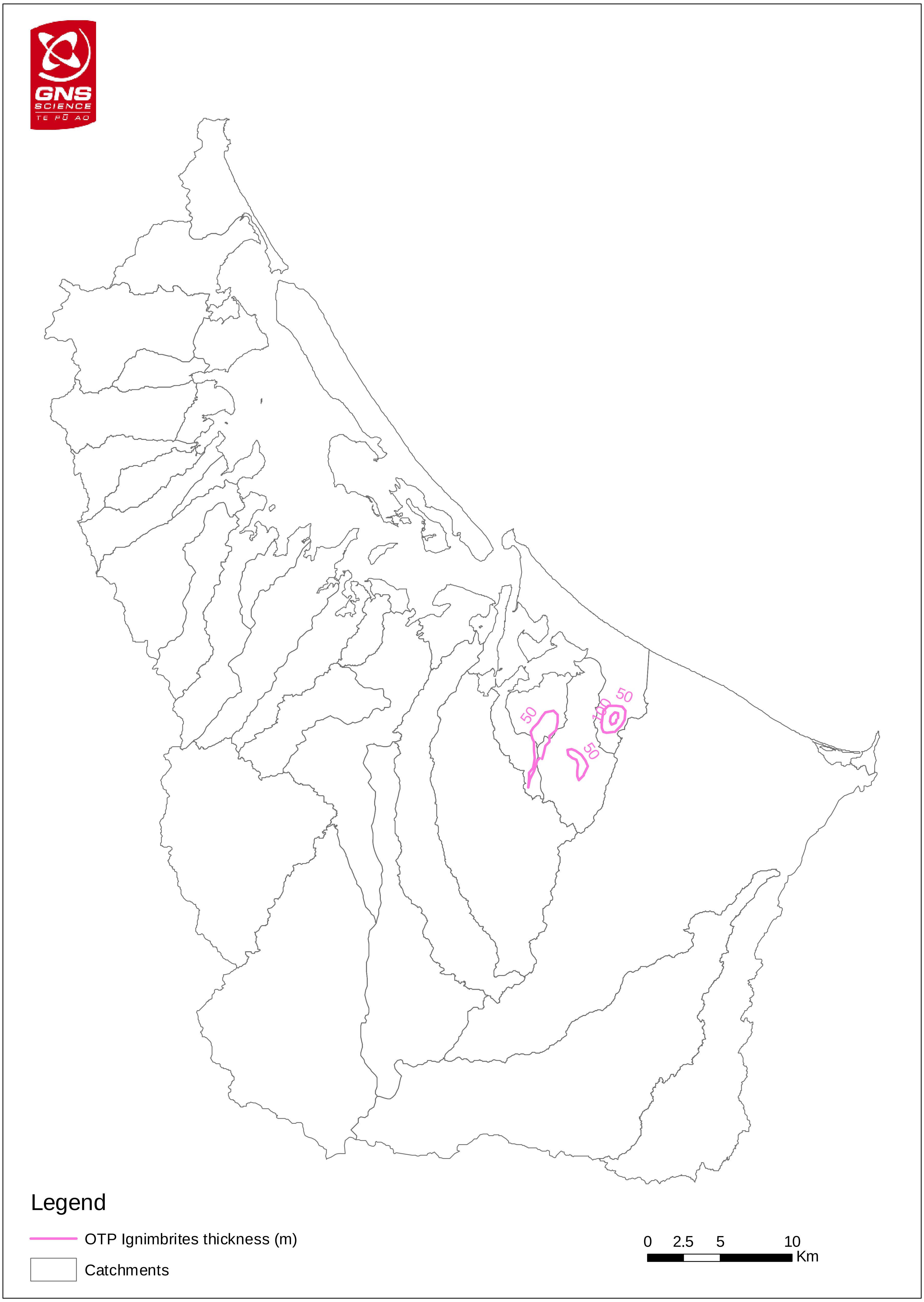


Figure 2.6 Isopach map – OTP Ignimbrites.

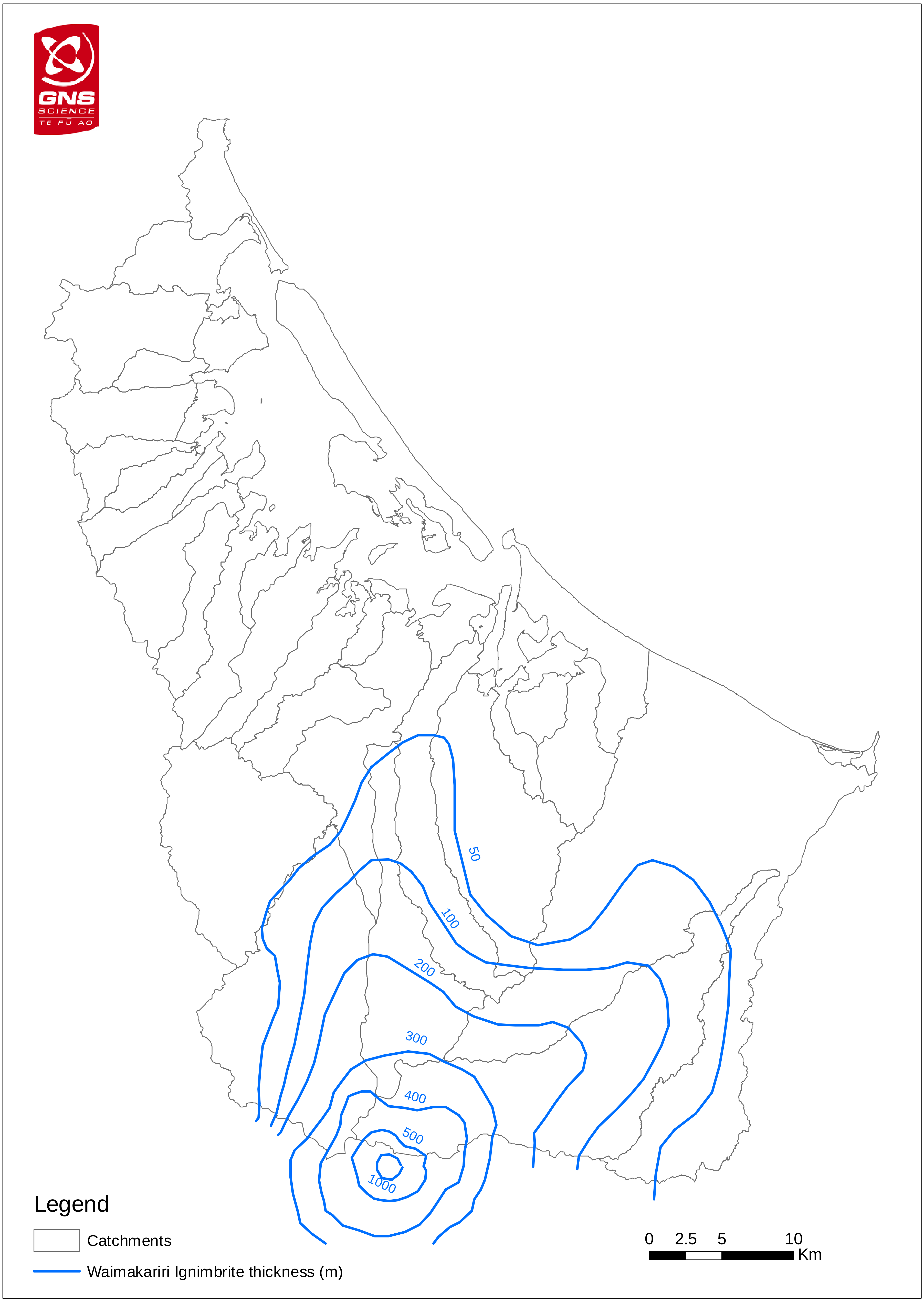


Figure 2.7 Isopach map – Waimakariri Ignimbrite.

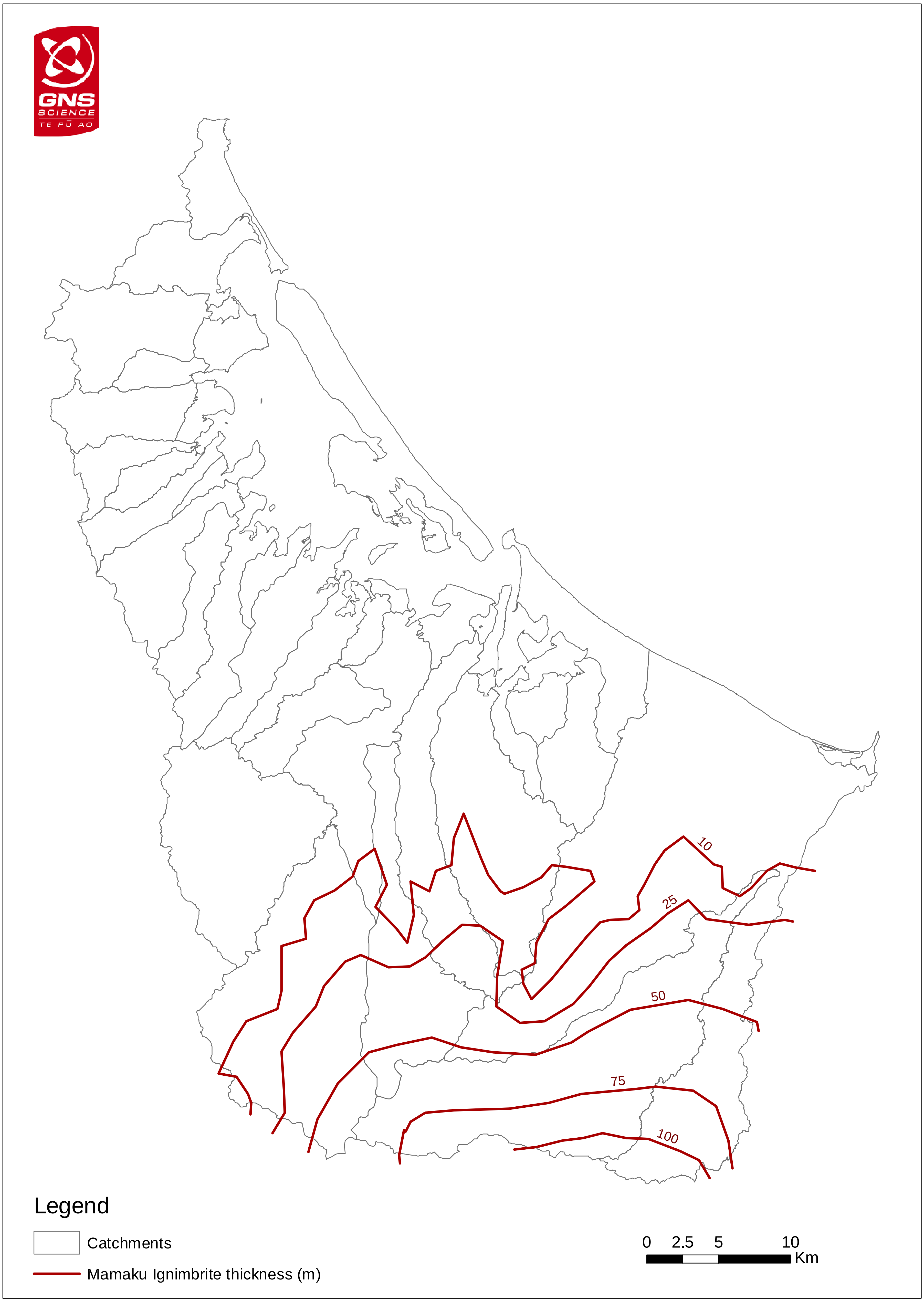


Figure 2.8 Isopach map – Mamaku Ignimbrite.

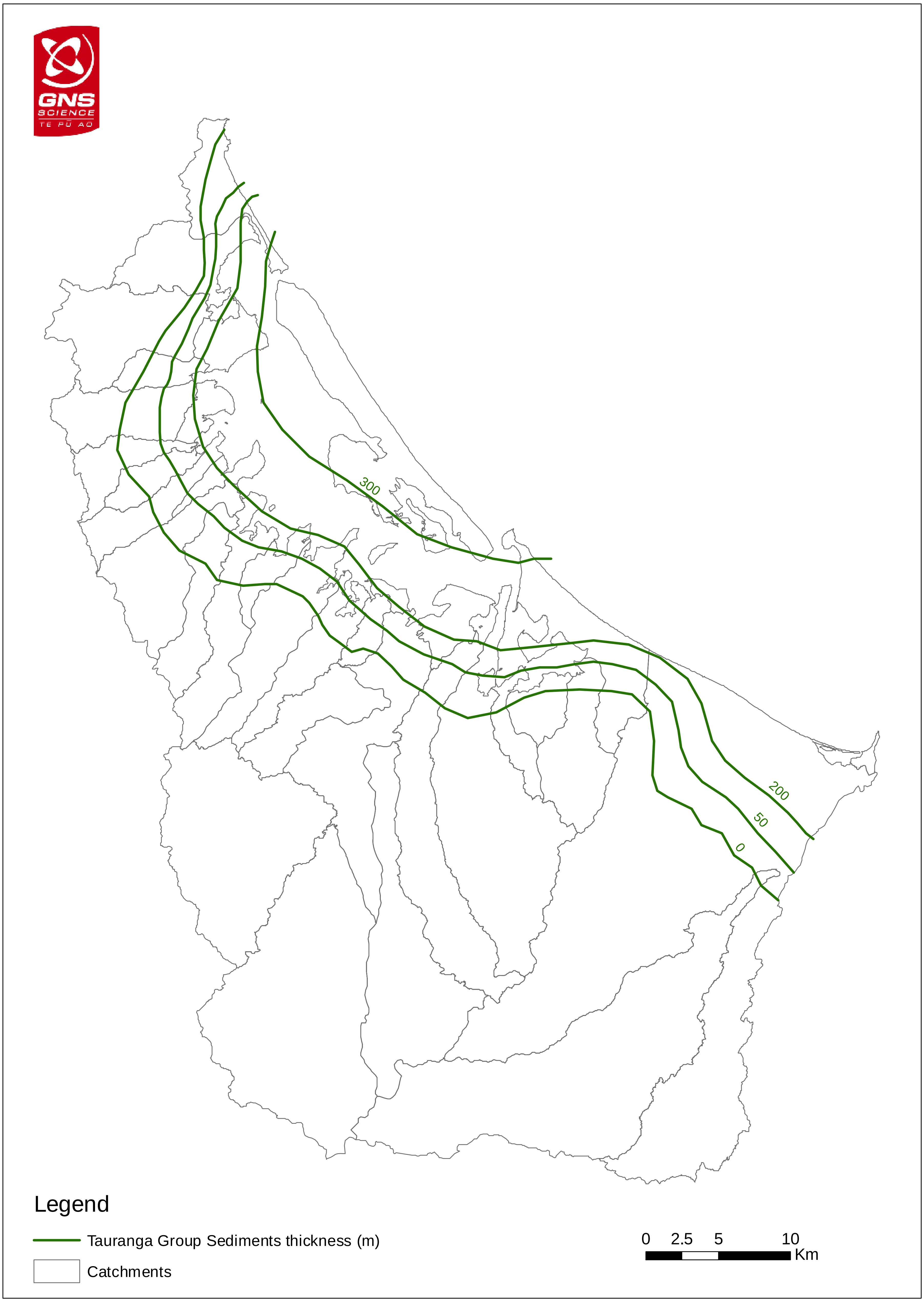


Figure 2.9 Isopach map – Tauranga Group Sediments.

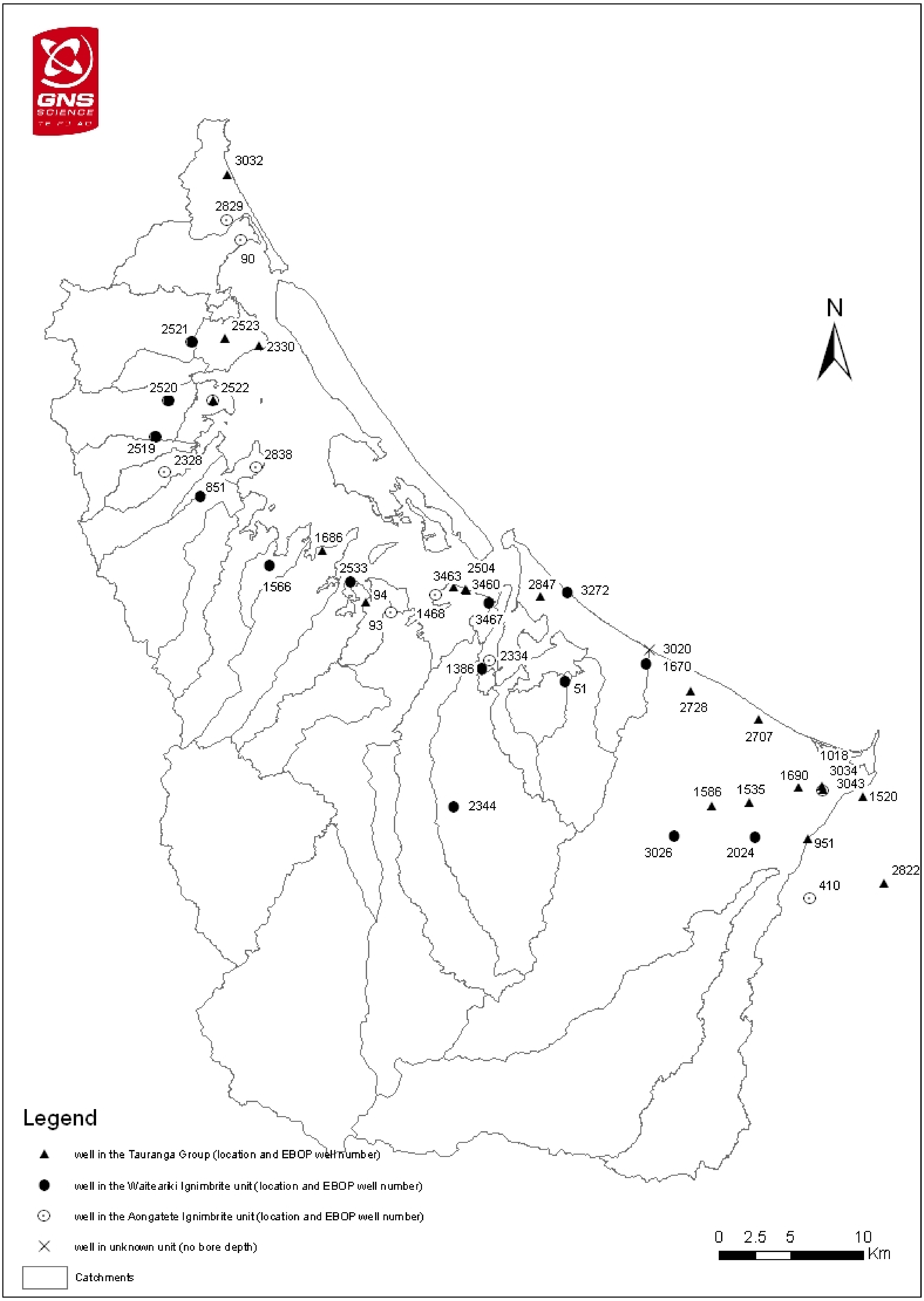


Figure 3.1 Location of wells with groundwater elevation estimates in the Western Bay of Plenty.

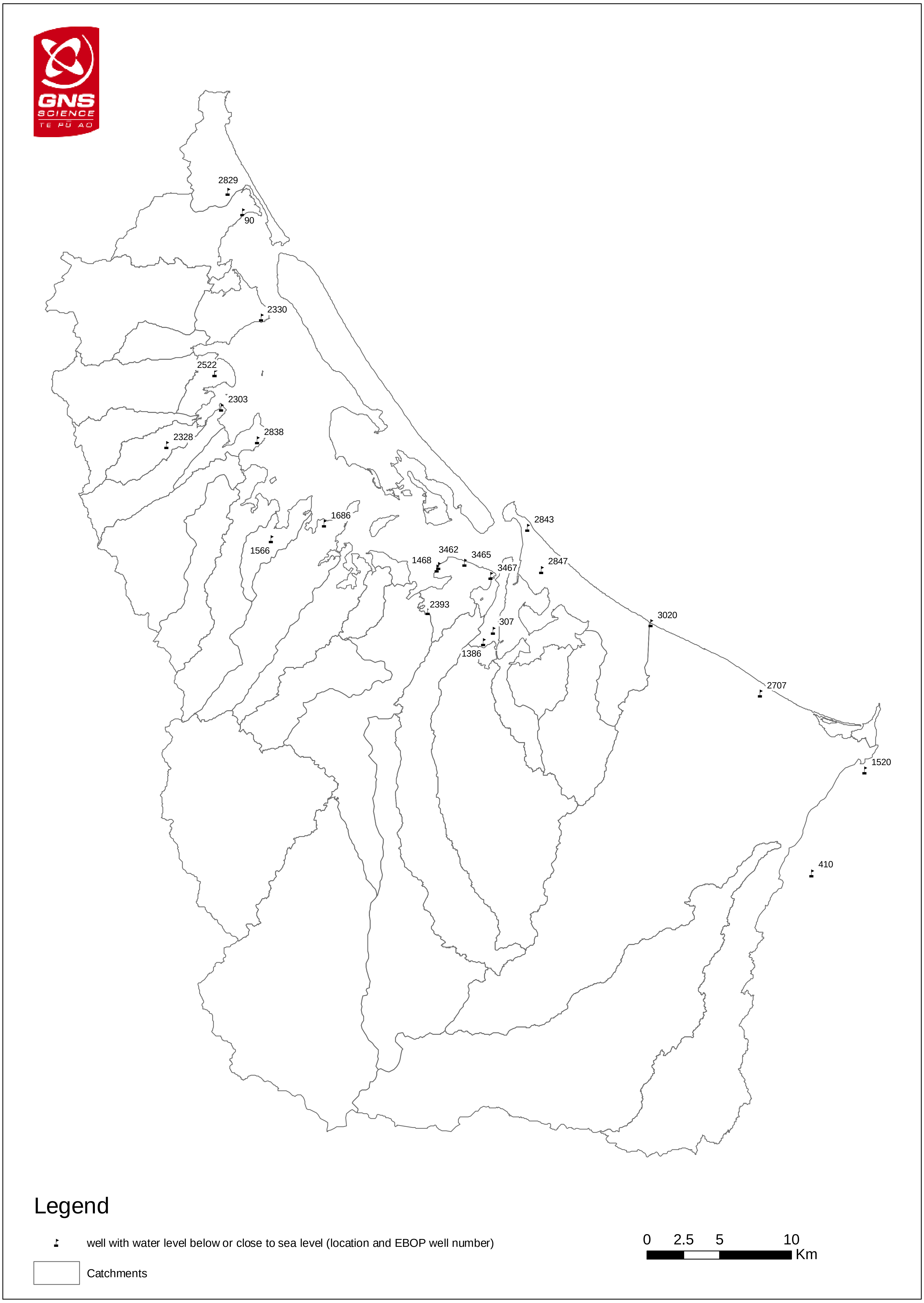


Figure 3.2 Wells with groundwater level below or close to sea level within the Western Bay of Plenty.

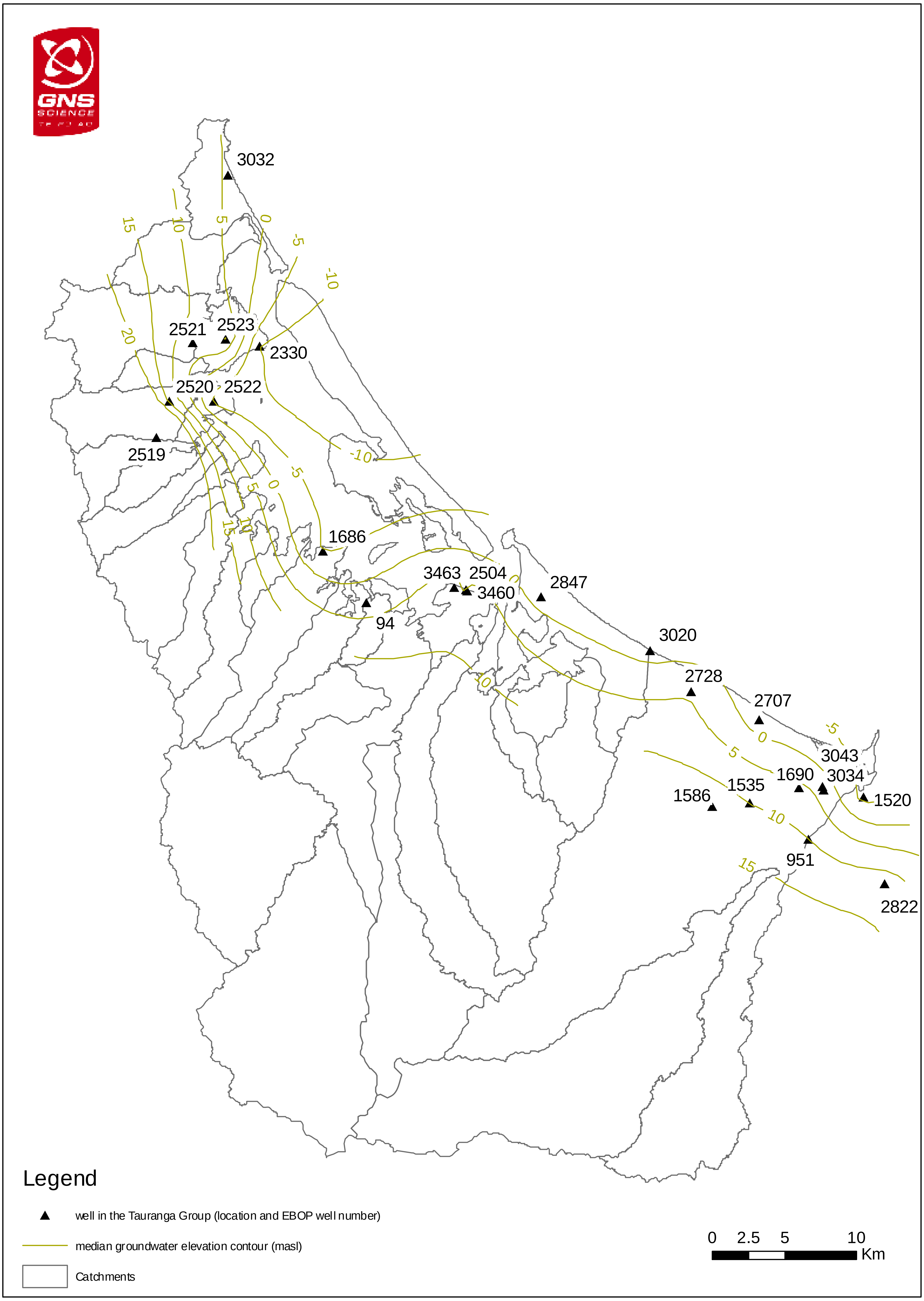


Figure 3.3 Median groundwater elevation within the Tauranga Group Sediments (masl).

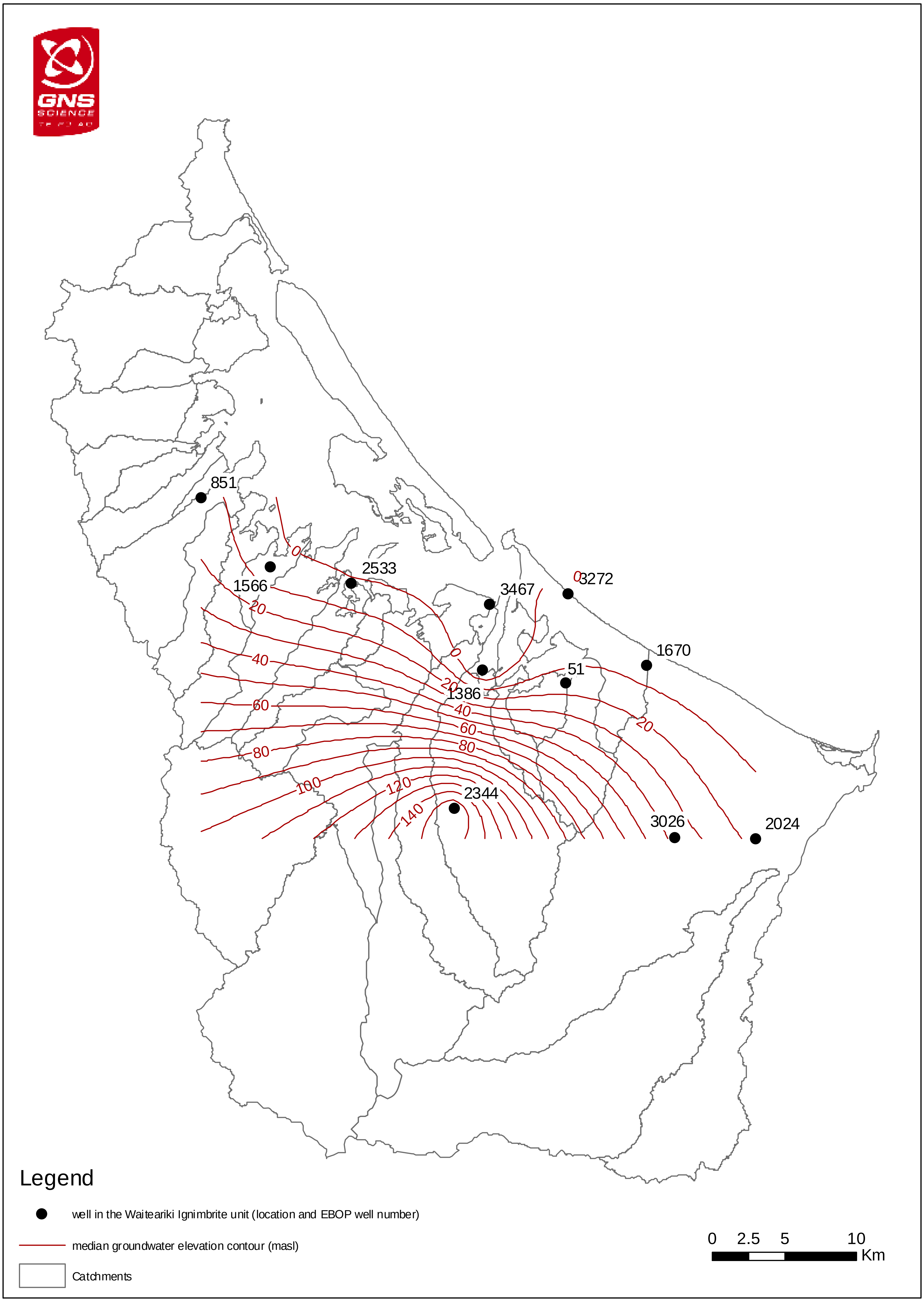


Figure 3.4 Median groundwater elevation within the Waitearik Ignimbrite unit (masl).

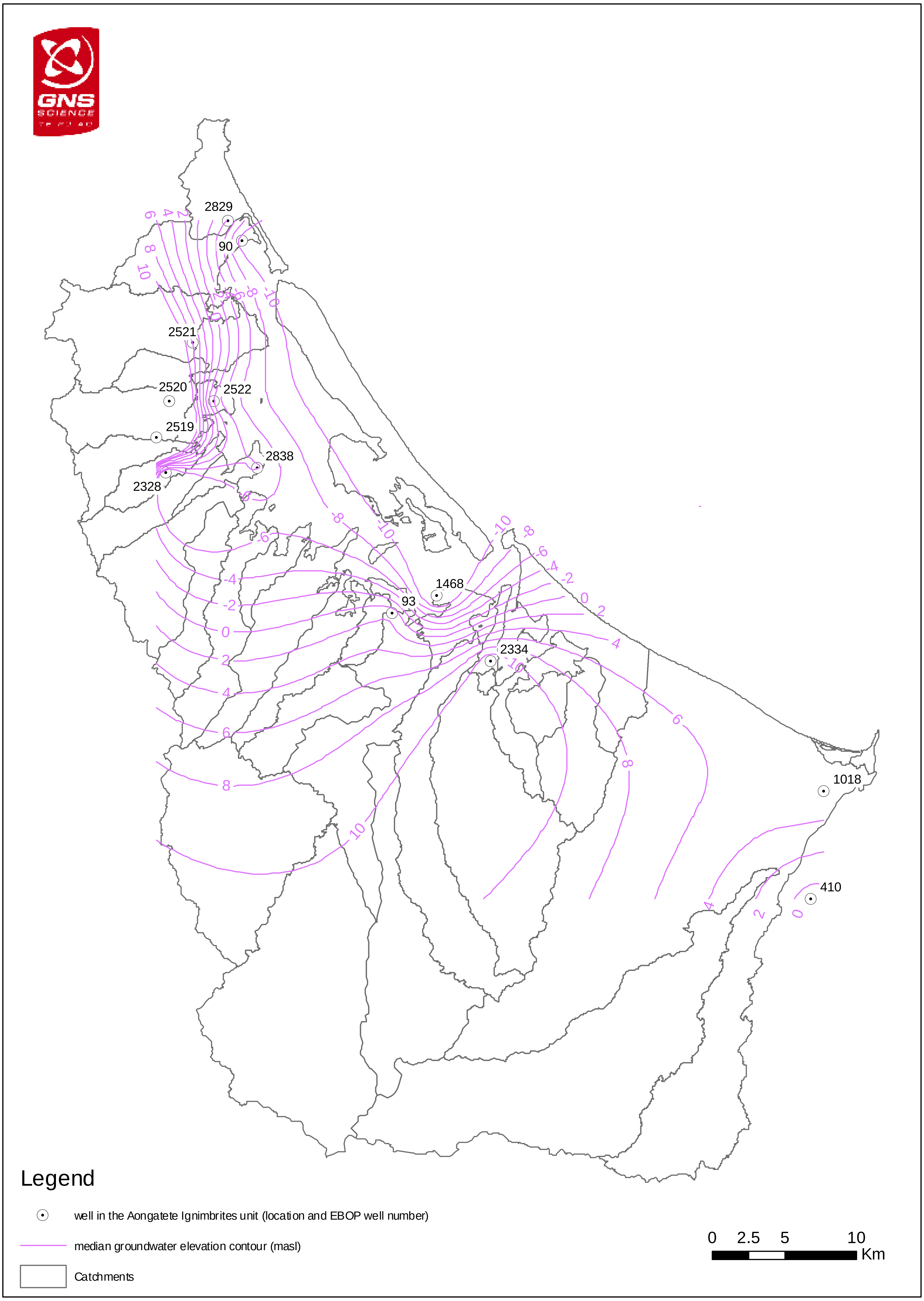


Figure 3.5 Median groundwater elevation within the Aongatete Ignimbrite unit (masl).

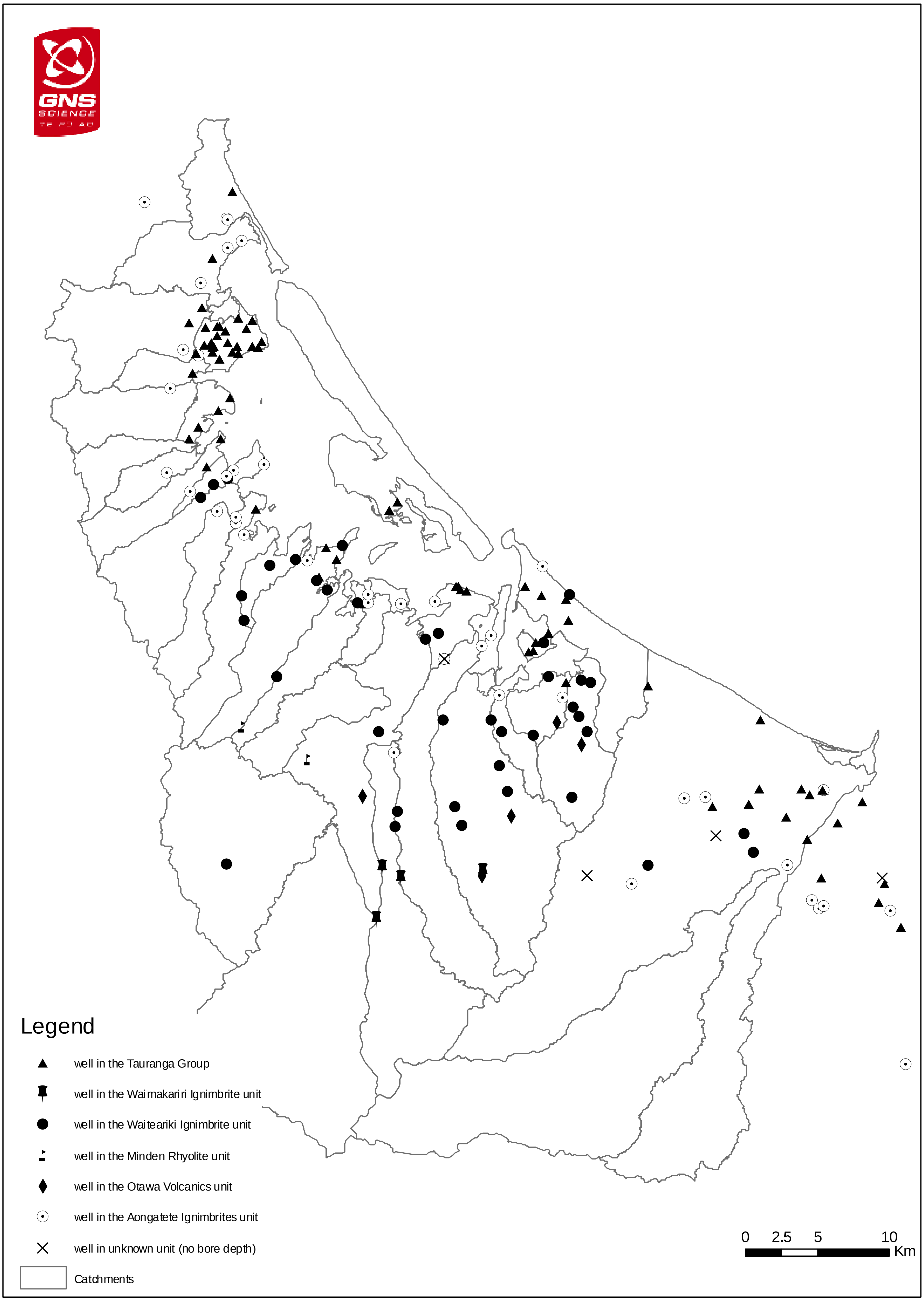


Figure 3.6 Groundwater chemistry data - location of wells within groundwater chemistry data and formation name in the Western Bay of Plenty.

Figure 3.7 Groundwater chemistry data – location of wells with major ion data and formation name.

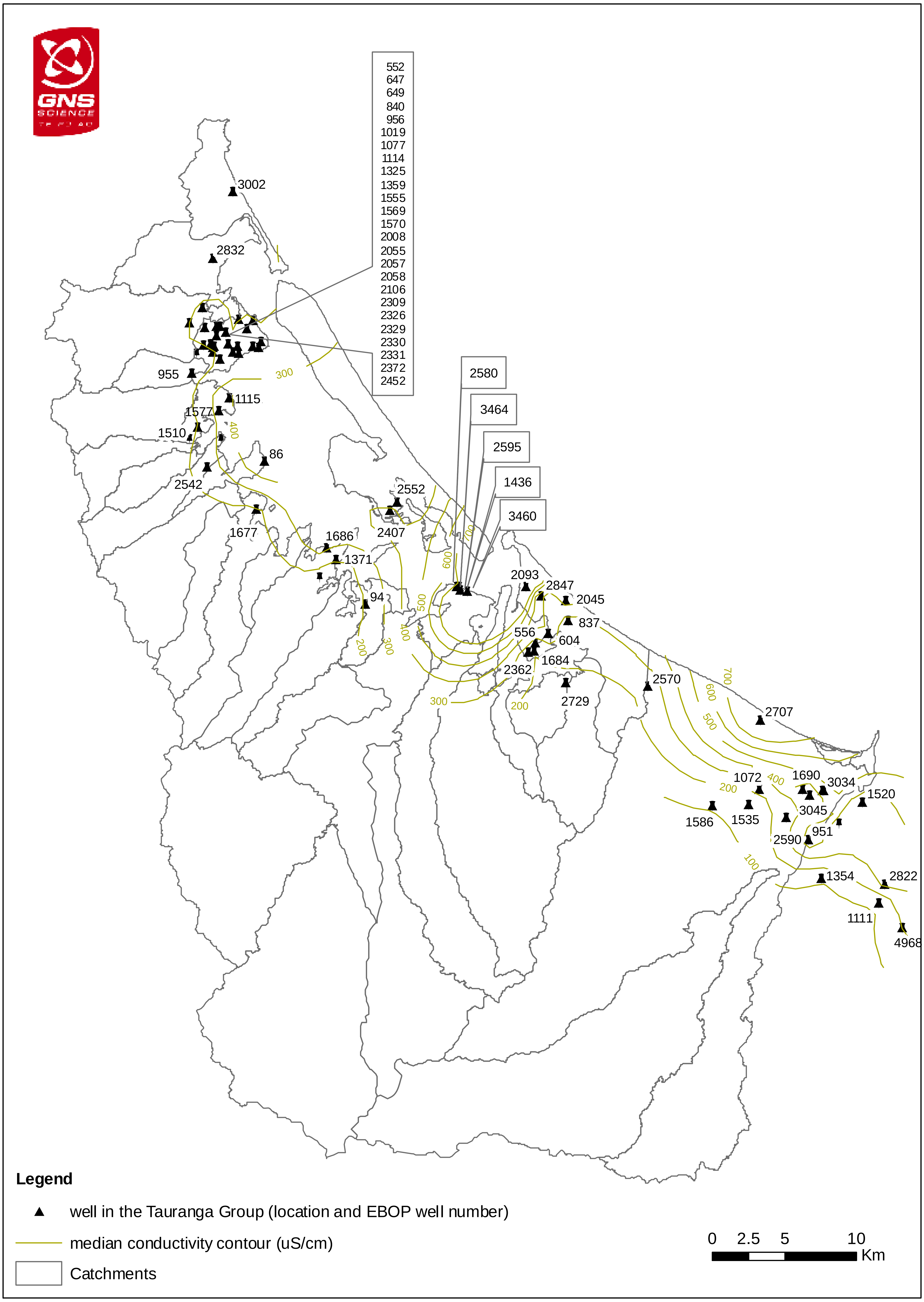


Figure 3.8 Groundwater conductivity contours within the Tauranga Group Sediments (micros/cm).

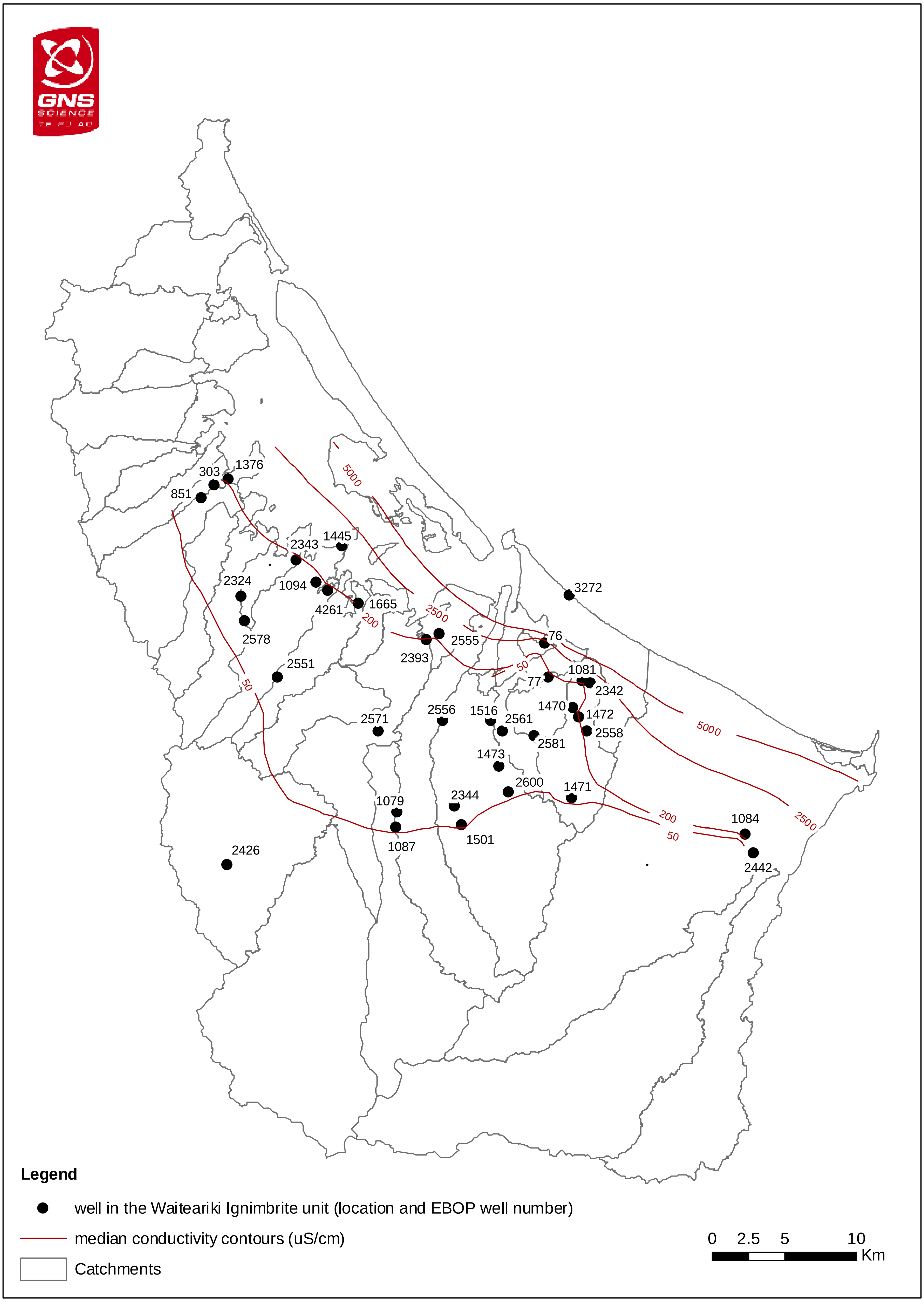


Figure 3.9 Groundwater conductivity contours within the Waitearaki Ignimbrite unit (micros/cm).

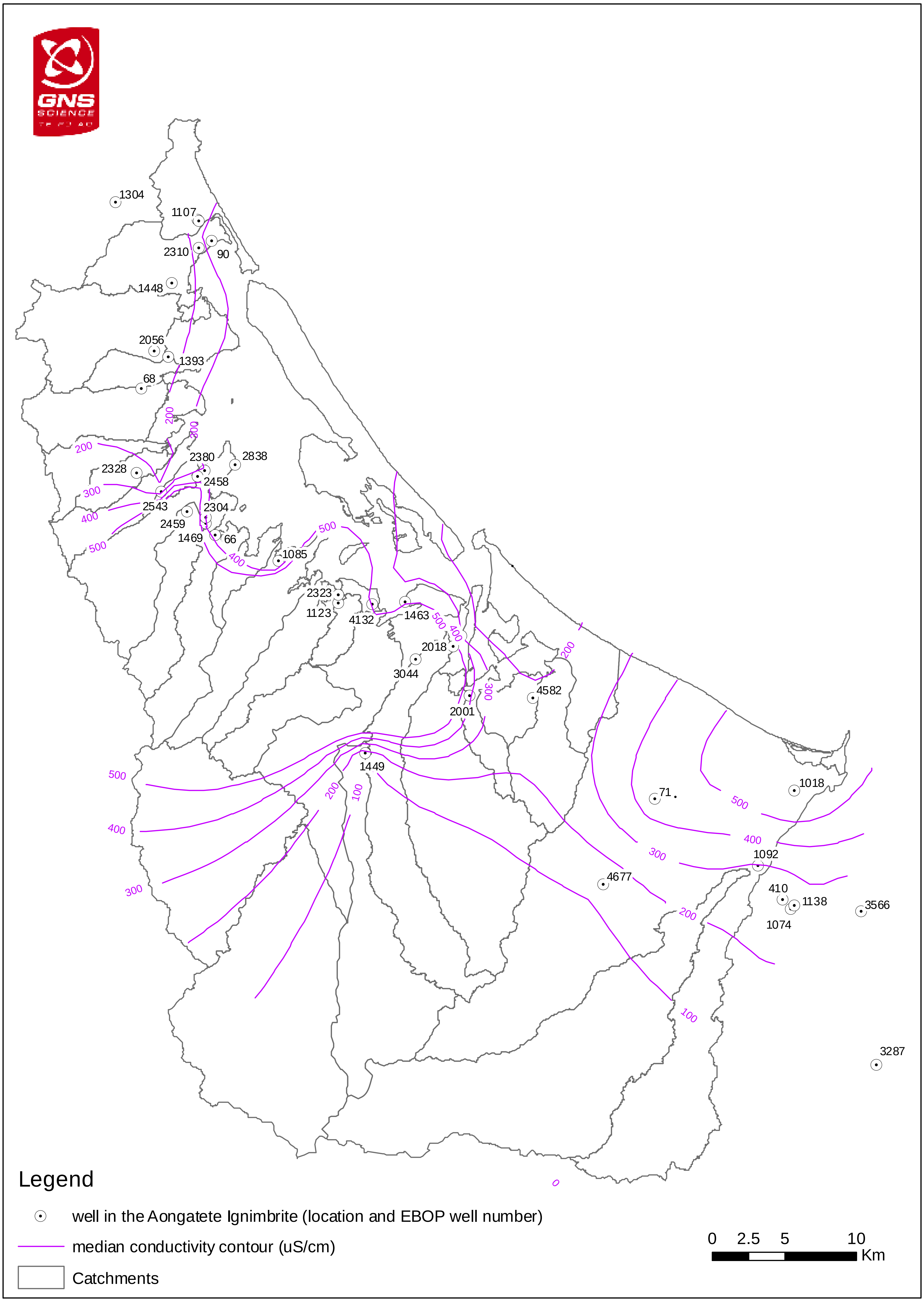


Figure 3.10 Groundwater conductivity contours within the Aongatete Ignimbrite unit (micros/cm).

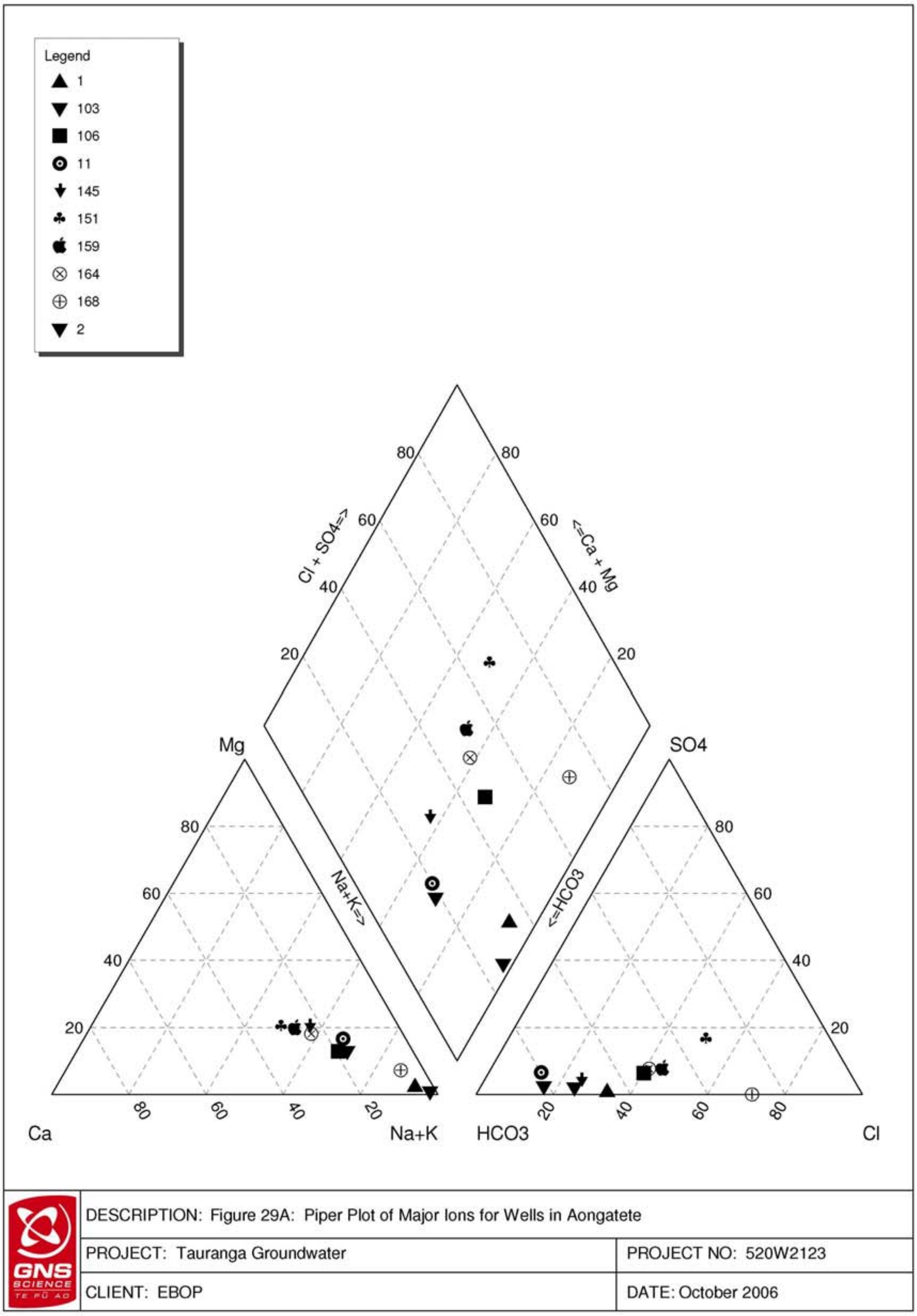


Figure 3.11 Piper plot of major ions for wells in Aongatete Ignimbrite.

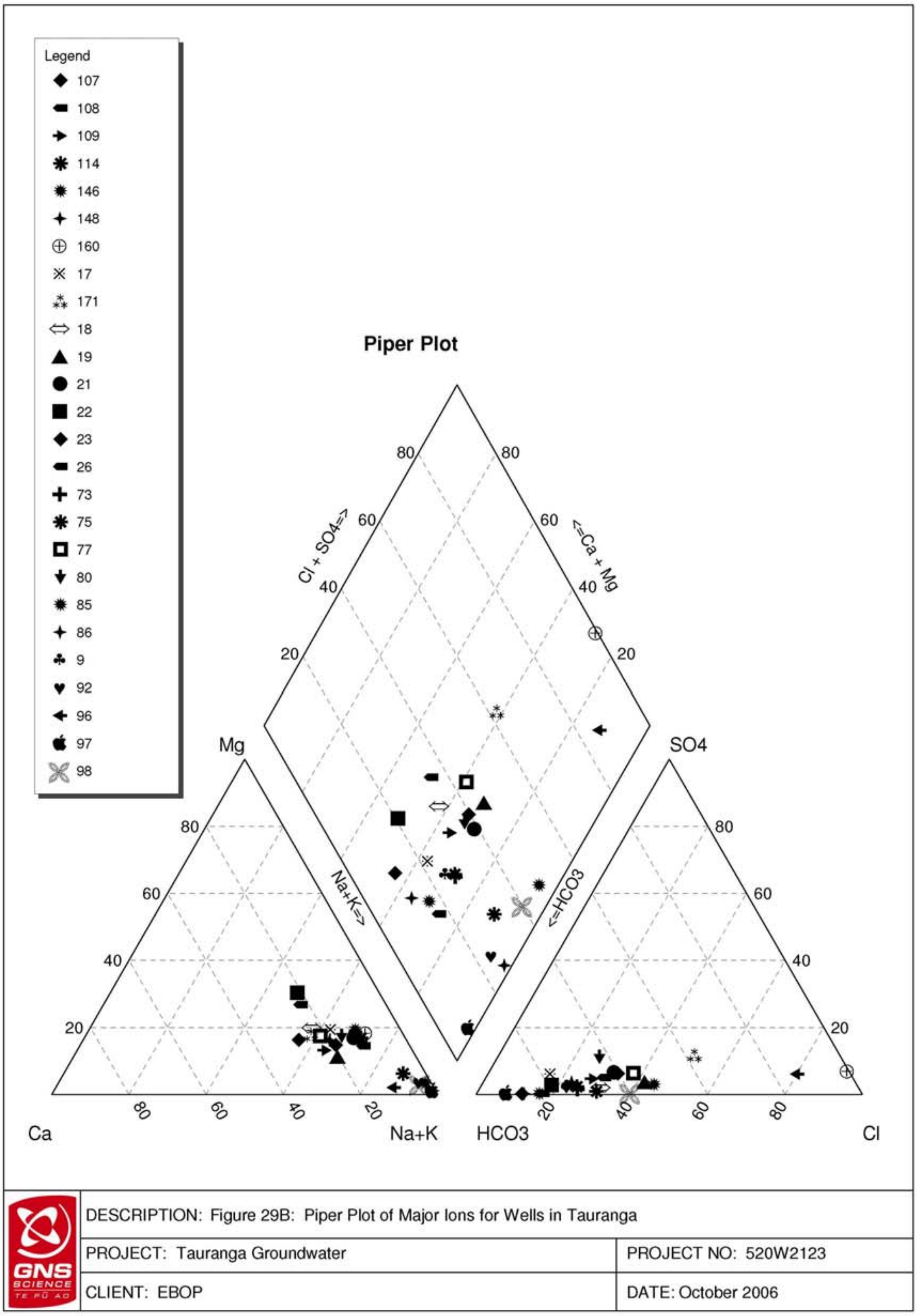


Figure 3.12 Piper plot of major ions for wells in Tauranga Group Sediments.

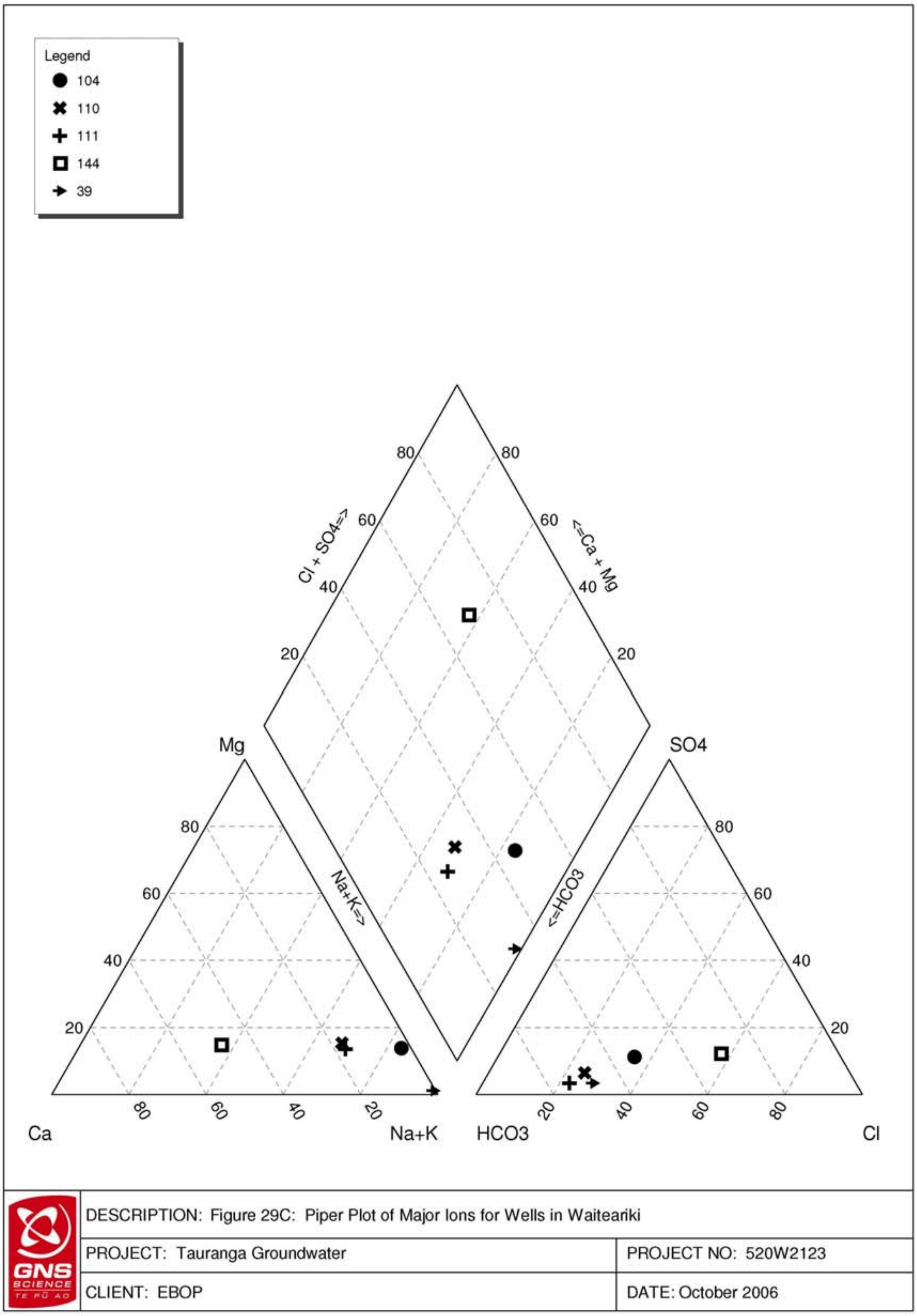


Figure 3.13 Piper plot of major ions for wells in Waiteariki Ignimbrite.

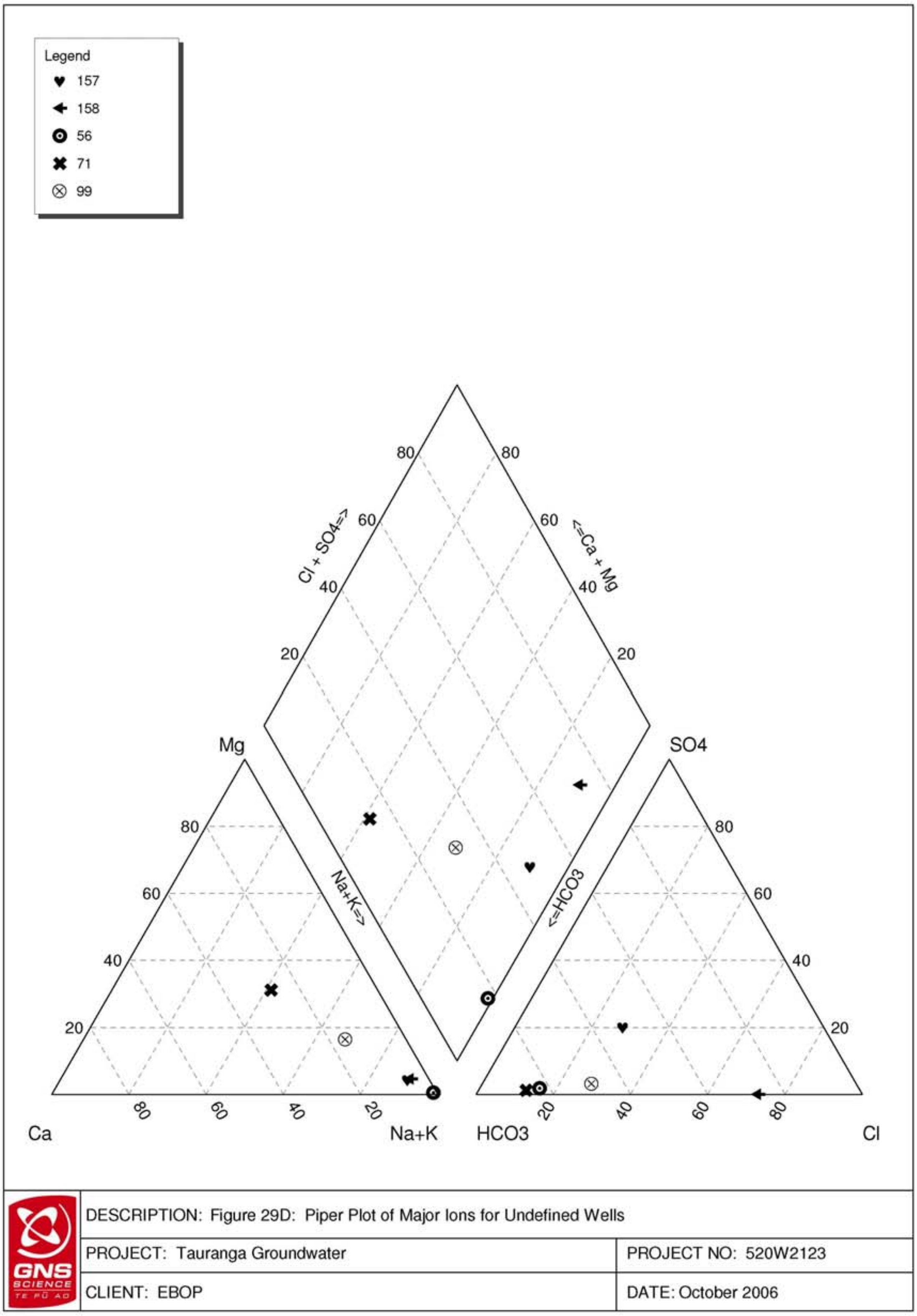


Figure 3.14 Piper plot of major ions for wells with unknown geology.

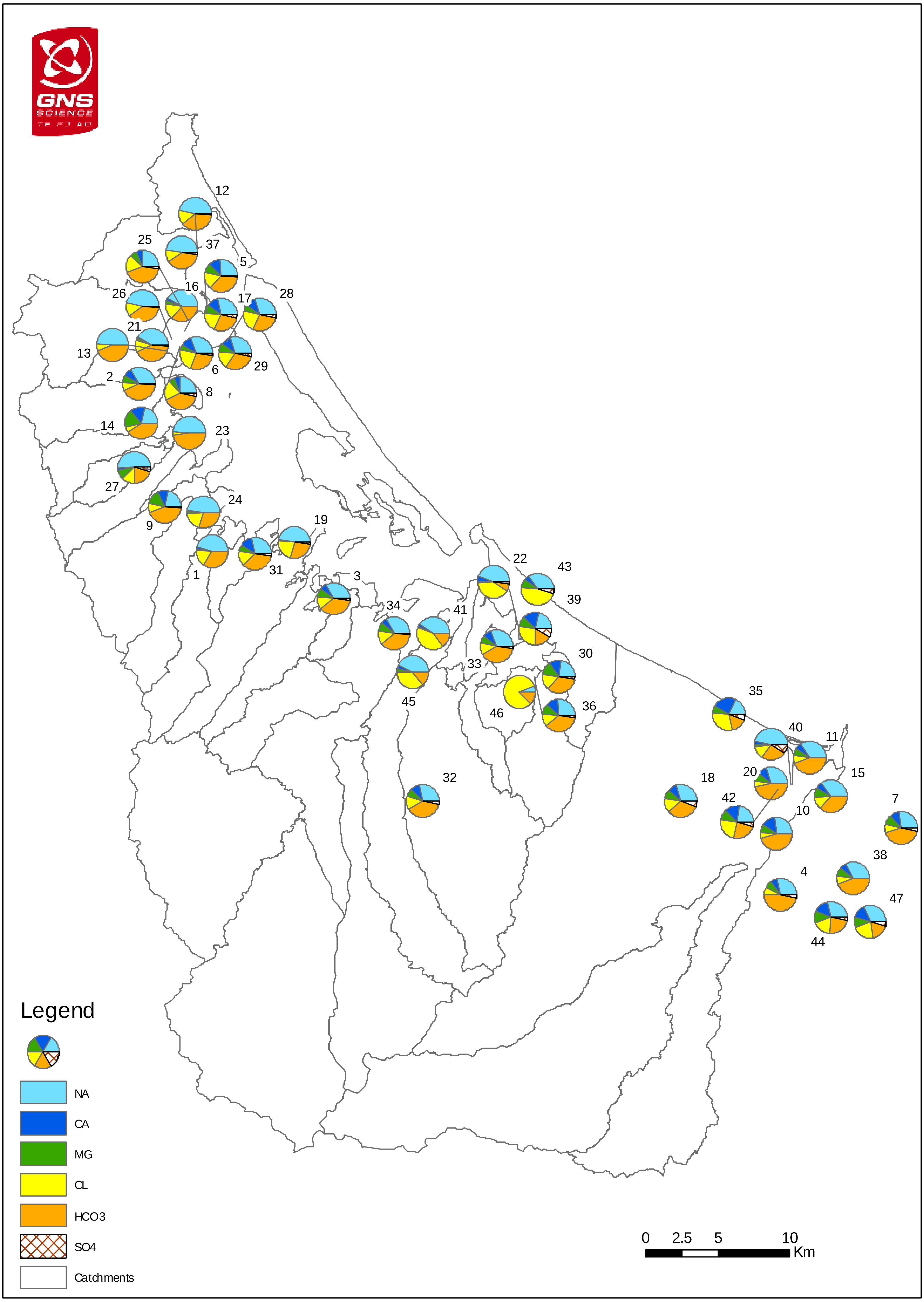


Figure 3.15 Summary of major ions.

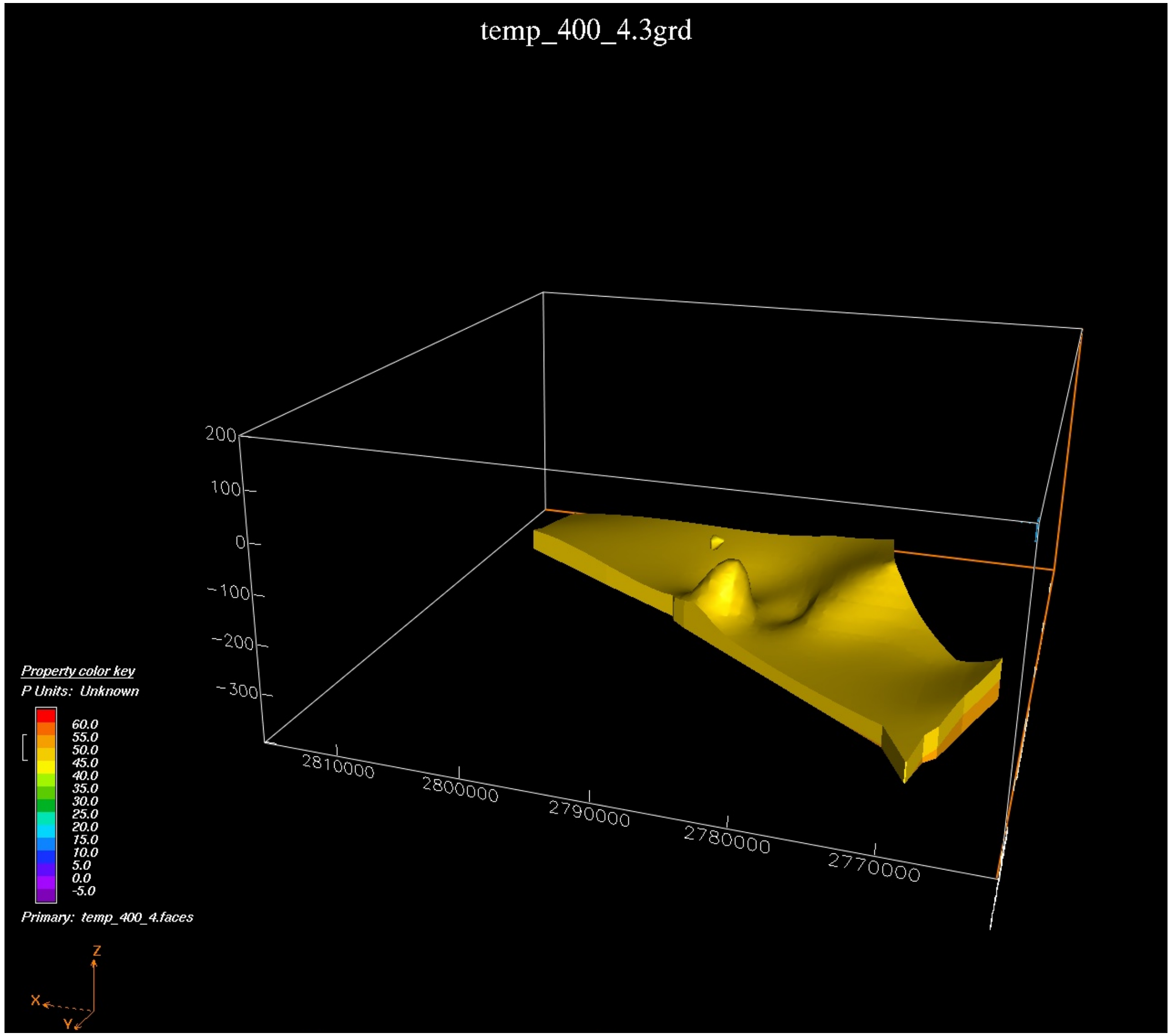


Figure 3.16 Model temperatures in the Western Bay of Plenty showing model temperatures in the range 45°C to 55°C, viewed from the north west.

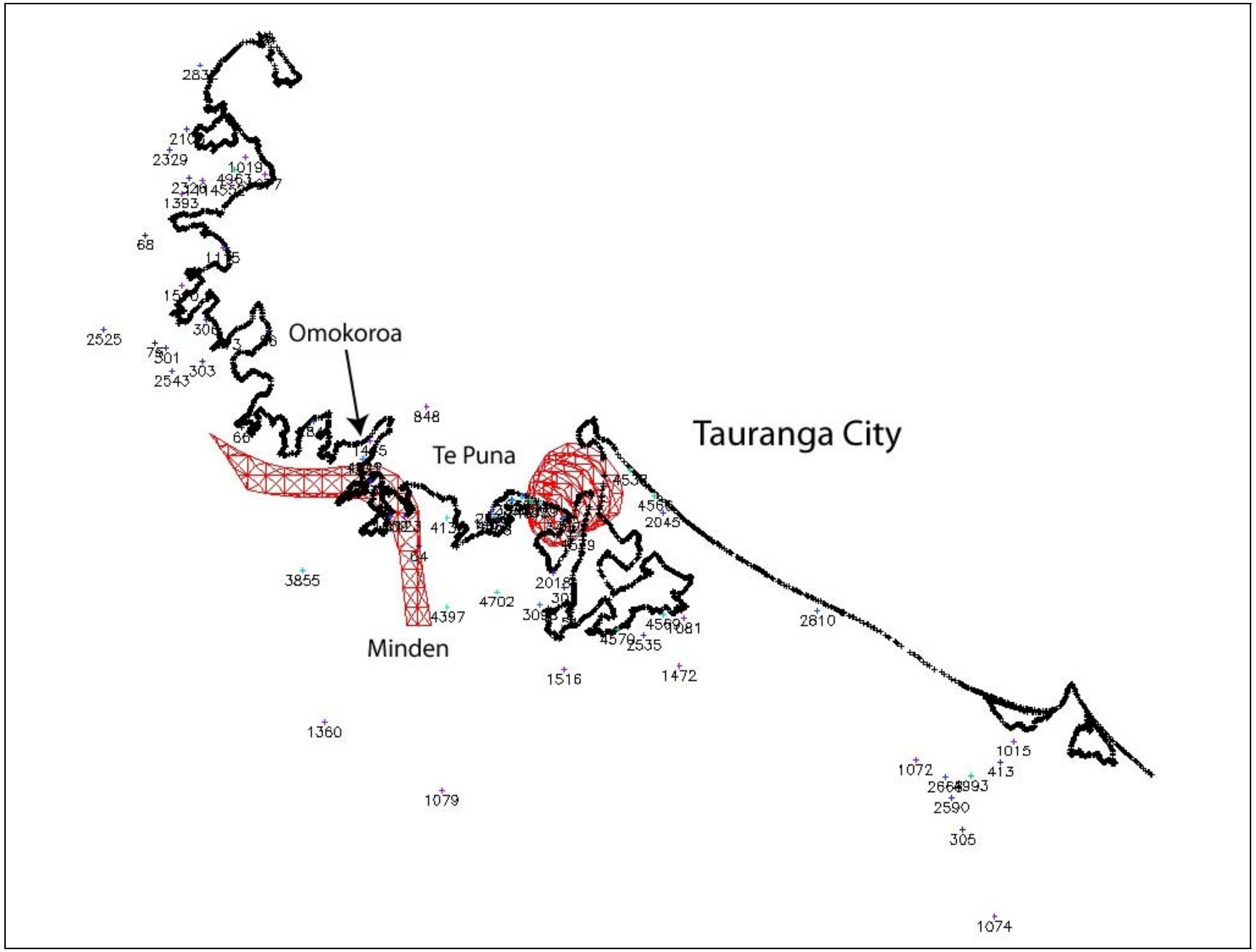


Figure 3.17 Model temperatures in the range 45°C to 55°C (shaded area) at 300 m below sea level. The locations, and EBOP well numbers, of wells with temperature measurements are also shown.

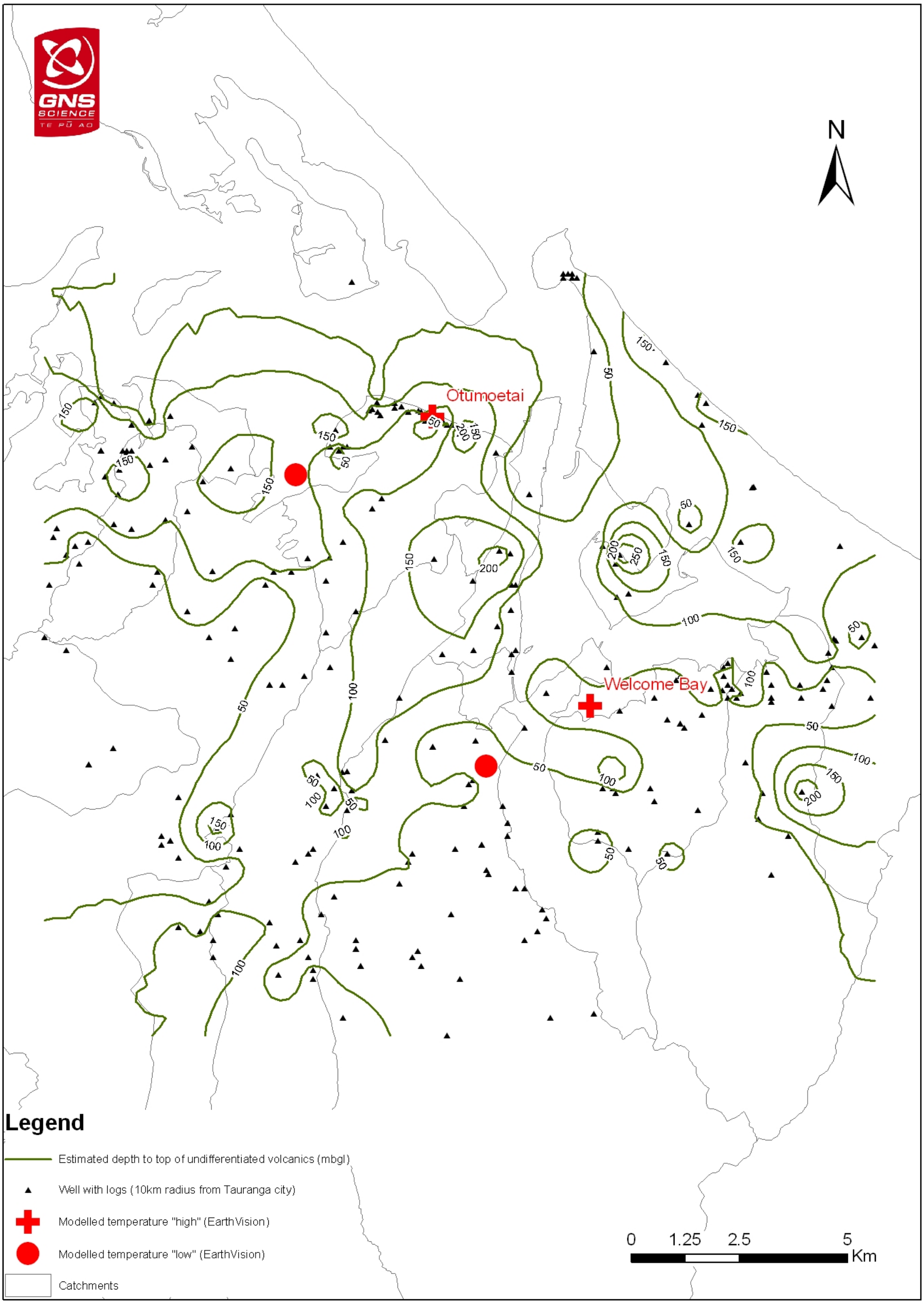


Figure 3.18 Contours of estimated depth to the top of the undifferentiated volcanics (in metres below ground level) in the Tauranga City area.

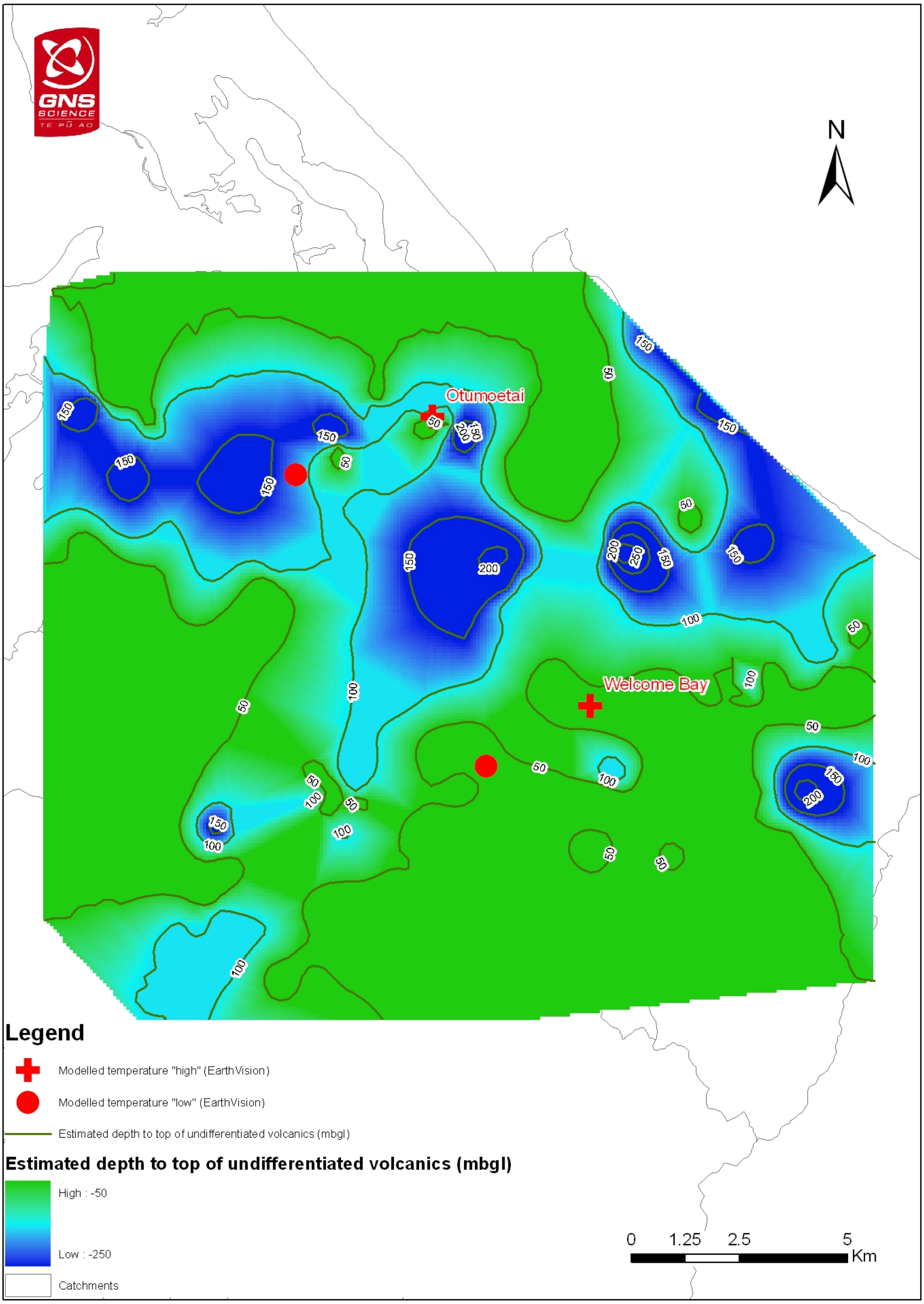


Figure 3.19 Estimated depth to the top of the undifferentiated volcanics (in metres below ground level) in the Tauranga City area.

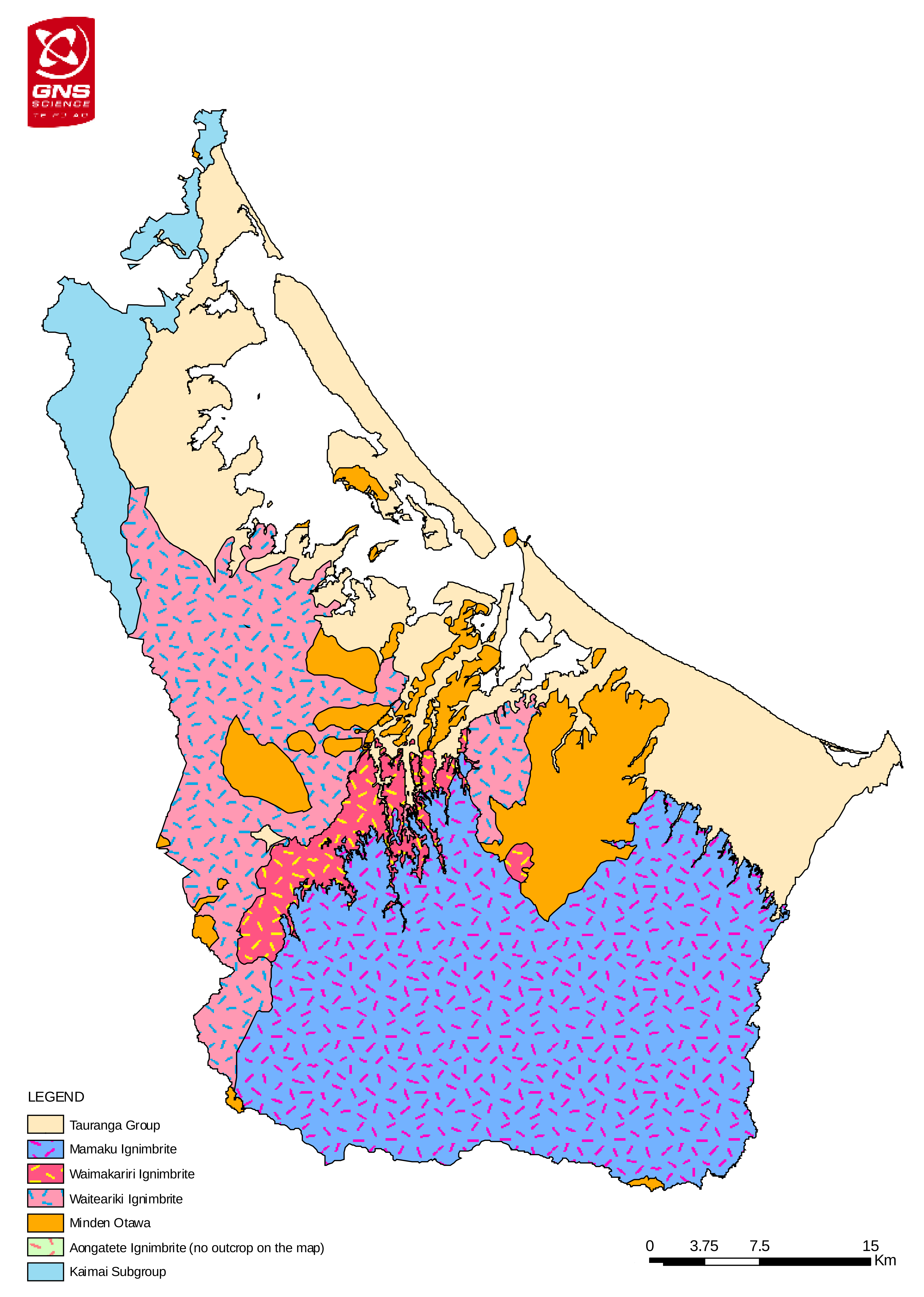


Figure 4.1 Summary map of Western Bay of Plenty geology.

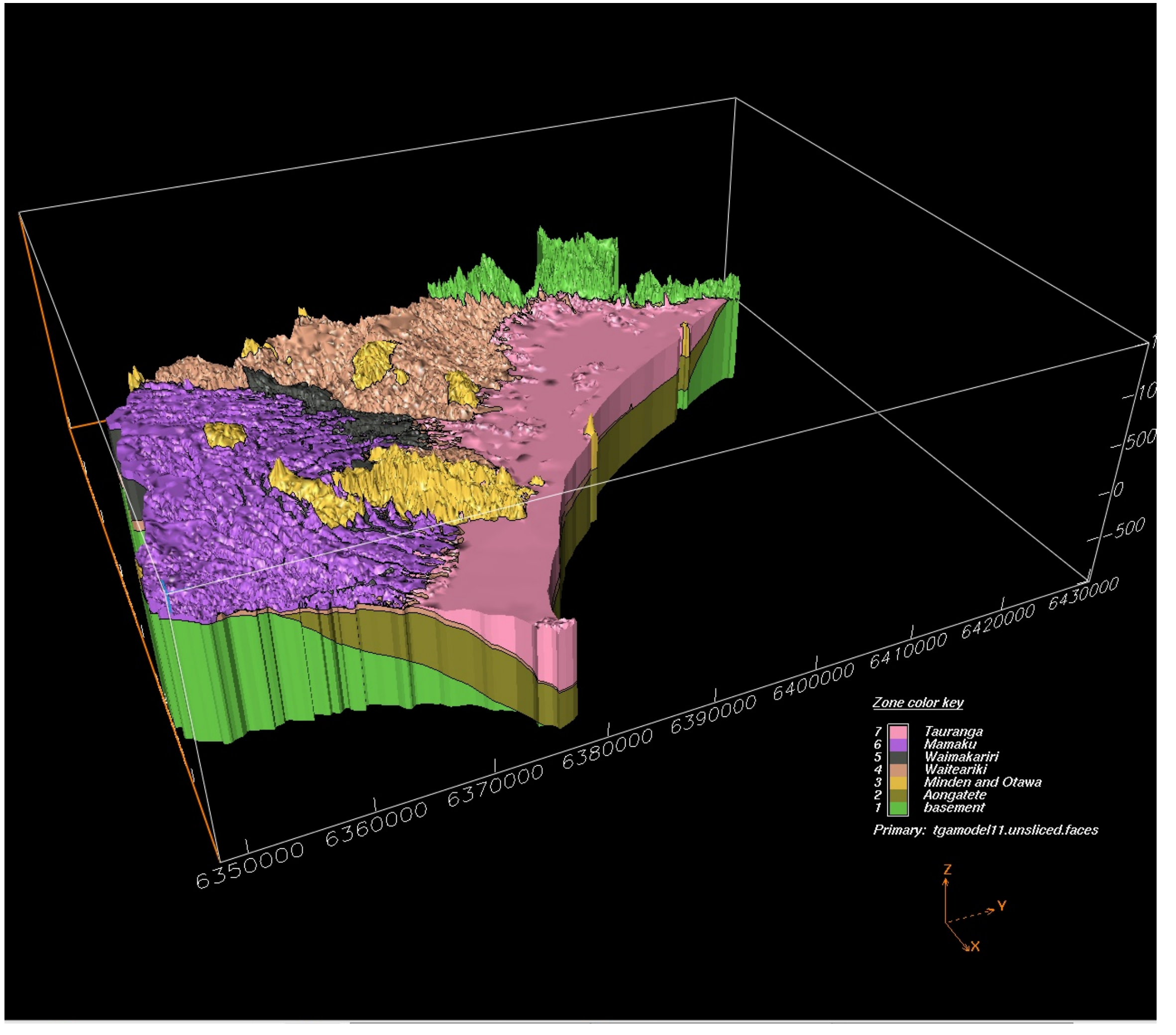


Figure 4.2 Western Bay of Plenty geological model, viewed from the North East.

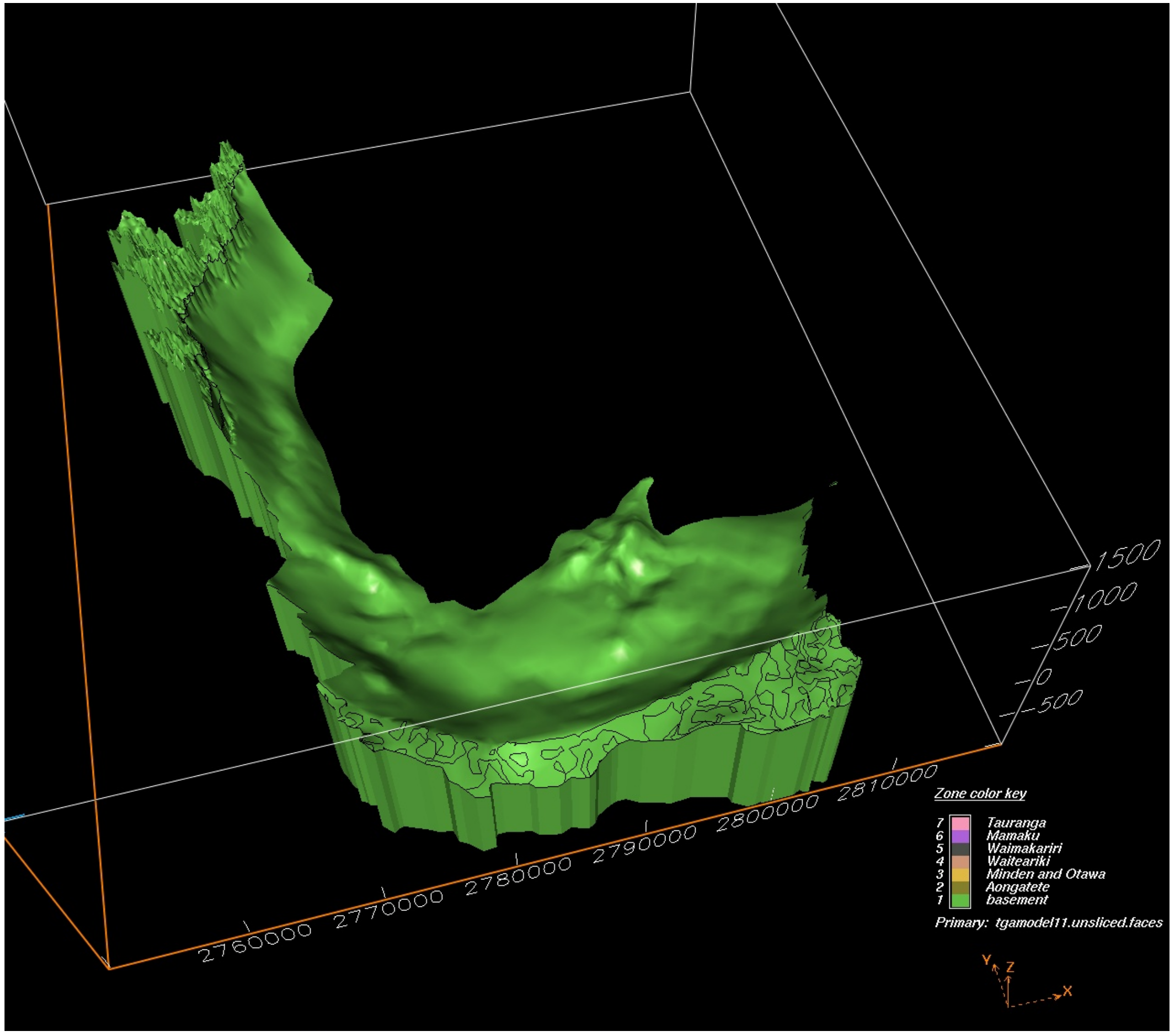


Figure 4.3 Western Bay of Plenty geological model viewed from the South East showing estimated basement at elevations above -1000 m (i.e. 1000 m below sea level).

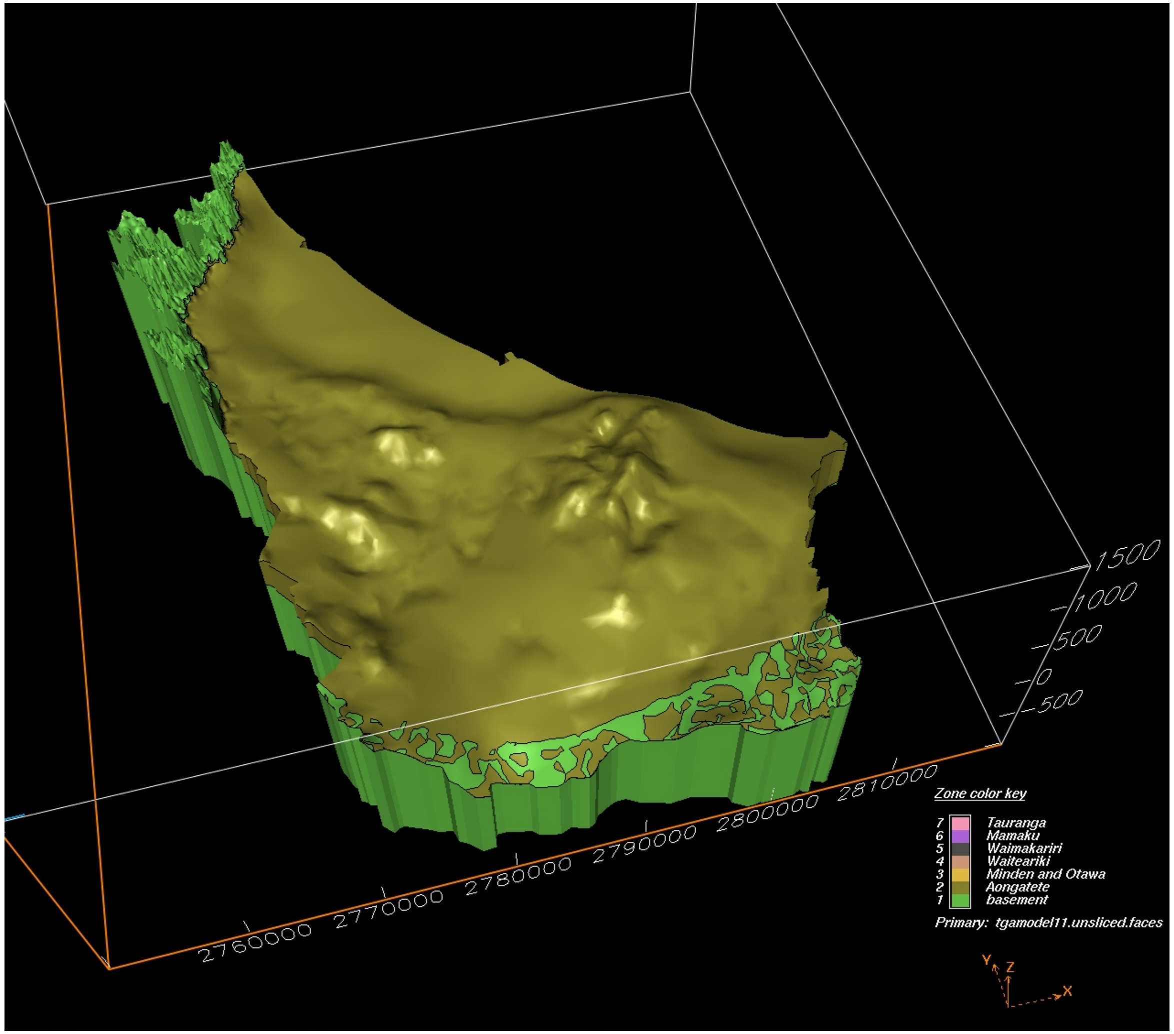


Figure 4.4 Western Bay of Plenty geological model viewed from the South East showing basement and Aongatete Ignimbrite.

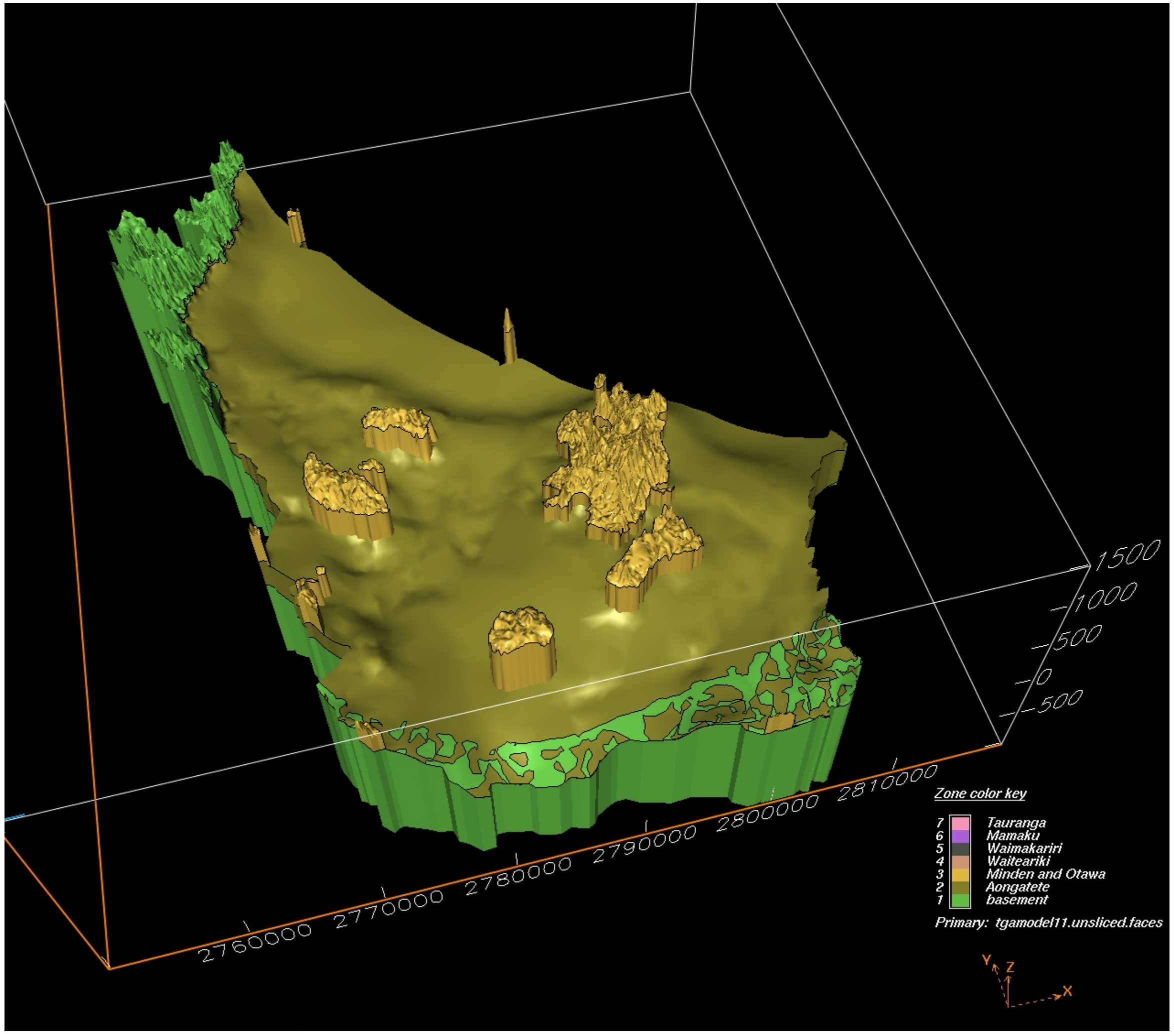


Figure 4.5 Western Bay of Plenty geological model viewed from the South East showing Otawa volcanics and rhyolite domes sitting on Aongatete Ignimbrite.

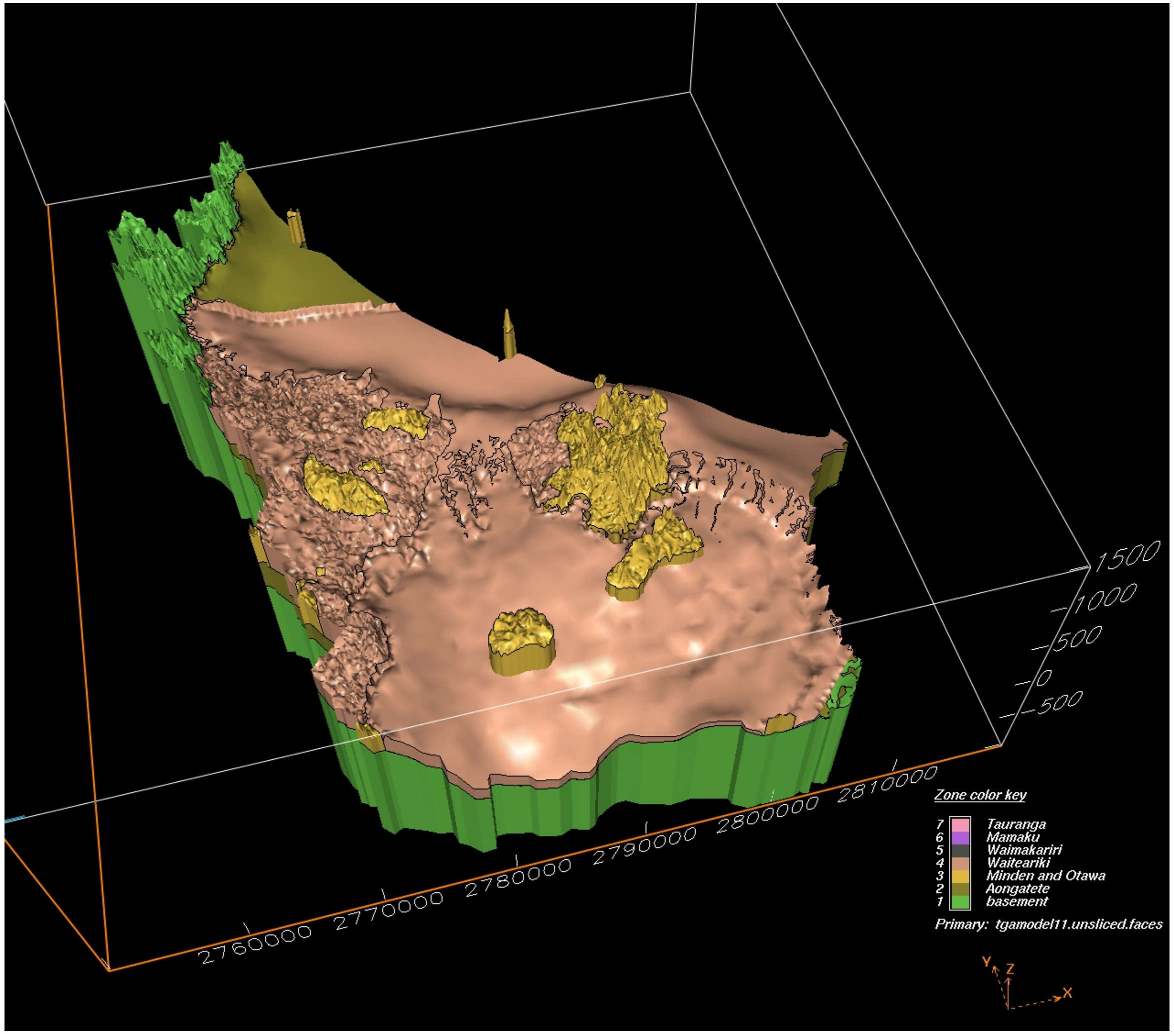


Figure 4.6 Western Bay of Plenty geological model viewed from the South East showing Waiteariki Ignimbrite sourced near Kaimai Range.

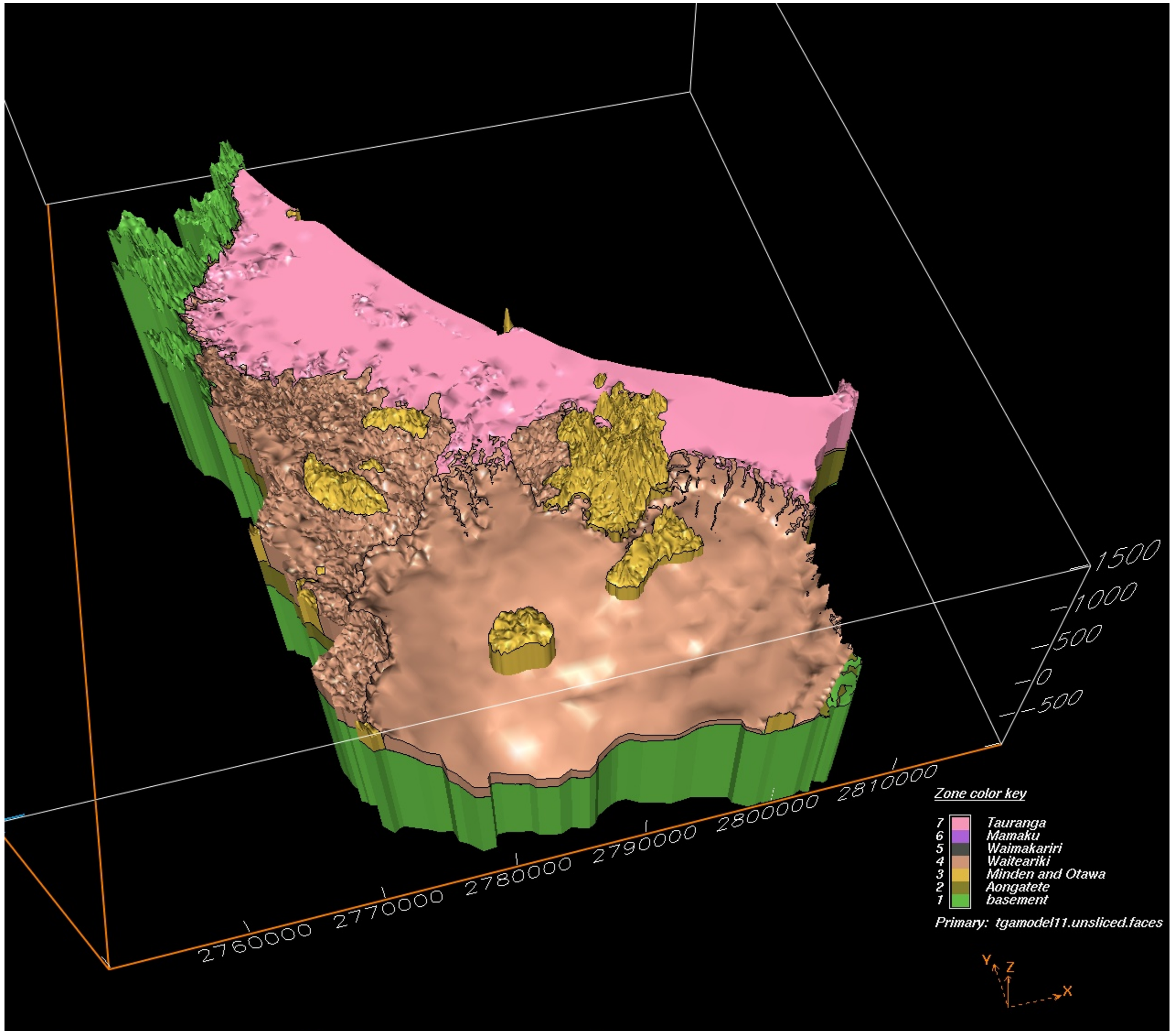


Figure 4.7 Western Bay of Plenty geological model viewed from the South East showing Tauranga Group Sediments.

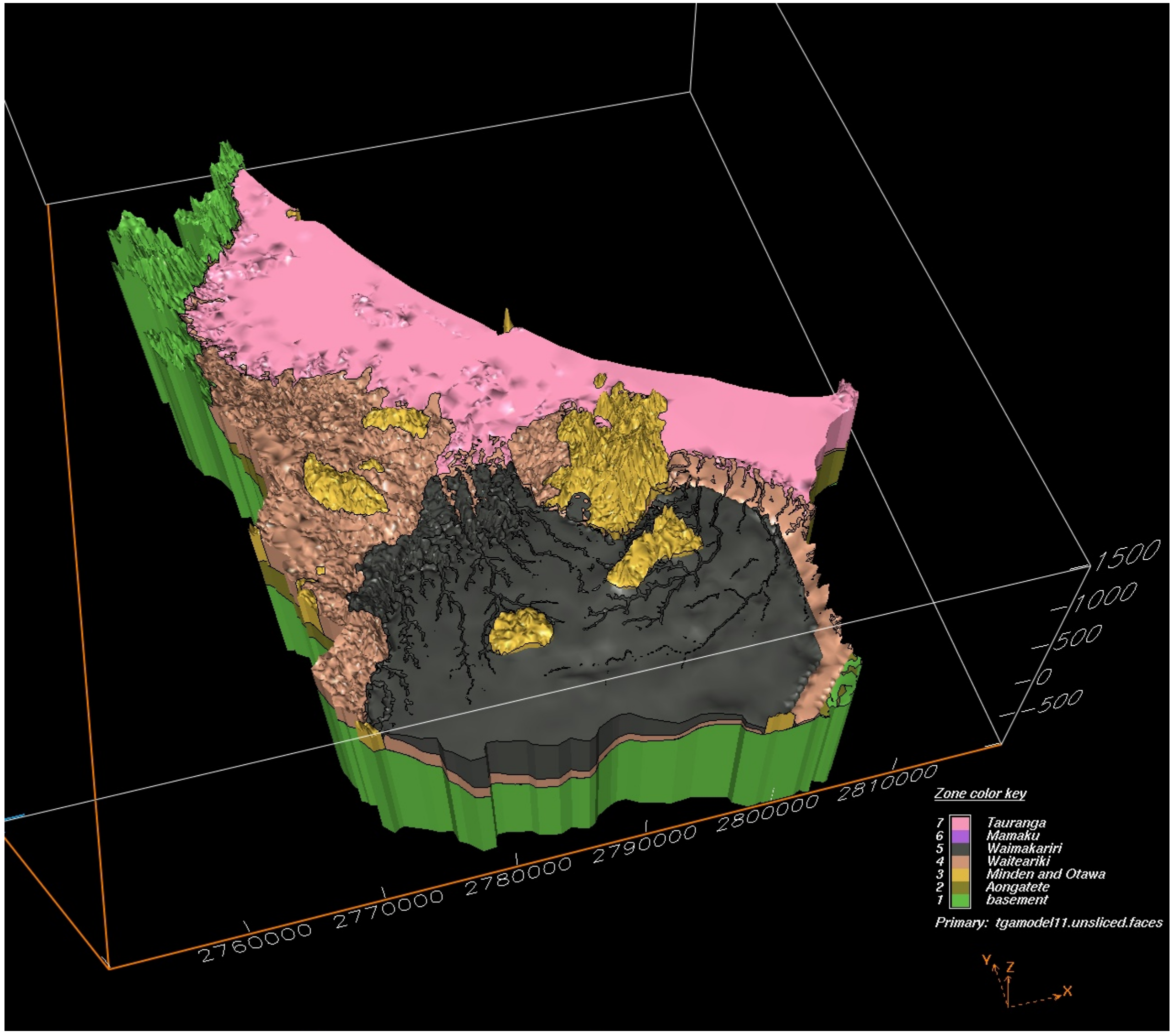


Figure 4.8 Western Bay of Plenty geological model viewed from the South East showing Waimakariri Ignimbrite sourced from near Lake Rotorua.

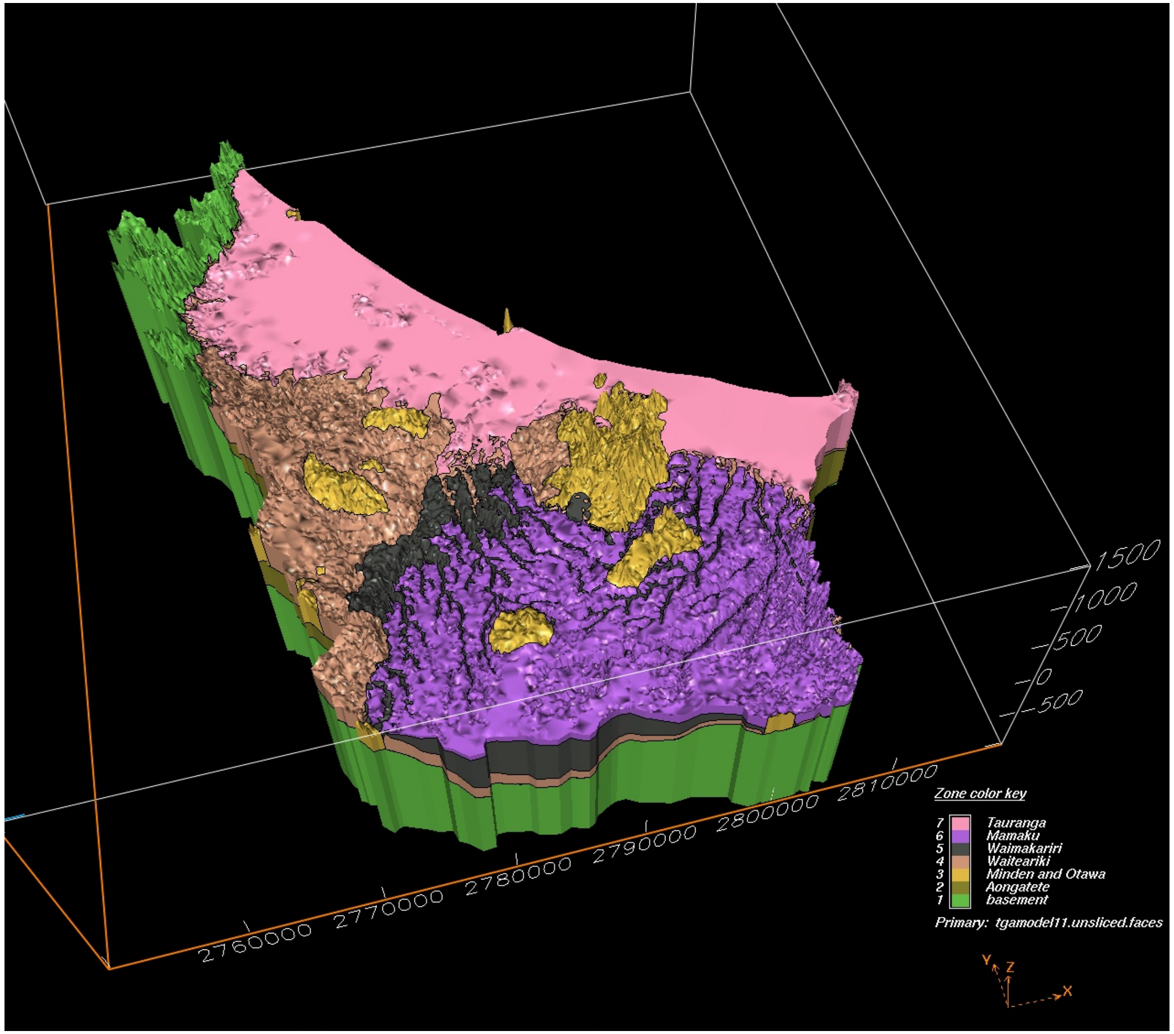


Figure 4.9 Western Bay of Plenty geological model viewed from the South East showing Mamaku Ignimbrite sourced from near Lake Rotorua.

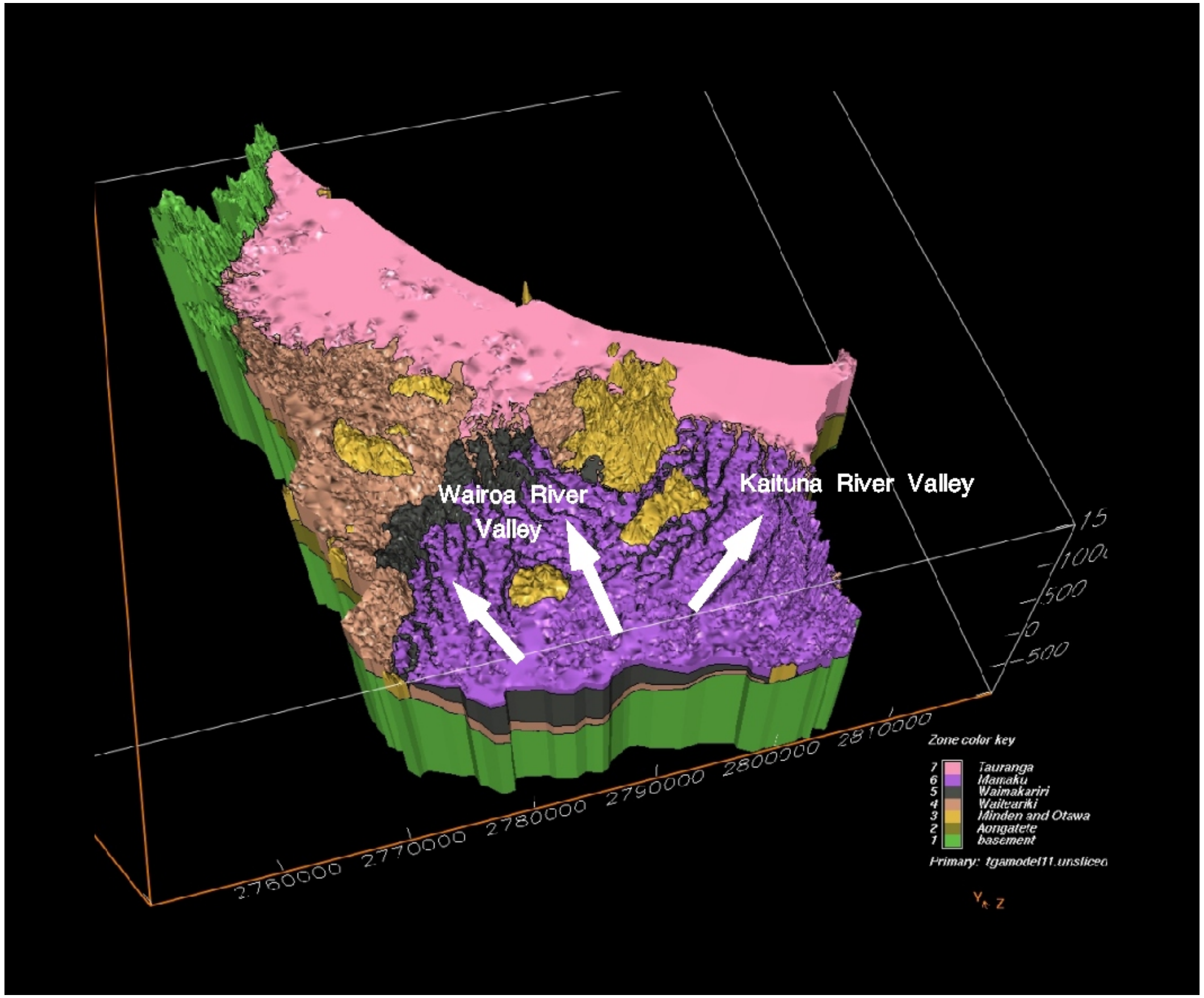


Figure 4.10 Western Bay of Plenty geological model viewed from the South East showing the direction of flow of the Waimakariri Ignimbrite and Mamaku Ignimbrite into the Wairoa River valley and Kaituna River valley

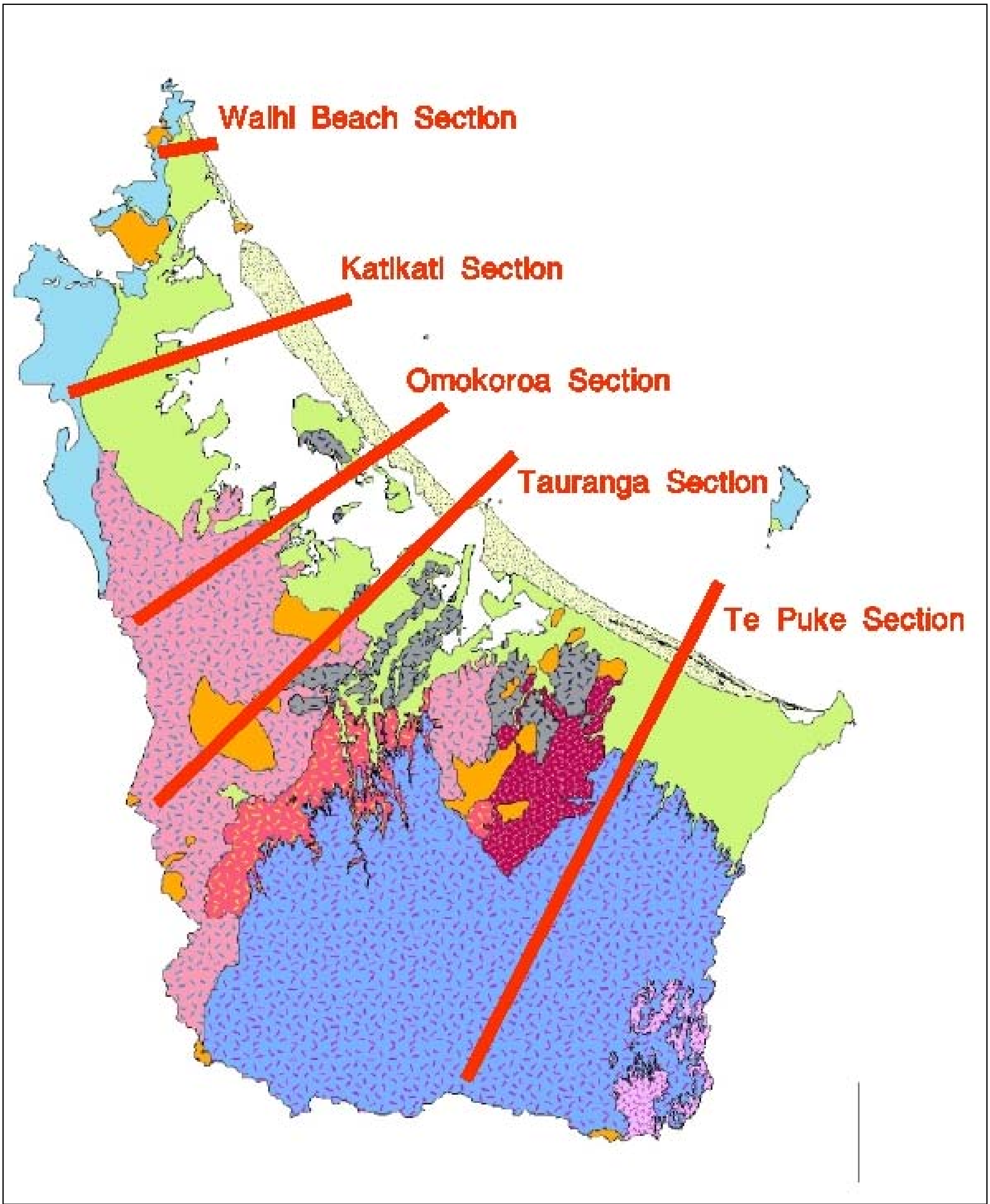


Figure 4.11 Location of five geological cross sections.

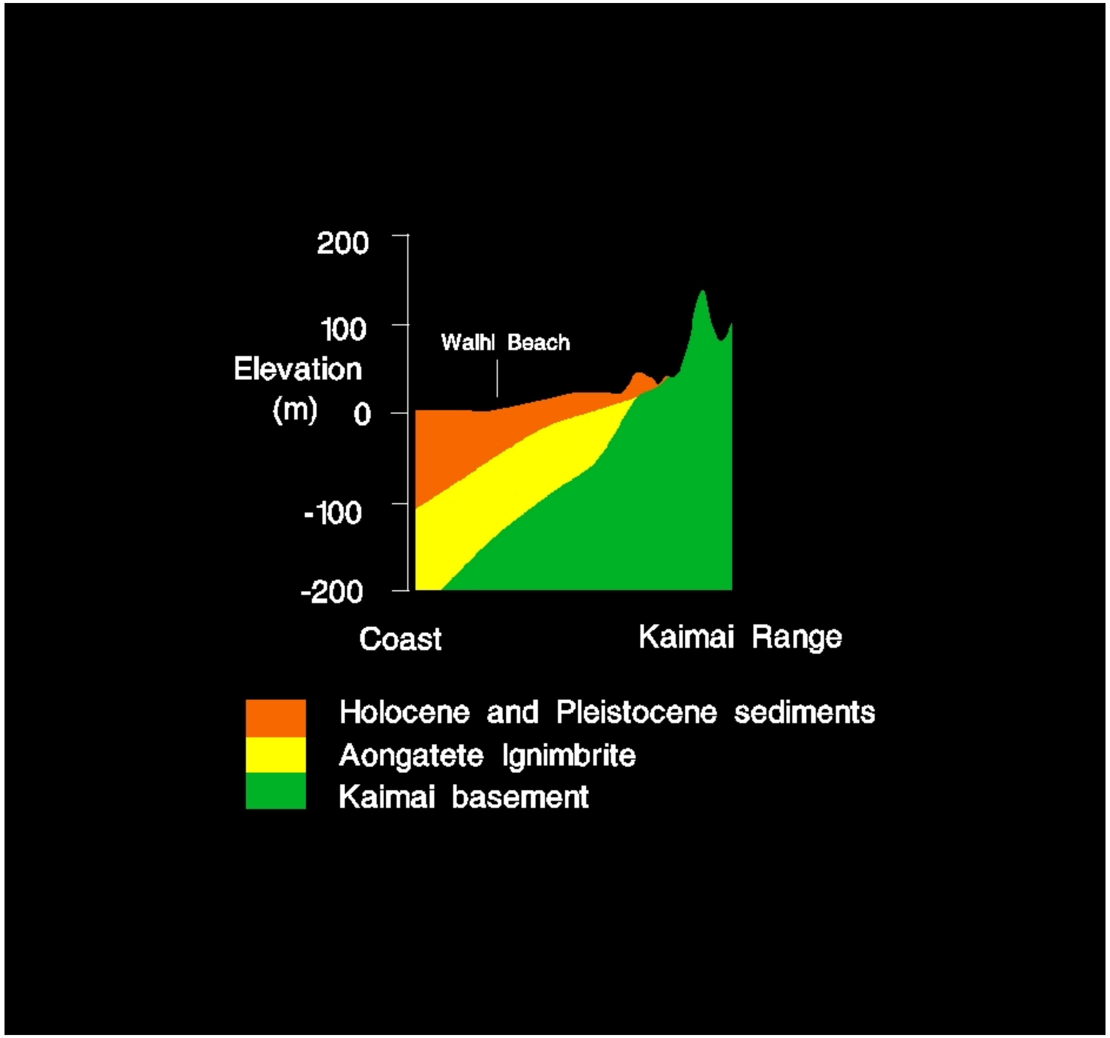


Figure 4.12 Geological cross section through Waihi Beach.

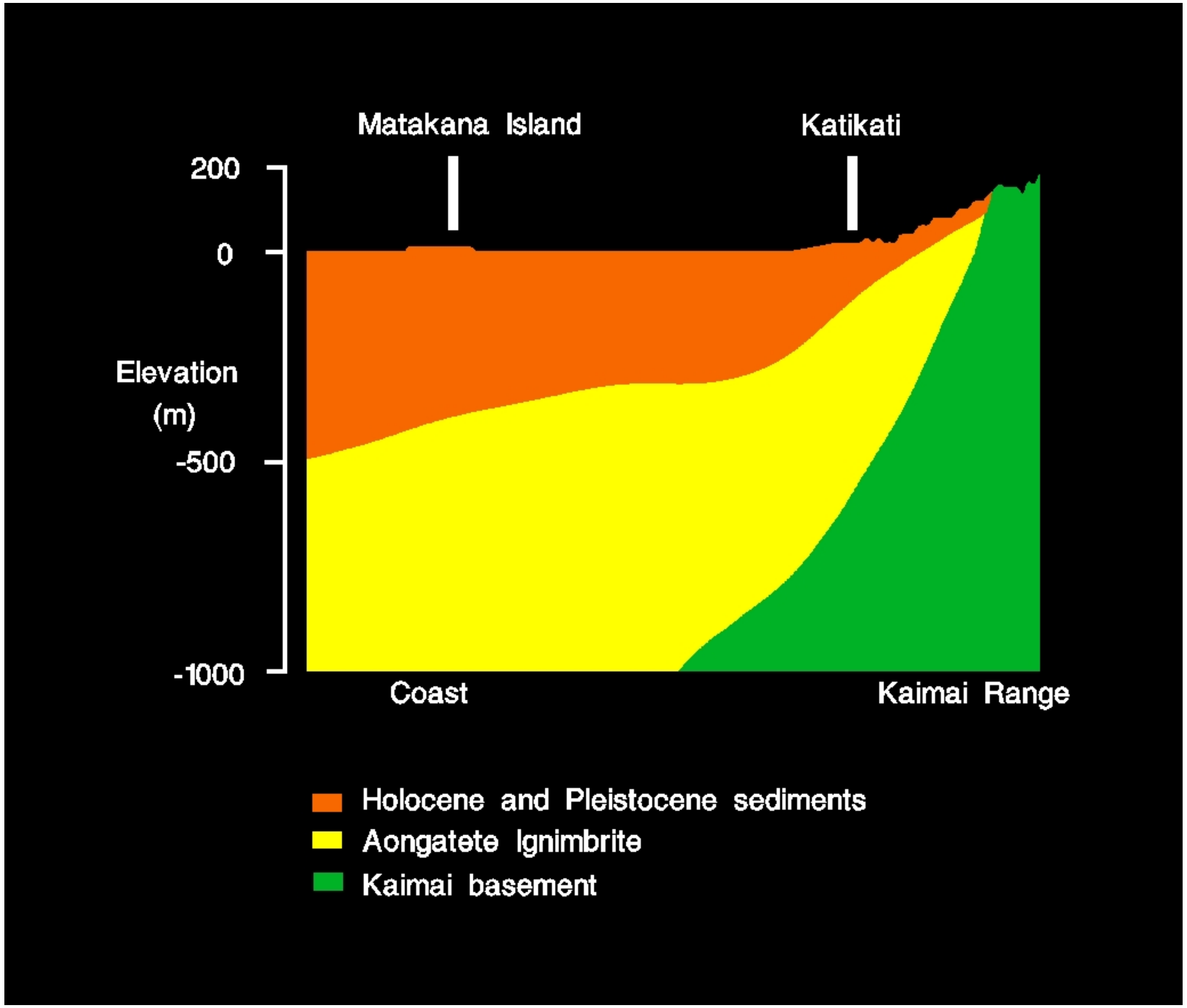


Figure 4.13 Geological cross section through Katikati.

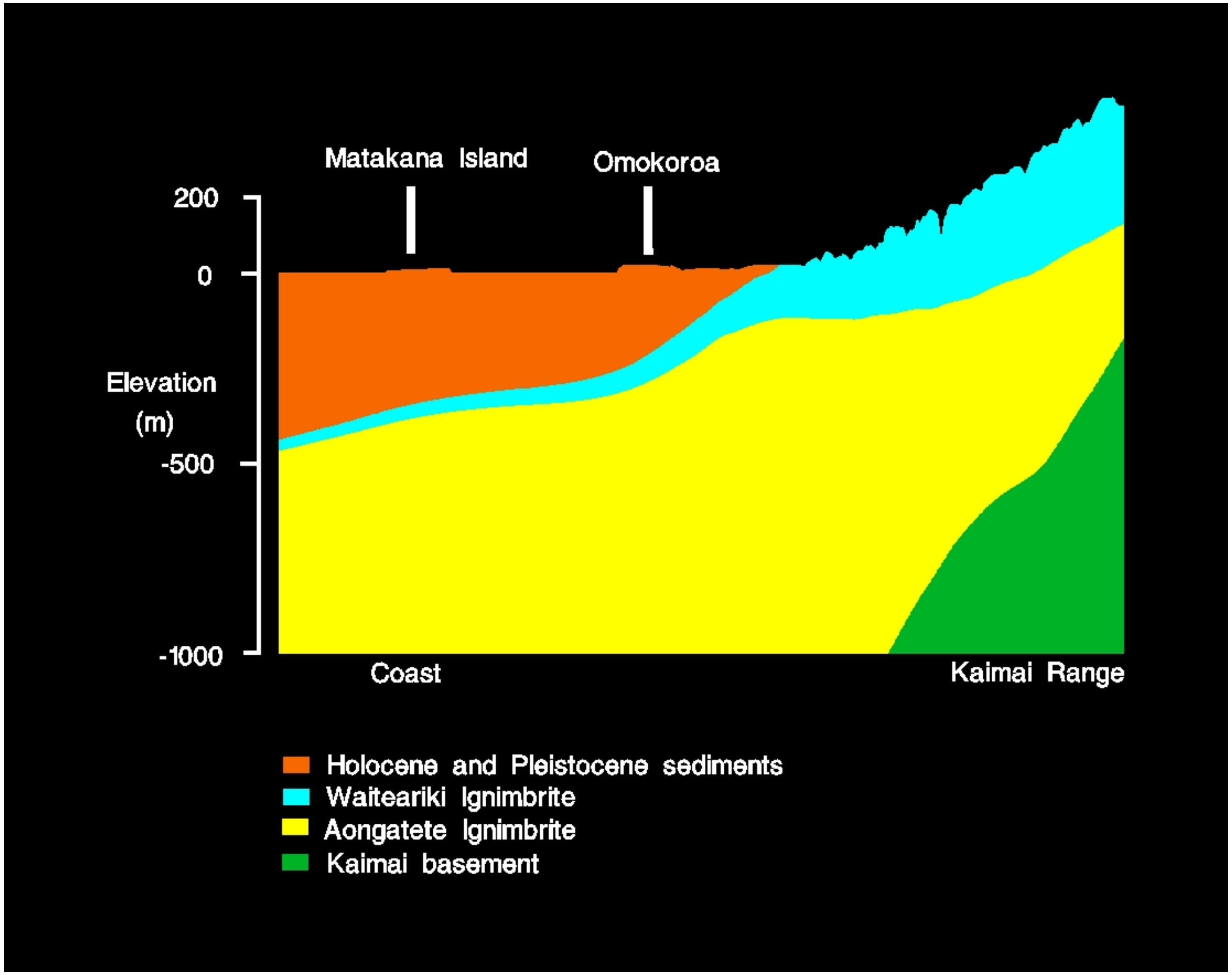


Figure 4.14 Geological cross section through Tauranga (Otumoetai and Mt Maunganui).

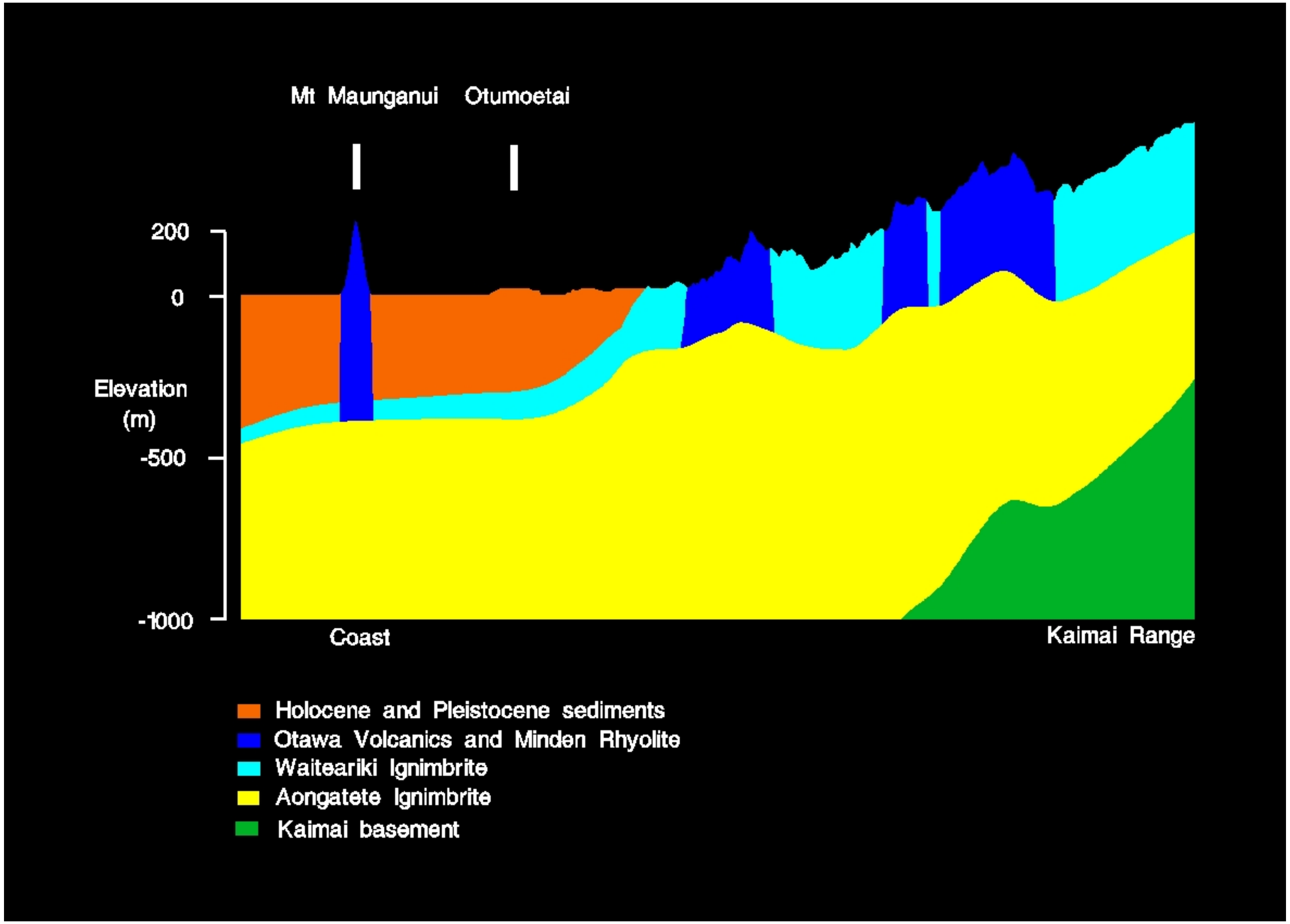


Figure 4.15 Geological cross section through Tauranga, including Mt Maunganui and Otumoetai.

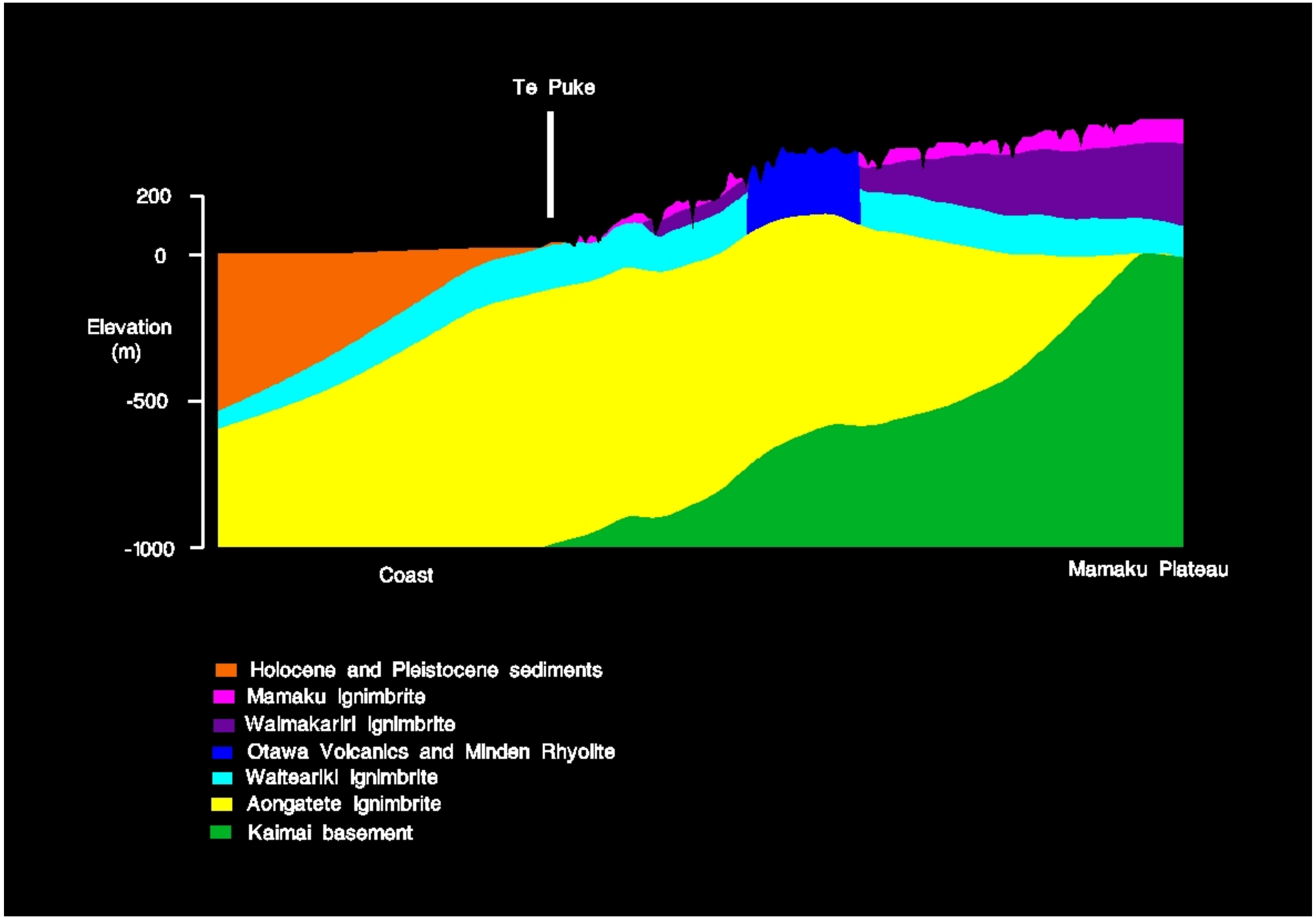


Figure 4.16 Geological cross section through Te Puke.

Figure 5.1 Annual rainfall in the Western Bay of Plenty.

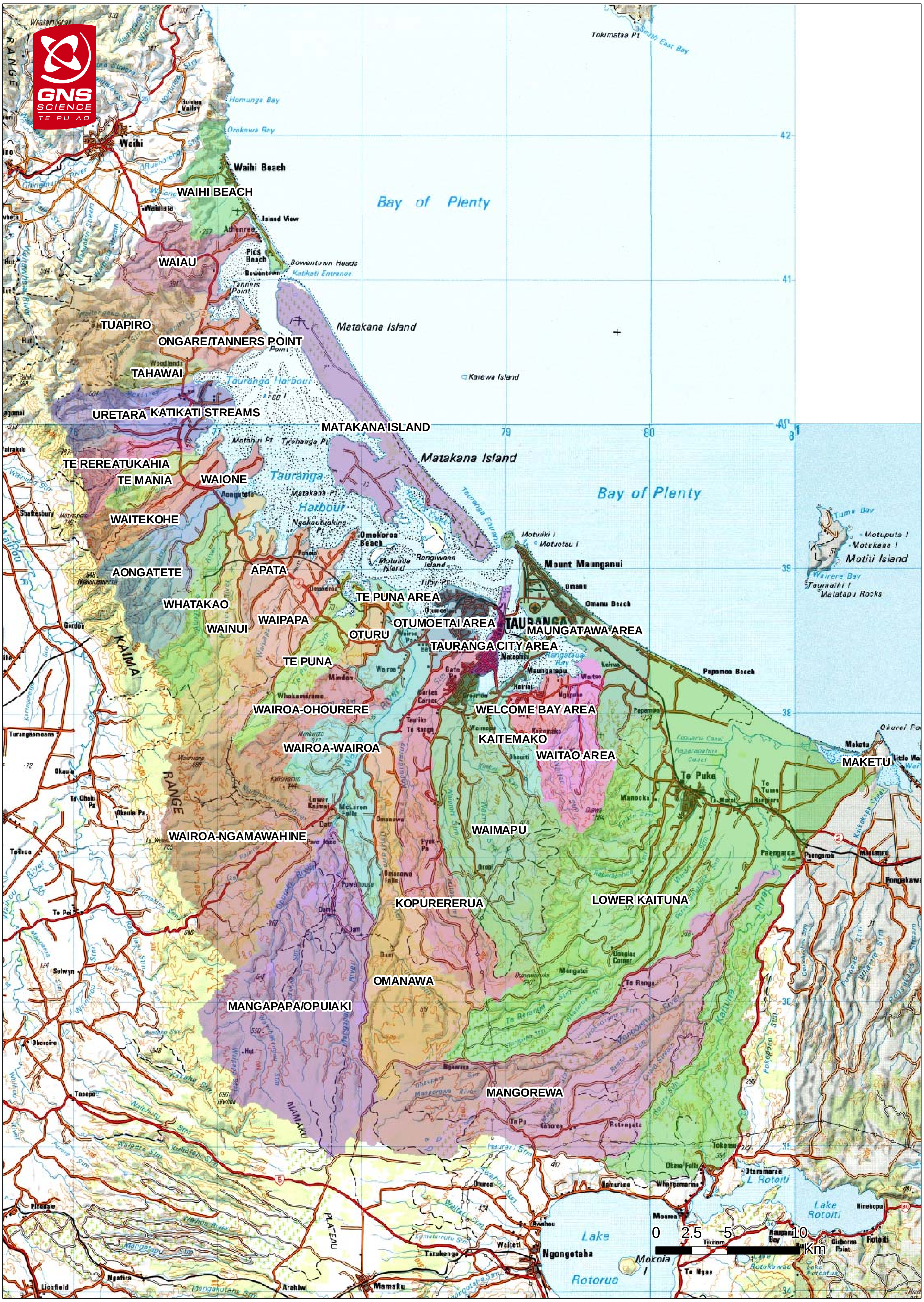


Figure 5.2 Surface water catchments in the Western Bay of Plenty.

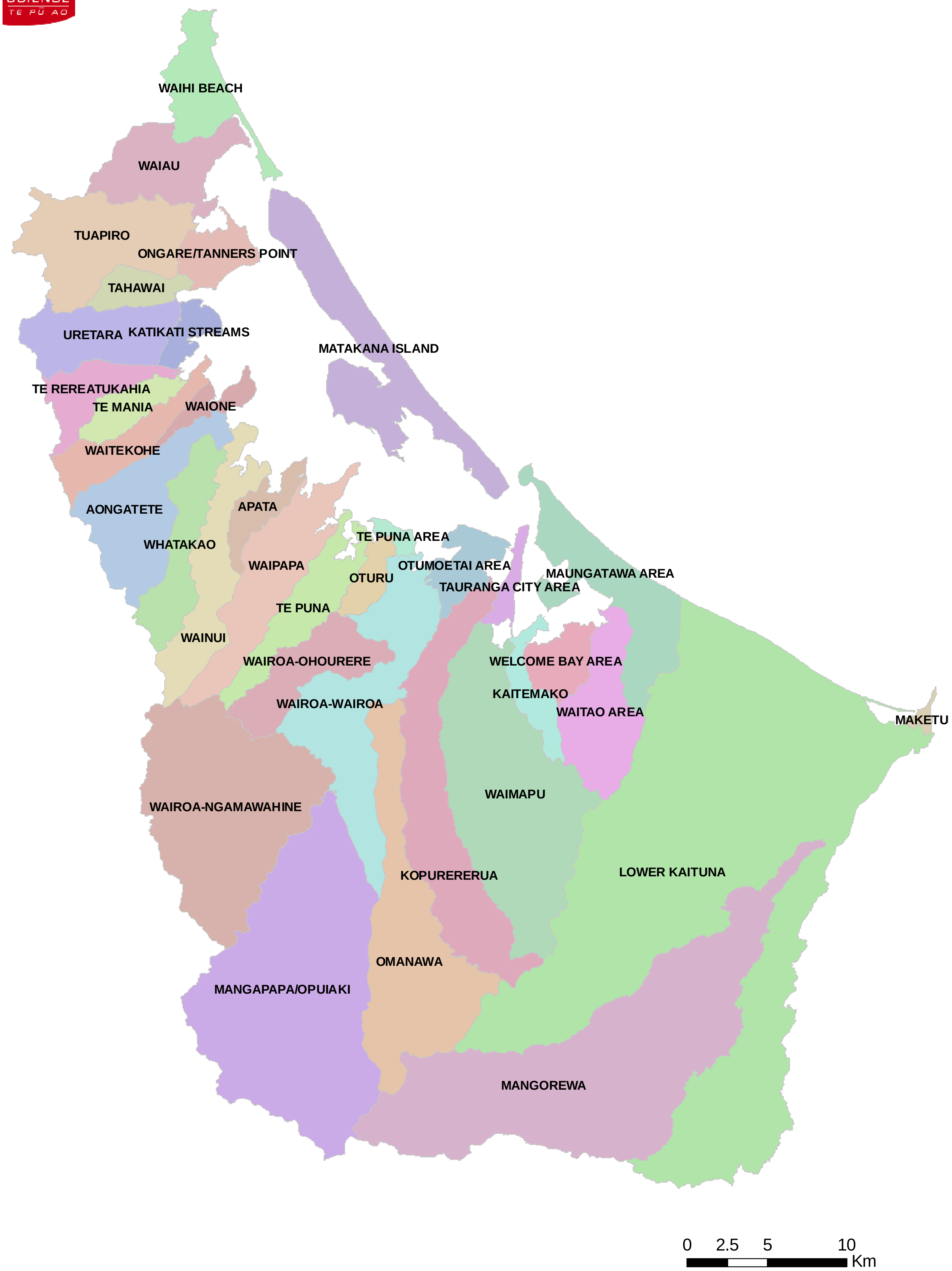


Figure 5.3 Surface water catchments in the Western Bay of Plenty.

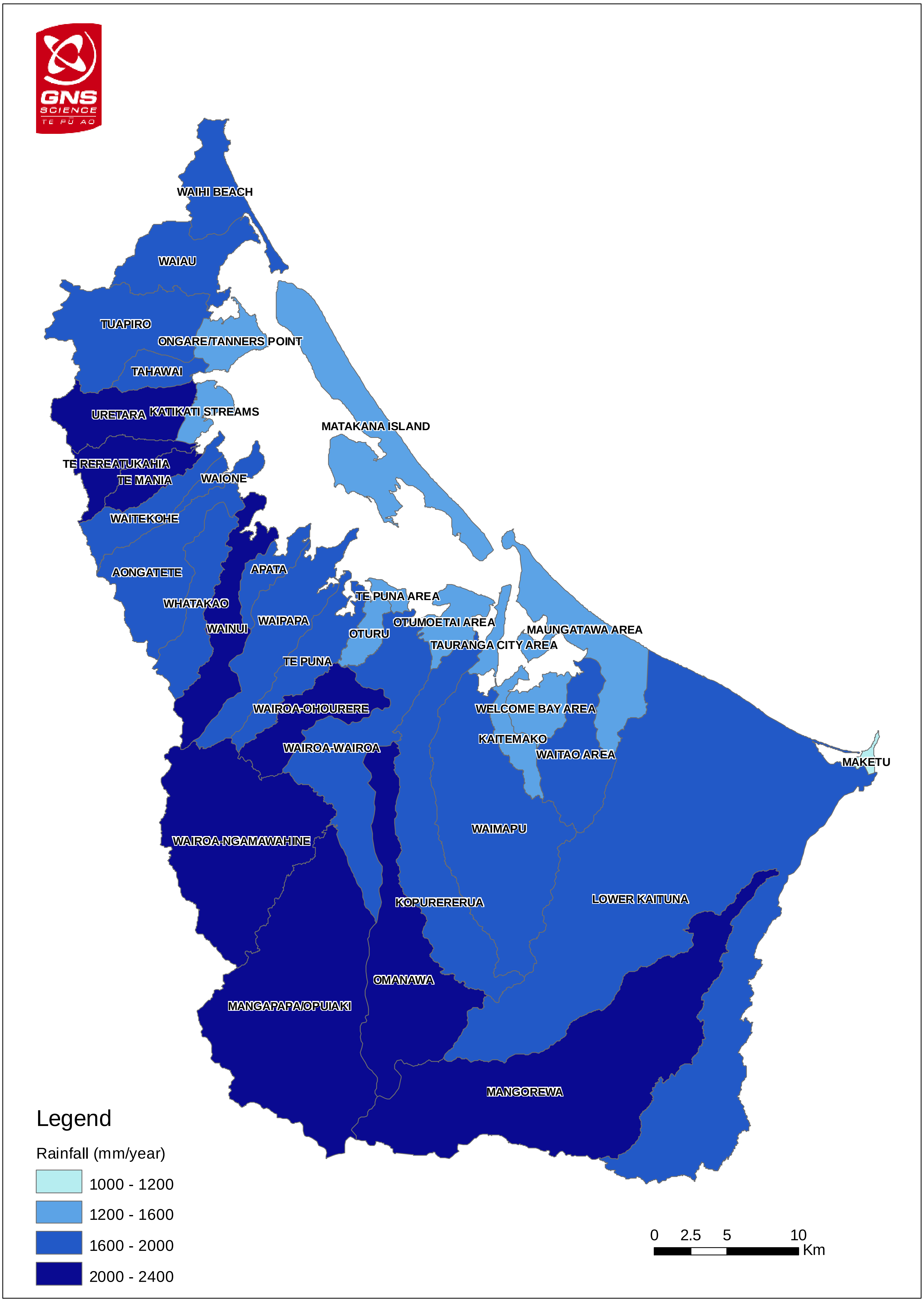


Figure 5.4 Mean annual rainfall estimates (mm/year) for surface water catchments.

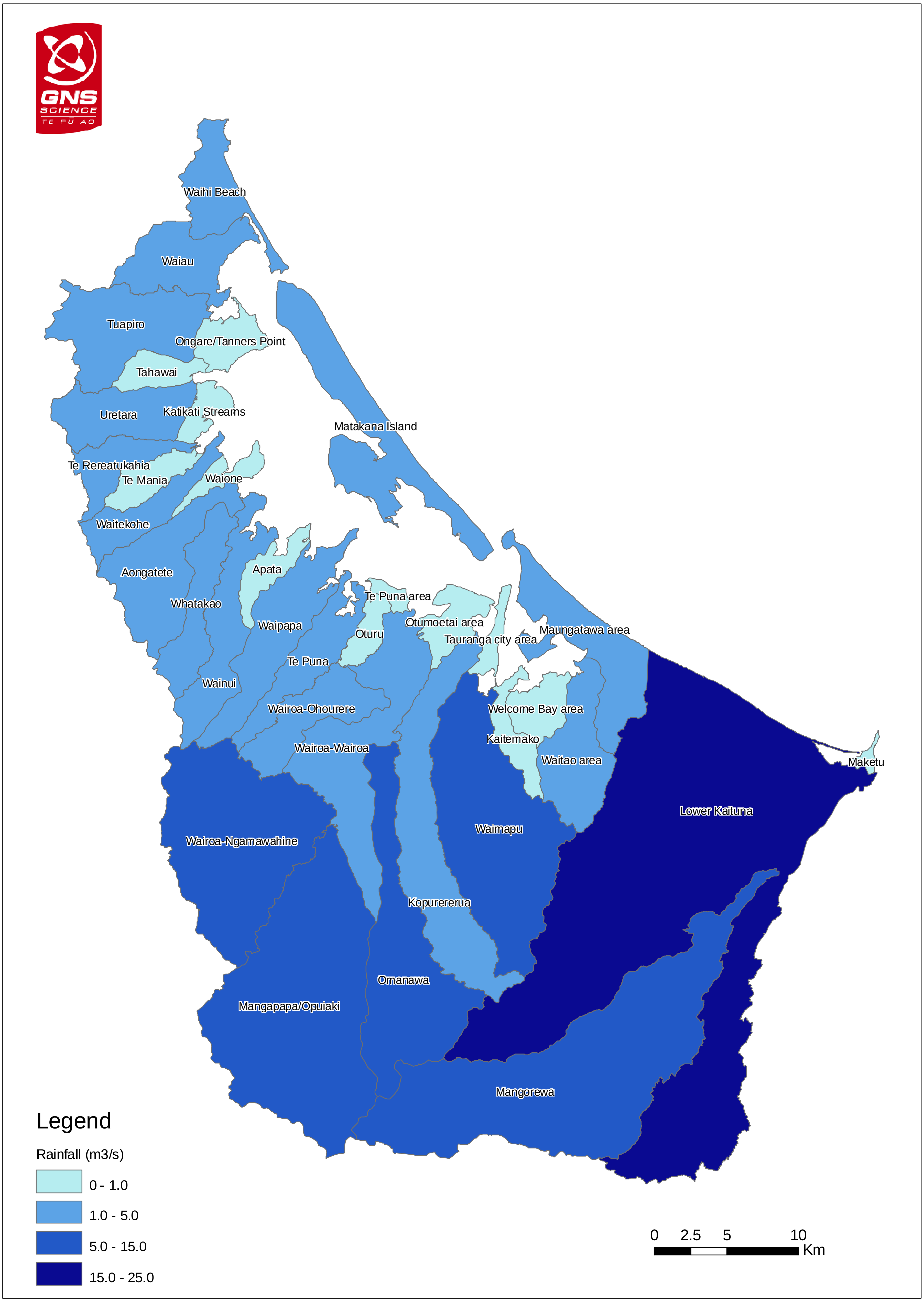


Figure 5.5 Mean annual rainfall estimates (m^3/s) for surface water catchments.

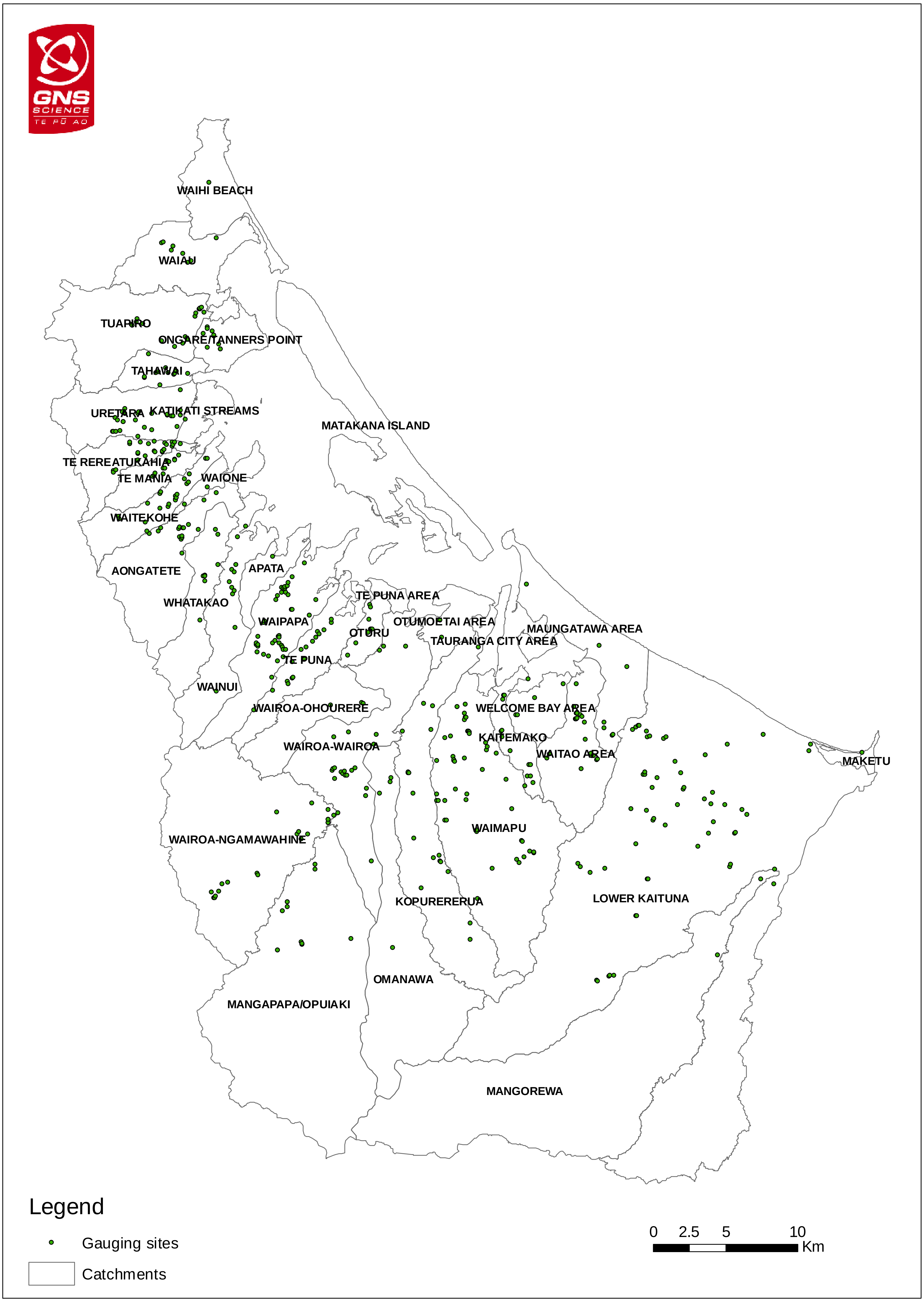


Figure 5.6 Locations of gaugings in the Western Bay of Plenty.

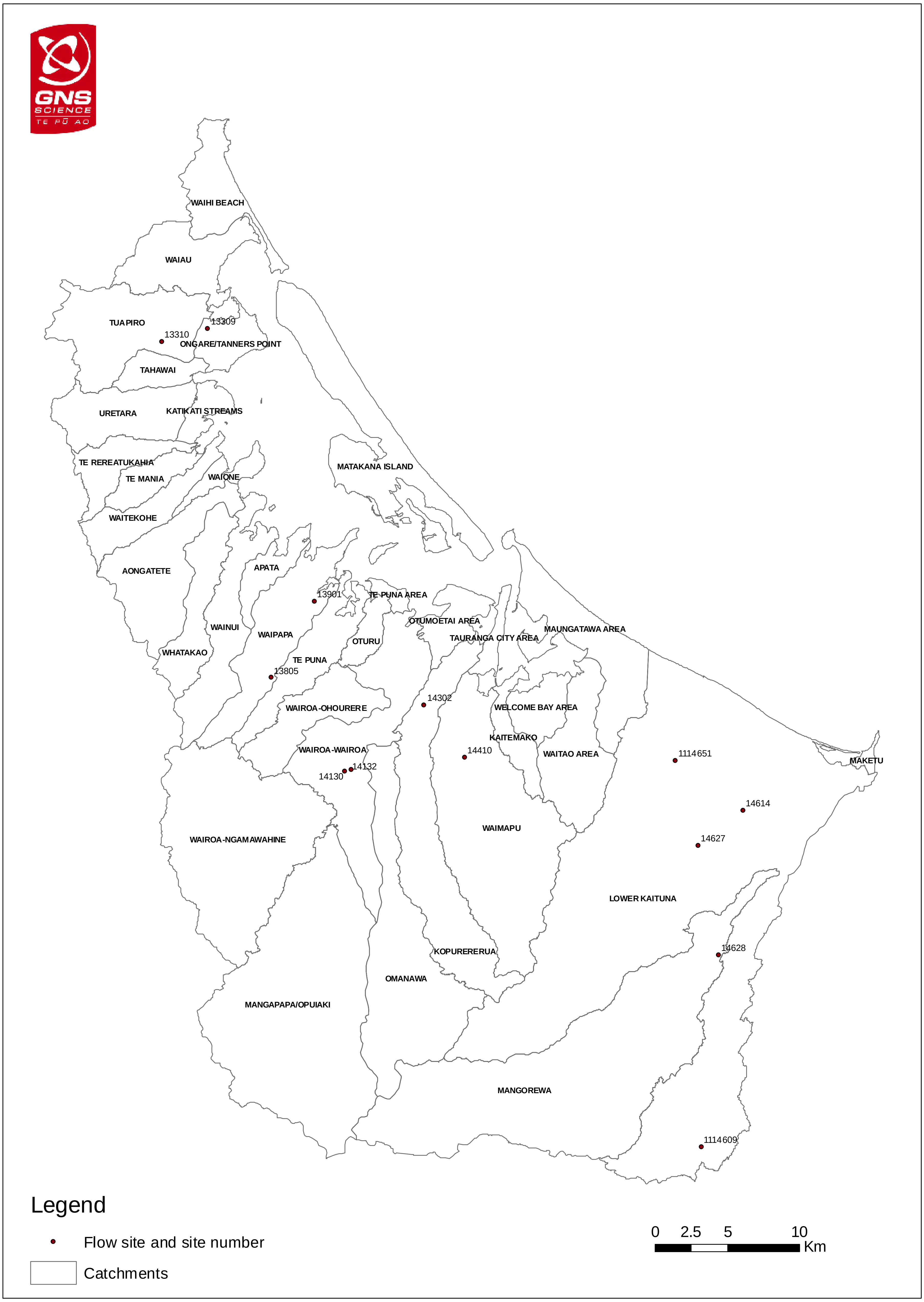


Figure 5.7 Locations of river flow measurement sites – Continuous recorders.

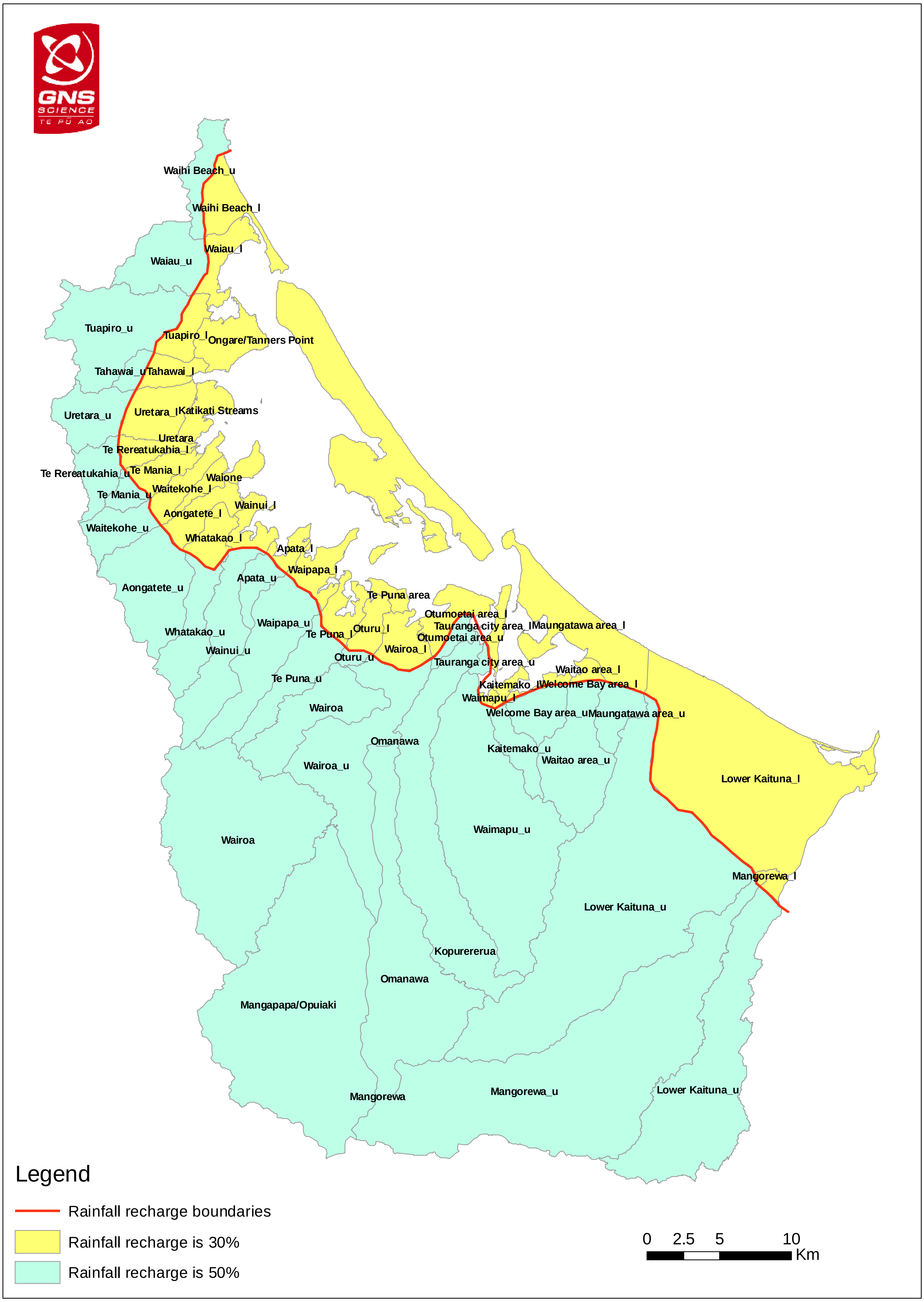


Figure 5.8 Rainfall recharge zones.

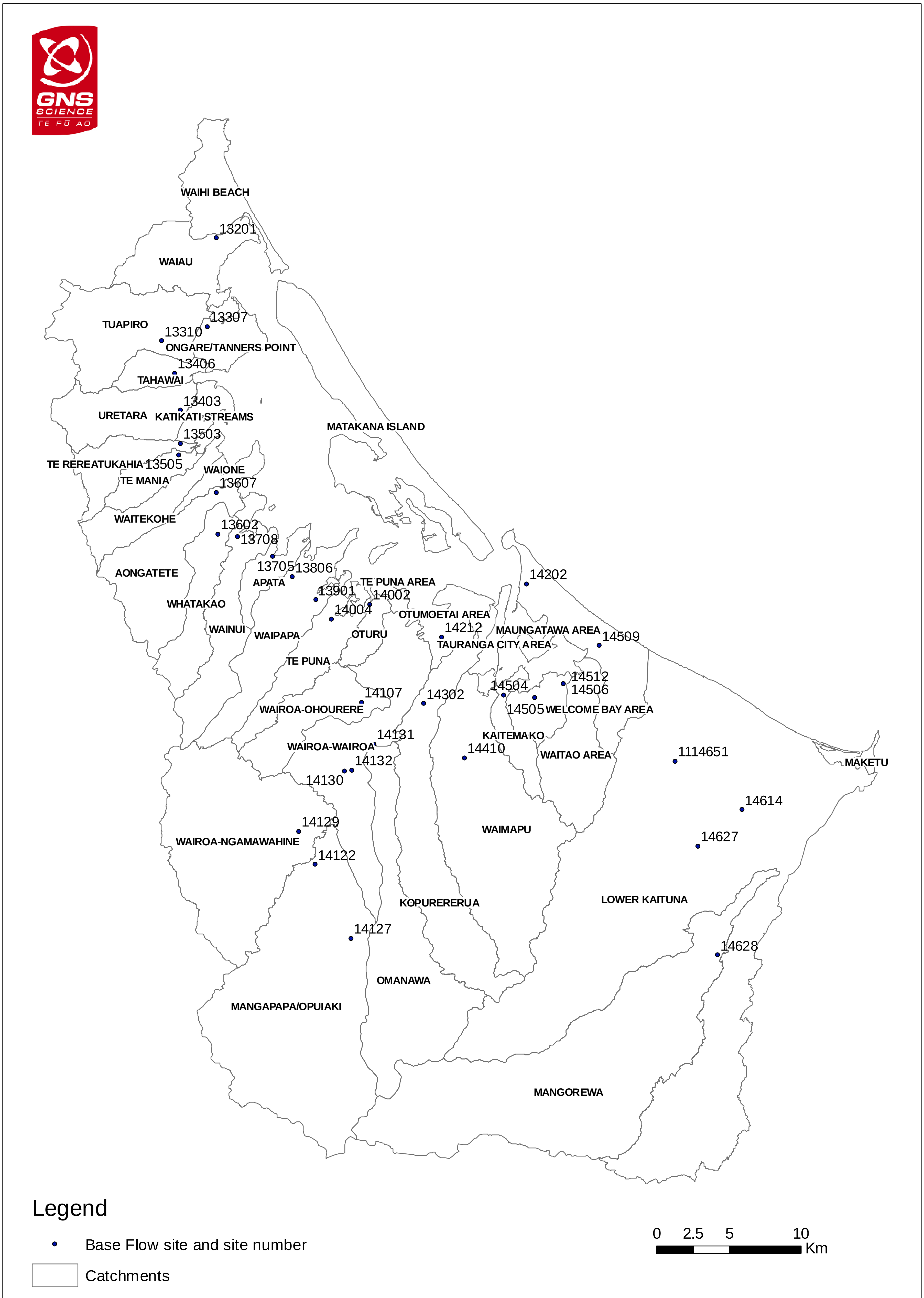


Figure 5.9 Base flow discharge from catchments – site locations.

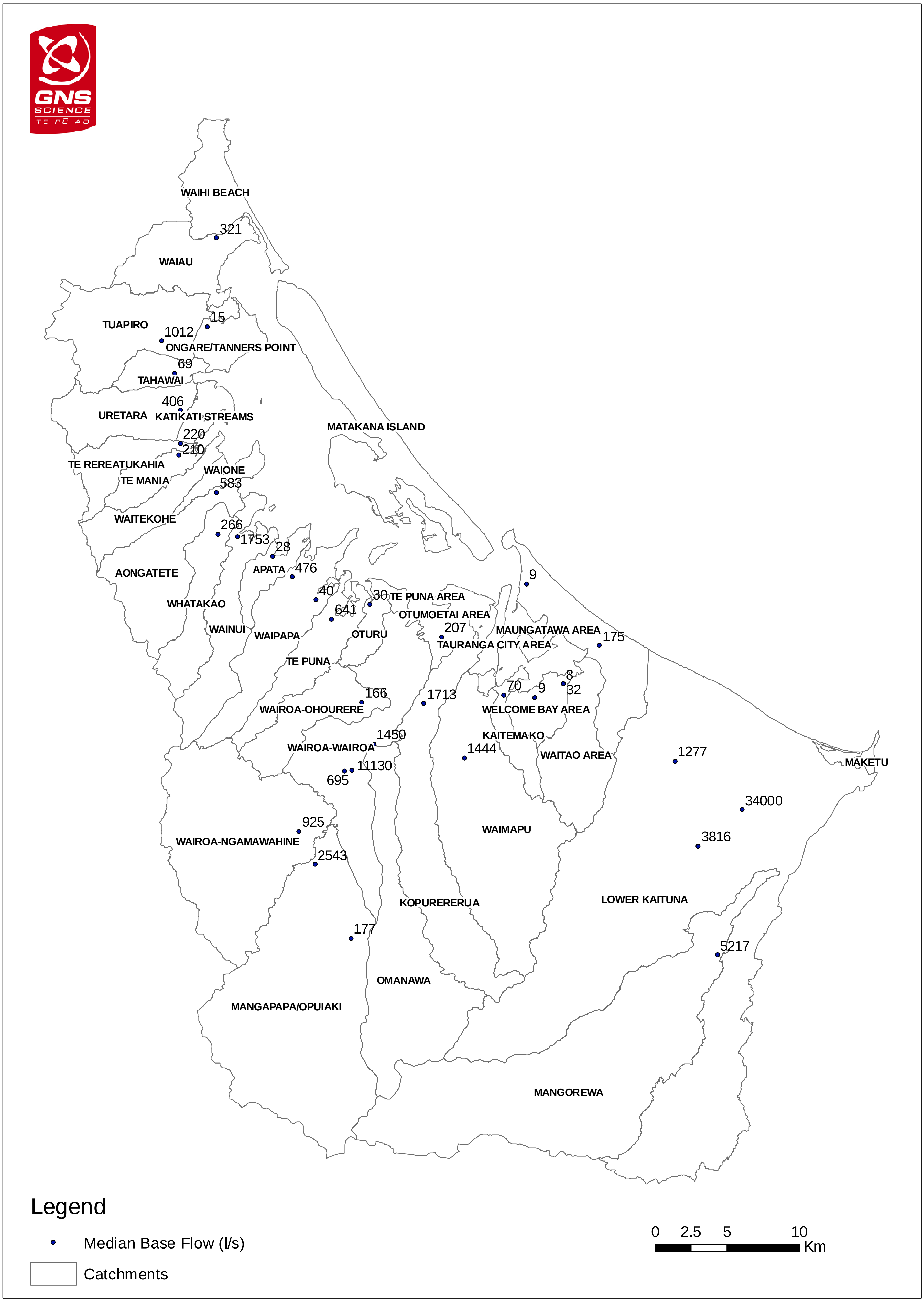


Figure 5.10 Base flow discharge from catchments.

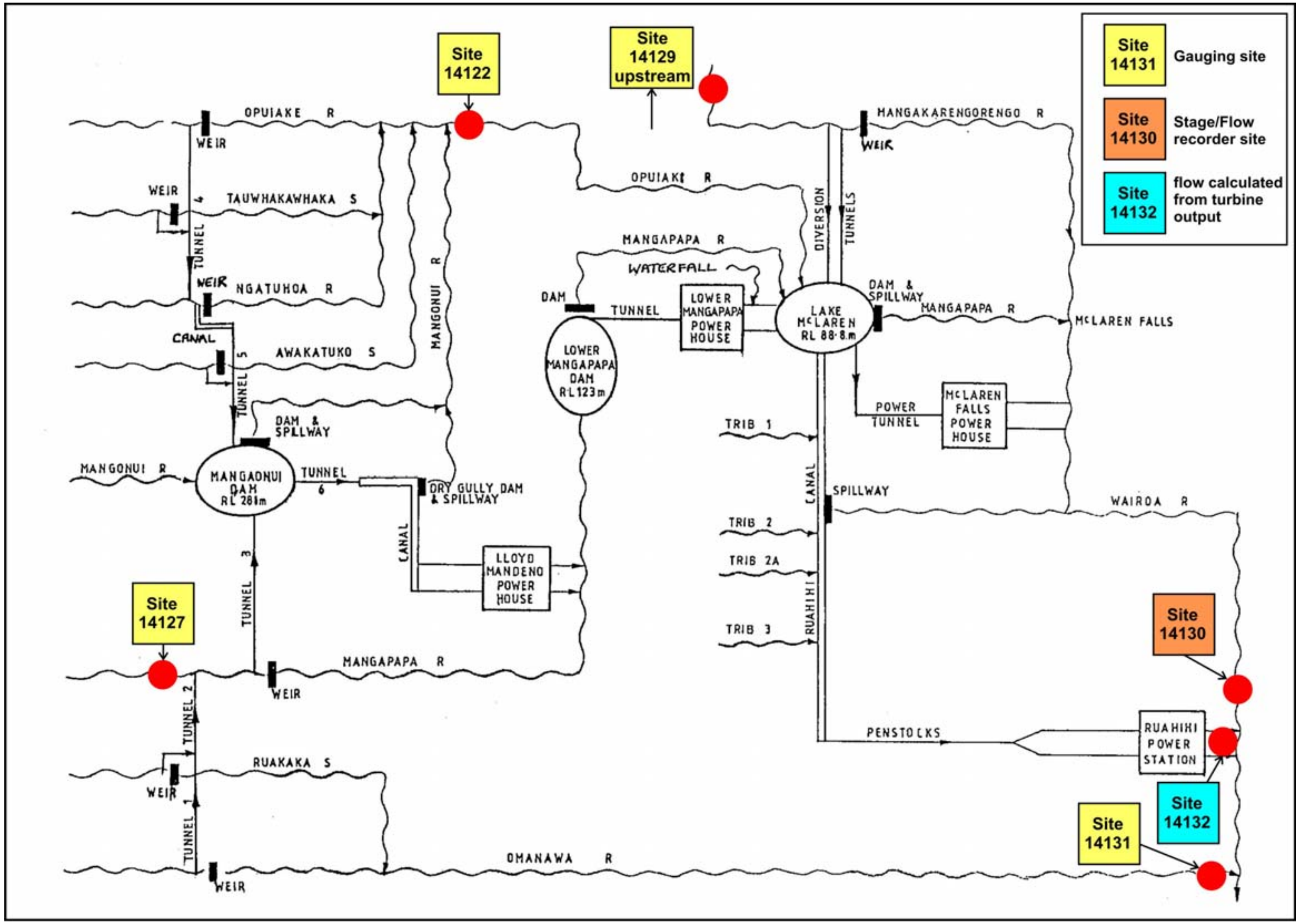


Figure 5.11 Schematic of Wairoa River hydropower schemes (Walpole, pers. comm.) and hydrological monitoring sites.

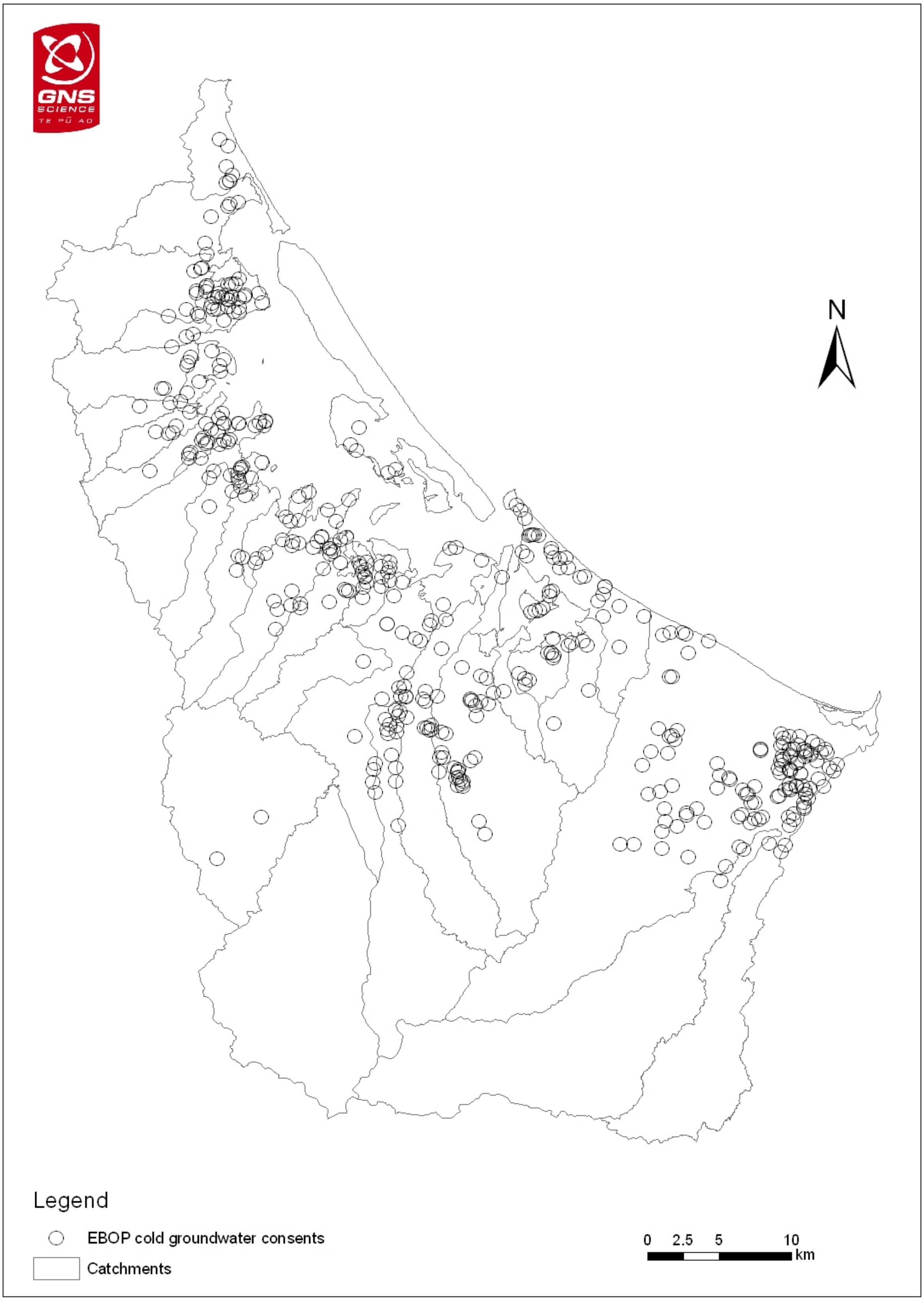


Figure 6.1 Location of wells with groundwater consents for cold water.

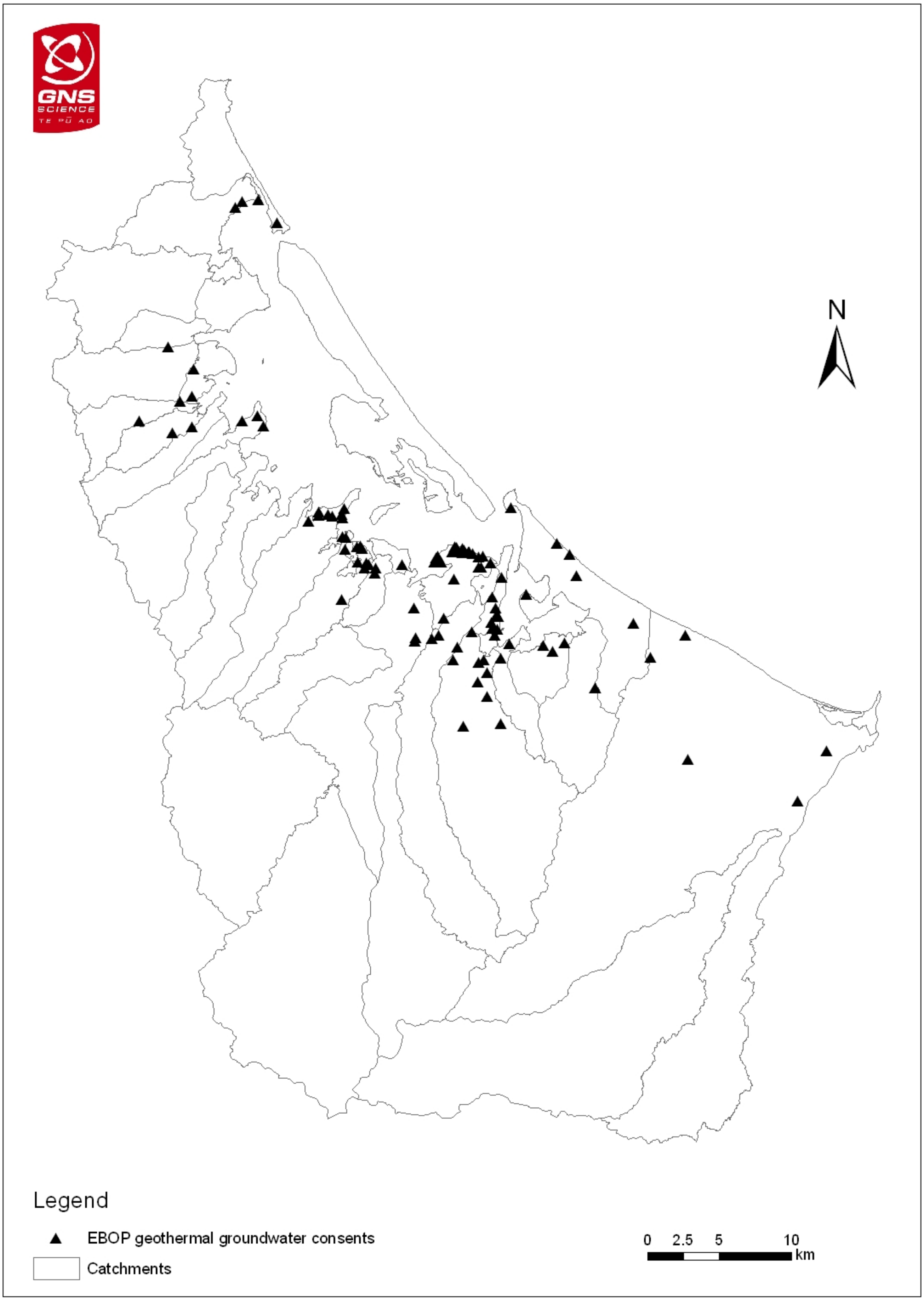


Figure 6.2 Location of wells with groundwater consents for geothermal water.

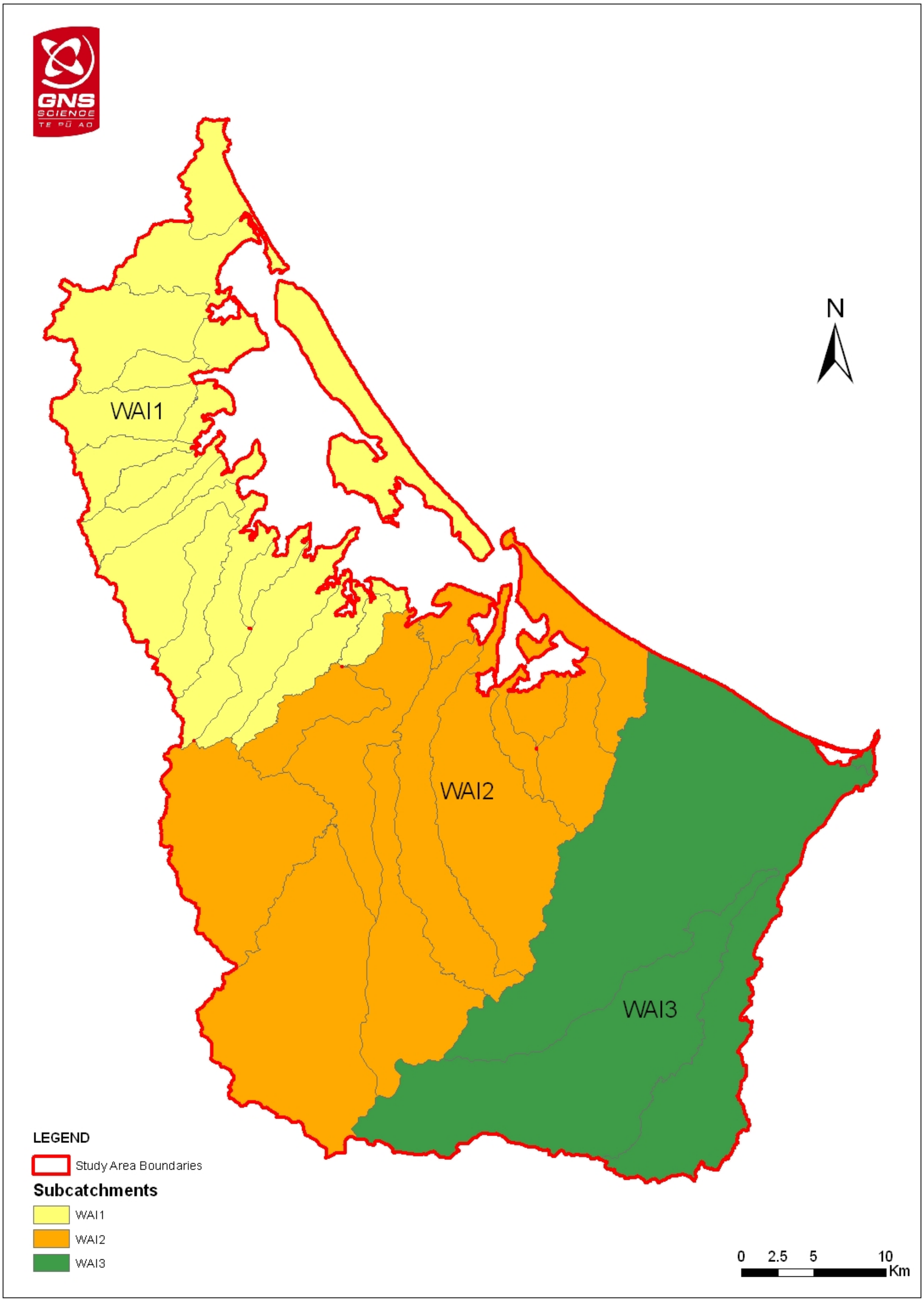


Figure 6.3 Groundwater allocation zones for the Waiteariki Ignimbrite, Aongatete Ignimbrite and Coromandel Volcanics.

APPENDIX 1 CONTRACT FOR WESTERN BAY OF PLENTY GROUNDWATER RESOURCES ASSESSMENT

Scope and Nature of the Services

The aim of the project to assess allocation limits on groundwater in the Western Bay of Plenty – Tauranga harbour area using groundwater flow models in the area defined by the following boundaries:

At the coast – the area between Waihi Beach and Maketu and inland to include:

1. Environment Bay of Plenty western regional boundary;
2. The Wairoa River catchment;
3. The boundary of the Lake Rotorua groundwater catchment;
4. The eastern boundary of the Kaituna River catchment.

This area includes sedimentary, volcanic and intrusive units. Warm (geothermal) water is found in groundwater in Tauranga (various locations) and at Maketu.

Existing information will be assessed to produce:

- a geological model of the area, including major units;
- estimates of aquifer extent and boundary conditions, and groundwater storage volumes and fluxes;
- a description of the locations of groundwater discharge to surface waters and the possible subsurface discharges of aquifers.

The current Environment Bay of Plenty priority is to assess allocation limits for groundwater in the area. Therefore, the project does not include an assessment of groundwater quality. However, groundwater temperature and groundwater salinity will be considered in the assessment of groundwater flow through the system.

Deliverables

GEOLOGICAL AND NUCLEAR SCIENCES LTD will deliver the following:

- 3D geological model;
- models of groundwater/surface water interaction;
- model (steady-state) of groundwater flows for use by Environment Bay of Plenty in resource allocation decisions;
- other models as outlined in the project design section of this proposal;
- estimates of groundwater recharge and discharge;
- maps and cross sections as outlined in the project design section of this proposal;
- a client report.

APPENDIX 2 GROUNDWATER LEVEL DATA

Potentiometric Surface Data						
EBOP well number	NZMG Coordinates		Geologic Unit	Median GW Level	Ground Level	Median GW Elev
	Easting	Northing				
0051	2794080	6382070	Waiteariki	5.28	20	14.72
0090	2771660	6412750	Aongatete	30.28	19	-11.28
0093	2782060	6386890	Aongatete	18.41	20	1.59
0094	2780290	6387570	Tauranga	17.27	20	2.73
0410	2811100	6367000	Aongatete	35.99	35	-0.99
0851	2768800	6394900	Waiteariki	15.23	20	15.23
0951	2810900	6371200	Tauranga	9.90	20	10.10
1018	2812000	6374480	Aongatete	3.23	9	5.77
1386	2788310	6382990	Waiteariki	31.76	20	-11.76
1468	2785130	6388070	Aongatete	14.71	0	-14.71
1520	2814780	6374110	Tauranga	26.77	20	-6.77
1535	2806860	6373720	Tauranga	7.20	17	9.80
1566	2773640	6390110	Waiteariki	31.92	35	3.08
1586	2804280	6373420	Tauranga	6.39	20	13.61
1670	2799680	6383310	Waiteariki	14.89	20	5.11
1686	2777300	6391190	Tauranga	5.36	0	-5.36
1690	2810280	6374740	Tauranga	2.69	9	6.31
2024	2807230	6371250	Waiteariki	16.89	20	16.89
2328	2766400	6396600	Aongatete	32.96	21.45	-11.51
2330	2772920	6405440	Tauranga	30.17	20	-10.17
2334	2788870	6383550	Aongatete	3.02	15	11.98
2344	2786380	6373390	Waiteariki	20.51	180	159.49
2504	2787200	6388500	Tauranga	0.85	3.72	2.87
2533	2779250	6389010	Waiteariki	2.43	3.44	1.01
2707	2807520	6379440	Tauranga	4.49	2	-2.49
2728	2802830	6381400	Tauranga	4.63	20	4.63
2822	2816220	6368110	Tauranga	7.43	20	12.57
2829	2770650	6414140	Aongatete	23.80	20	-3.80
2838	2772680	6396970	Aongatete	3.65	0	-3.65
2847	2792370	6387990	Tauranga	1.91	0	-1.91
3020	2799920	6384300	Tauranga	2.00	0	-2.00
3026	2801630	6371380	Waiteariki	61.15	98	36.85
3032	2770680	6417300	Tauranga	2.50	7	4.50
3034	2811970	6374600	Tauranga	4.46	8	3.54
3043	2811900	6374800	Tauranga	1.37	3.74	2.37
3272	2794280	6388220	Waiteariki	3.19	1	3.19
3460	2787270	6388440	Tauranga	0.90	9	8.10
3463	2786350	6388650	Tauranga	1.98	10	8.02
3467	2788830	6387550	Waiteariki	0.53	0	-0.53
2519-1	2765700	6399100	Aongatete	2.93	51	48.07
2519-2	2765700	6399100	Aongatete	3.10	51	47.90
2519-3	2765700	6399100	Tauranga	3.84	51	47.16
2520-1	2766600	6401600	Aongatete	15.31	40	24.69
2520-2	2766600	6401600	Aongatete	26.82	40	13.18
2520-3	2766600	6401600	Tauranga	26.74	40	13.26
2521-1	2768240	6405650	Aongatete	22.94	31	8.06
2521-2	2768240	6405650	Tauranga	20.56	31	10.44
2521-3	2768240	6405650	Tauranga	24.28	31	6.72
2522-1	2769740	6401600	Aongatete	3.28	0	-3.28
2522-2	2769740	6401600	Tauranga	6.67	0	-6.67
2522-3	2769740	6401600	Tauranga	6.66	0	-6.66
2522-4	2769740	6401600	Tauranga	6.75	0	-6.75
2523-1	2770490	6405850	Tauranga	33.85	40	6.15
2523-2	2770490	6405850	Tauranga	29.46	40	10.54

APPENDIX 3 GROUNDWATER CHEMISTRY DATA, FIELD DATA, MISCELLANEOUS AND NUTRIENTS

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
			Coordinates				Field and Miscellaneous Data								Nutrients				
ID	EBOP Well Number	Data Source	Easting	Northing	Sam	Date	Cond	DO	Entero	FC	pH	SiO_2	Temp	TDS	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP
1	66	a,b	2771800	6392300	7	79-96	362	1.05			7.35		34.0	692.0	0.1		0.0	0.1	0.1
2	68	a,b	2766700	6402500	14	82-05	148	5.20			7.57	89.2	21.7	119.0	0.0	0.0	0.1	0.1	0.1
3	70	a	2780000	6374200	1	24-Nov-82	100				5.40			68.5					
4	71	a	2802300	6374000	1	12-Jul-82	469				7.20			320.0					
5	76	a	2792600	6384800	1	16-May-85	260				8.10			200.0					
6	77	a	2792900	6382500	1	10-May-85	250				6.80			175.0					
7	86	a	2773200	6397400	2	82-87	516				7.93						0.0		
8	90	a	2771600	6412700	2	Jan-Jun 86	425				8.30			297.7					
9	94	b	2780200	6387500	6	91-95	198	3.45			7.25		25.0		0.0		0.6	0.1	0.1
10	303	a	2769700	6395800	1	16-Nov-87	20				6.10		37.0				0.0		
11	410	b	2811200	6367000	7	94-05	205				6.80	76.5	15.3		0.070	0.001	0.004	0.008	0.009
12	413	a	2812000	6374600	4	84-87	608	8.00			6.63		15.8	409.0					
13	432	a	2788300	6368700	1	29-Oct-84	137				6.50			96.0					
14	552	a	2771300	6405400	4	82-88	264	5.50			6.90		26.4	217.5			0.0		
15	556	a	2792000	6384800	1	3-Dec-87	233				6.50			163.0					
16	604	a	2792900	6385500	2	Nov 86	424				6.70			305.5					
17	643	b	2819600	6371600	10	91-04	435	0.5	18	4	6.60	73.0	16.3		0.105	0.001	0.009	0.409	0.425
18	647	a	2771400	6407300	1	9-Mar-88	188				6.50						0.0		
19	649	a	2770700	6405600	1	9-Mar-88	162				6.20						0.1		
20	837	a	2794300	6386400	1	-	213				6.15			154.0					
21	840	a	2769600	6405000	2	83-87	129				6.63						0.0		
22	851	a,b	2768800	6394900	13	87-04	163	3.25			6.75	83.0	19.8	91.0	0.0	0.0	0.0	0.1	0.1
23	951	a,b	2810900	6371200	12	81-05	486	4.40			6.90	93.1	24.8	320.0	0.2	0.0	0.0	0.1	0.3
24	955	a	2768200	6403500	2	87-88	166				7.15			106.0			0.0		
25	956	a	2769500	6405500	1	12-Nov-87	163				7.20						0.0		
26	1018	b	2812000	6374600	11	91-05	637	0.80			6.70	137.0	32.4		0.1	0.0	0.0	0.1	0.2
27	1019	a	2772000	6406600	3	86-87	270				7.10			18.9			1.0		
28	1072	a	2807500	6374700	2	83-84	183				7.30			135.0			0.0		
29	1074	a	2811700	6366400	1	8-Dec-87	345	7			6.64		20	218.0					
30	1077	a	2773000	6405700	1	30-Jul-85	190	7			7.60		25.1	133.0					
31	1079	a	2782400	6373100	2	85-86	180				6.80			126.0					
32	1081	a	2795200	6382200	1	22-Aug-85	168				7.10		18.4	118.0					
33	1084	a	2806500	6371600	1	18-Sep-85	121				6.80			85.0					
34	1085	a	2776200	6390500	1	25-Sep-85	150				7.00			105.0					
35	1087	a	2782300	6372100	1	1-Oct-85	92				6.40			64.0					
36	1092	a	2809500	6369400	1	3-Dec-85	290				6.00			203.0					
37	1094	a	2776800	6389100	1	16-Jan-86	132				6.60			92.4					
38	1095	a	2781400	6369200	2	Jan-Apr 86	165				6.15			115.5					
39	1107	a	2770600	6414200	1	10-Mar-88	230				8.80						0.0		
40	1111	a	2815800	6366800	1	21-Feb-86	94				6.10			62.0					
41	1114	a	2769700	6405400	3	84-87	384				7.10			245.0			0.5		
42	1115	a	2770800	6401800	4	82-87	420				7.07			300.0			0.0		
43	1119	a	2823800	6369100	1	3-Feb-88	360				5.30			232.0					
44	1123	a	2780400	6387600	1	-	3070						56	2240.0					
45	1131	a	2768000	6399000	1	10-Feb-87					7.70			115.0			0.5		

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
			Coordinates				Field and Miscellaneous Data								Nutrients				
ID	EBOP Well Number	Data Source	Easting	Northing	Sam	Date	Cond	DO	Entero	FC	pH	SiO_2	Temp	TDS	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP
46	1138	a	2812000	6366600	1	10-Apr-87	315				6.70			210.0			1.0		
47	1304	a	2764900	6415400	2	Apr-May 86	116				7.40			81.0					
48	1325	a	2770500	6406400	1	9-Mar-88	219				6.50						0.0		
49	1354	a	2811800	6368500	1	7-Mar-86	106				6.70			74.0					
50	1359	a	2769600	6405300	1	8-Apr-86	149				7.00			104.0					
51	1360	a	2776200	6376700	1	21-Apr-86	51	5			6.10		18.8	36.0			0.0		
52	1371	a	2778200	6390600	1	20-Jan-87	146	8					15.2	115.0					
53	1374	a	2777000	6389400	1	8-Jun-82					6.80								
54	1376	a	2770700	6396200	2	81-83	213				7.68			144.0					
55	1384	a	2782700	6368500	1	23-Jul-85	480				6.80			34.0					
56	2728	b	2802800	6381400	11	1991-2005	574	1.3			6.70	84.0	21.4		0.350	0.001	0.009	0.018	0.027
57	1393	a,b	2768600	6404700	13	87-05	165	1.25			8.00	111.0	26.5		0.0	0.0	0.0	0.2	0.2
58	1436	a	2786800	6388500	1	14-Nov-89	644				5.70			451.0					
59	1445	a	2778600	6391600	1	20-Mar-90	995	1			8.30		16.5	697.0					
60	1448	a	2768800	6409800	1	11-Apr-90	104				5.80			73.0					
61	1449	a	2782200	6377200	1	7-May-90	101				6.20			71.0					
62	1463	a	2785000	6387700	1	8-May-90	476	2			7.80		20.1	333.0					
63	1469	a	2771200	6393100	1	28-Nov-89	282				6.90			197.0					
64	1470	a	2794600	6380400	1	8-Dec-89	183				6.40			128.0					
65	1471	a	2794500	6374100	1	12-Dec-89	141				6.60			99.0					
66	1472	a	2795000	6379700	1	3-Jan-90	249	7			8.40		16.6	174.0					
67	1473	a	2789500	6376300	1	15-Jan-90	265				7.40			186.0					
68	1474	a	2790300	6372800	1	17-Jan-90	136				6.70			95.0					
69	1475	a	2795200	6377800	1	26-Jan-90	159				6.80			11.0					
70	1501	a	2786900	6372200	1	1-Sep-83	83				7.50			55.0			1.0		
71	1510	a	2768600	6399800	3	Feb-Nov 87	184				6.95			139.0			0.0		
72	1516	a	2788900	6379500	1	28-Sep-83	147	8			7.25		17.2						
73	1520	b	2814700	6373800	10	91-05	313	4.55			6.55	98.0	22.1		0.0	0.0	1.8	0.1	0.1
74	1535	a	2806800	6373600	1	25-Oct-85	170				7.30			112.0					
75	1555	a	2769900	6406100	1	9-Mar-88	410				6.30						0.0		
76	1566	a	2773600	6390200	1	-													
77	1569	a	2772400	6407200	2	87-88	192				6.15						0.2		
78	1570	a	2769500	6405600	4	83-88	296				7.33			270.0			0.0		
79	1577	a	2770000	6400900	3	86-87	325				7.50			234.0			0.0		
80	1586	b	2804300	6373500	11	91-05	107	0.95	0.5	0.5	6.35	89.3	17.4		0.0	0.0	0.2	0.0	0.0
81	1652	a	2813000	6372300	1	11-Dec-86					6.10								
82	1665	a	2779700	6387600	1	30-Sep-83	178				7.20			125.0					
83	1677	a	2772600	6394100	1	7-Mar-88	172				6.80			120.0					
84	1684	a	2791900	6384300	3	84-87	211				7.20			161.0					
85	1686	b	2777500	6391400	10	91-05	378	0.95			7.66	99.8	26.8		0.0	0.0	0.0	0.2	0.2
86	1690	a,b	2810500	6374700	11	85-05	422	3.00			6.90	100.8	26.5	297.0	0.2	0.0	0.0	0.1	0.2
87	2001	a	2789500	6381200	1	4-Nov-86	377				8.60			264.0					
88	2008	a	2771000	6405000	1	21-Jan-87	177				6.30			124.0					
89	2018	a	2788300	6384600	1	29-Jul-87	569	1			8.90		19	398.0					
90	2045	a	2794100	6387800	2	88-91	493				7.40			344.5					
91	2055	a	2768500	6404900	1	10-Mar-79					7.90								
92	2056	a	2767600	6405100	2	85-88	156				8.00			97.0			0.3		

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
			Coordinates				Field and Miscellaneous Data								Nutrients				
ID	EBOP Well Number	Data Source	Easting	Northing	Sam	Date	Cond	DO	Entero	FC	pH	SiO_2	Temp	TDS	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP
93	2057	a	2771400	6404900	4	87-92	158				6.35			111.0					
94	2058	a	2769900	6406800	1	11-Nov-86	432				6.50			290.0			2.0		
95	2106	a	2768900	6408100	1	10-Feb-86	207				6.30		33.3	133.0					
96	2093	b	2791300	6388700	7	91-02	1198	1.40	0.5	0.5	6.50	40.1	18.1		0.1	0.0	1.8	0.0	0.0
97	2303	a,b	2770200	6399000	14	80-05	474	0.20			7.43	109.5	35.5	280.0	0.5	0.0	0.0	2.6	2.4
98	2304	a	2771200	6393500	1	16-Nov-87	455				8.00						0.0		
99	2309	a	2770100	6406800	1	9-Mar-88	189				6.40						0.0		
100	2310	a	2770700	6412200	1	14-Mar-85	220				9.00			154.0					
101	2323	a	2780400	6388200	1	31-May-82	1960				8.00			1370.0					
102	2324	a	2771600	6388100	1	12-Jul-83	113				6.70			75.0					
103	2326	a	2769000	6405500	1	10-Mar-88	177	6			7.80		16.5				0.4		
104	2328	a	2766400	6396600	3	83-87	250				7.20			139.0			0.0		
105	2329	a	2768000	6407000	2	85-87	197	6.00			7.60		16.8	130.0			1.0		
106	2330	b	2772800	6405300	11	91-05	178	4.10			6.40	85.0	18.4		0.0	0.0	0.1	0.0	0.0
107	2331	a	2772400	6405400	5	87-88	190				6.30			137.0			0.0		
108	2342	b	2795800	6382100	11	91-05	197	7.30			7.00	91.5	22.0		0.0	0.0	0.1	0.1	0.1
109	2343	b	2775400	6390600	11	91-05	106	7.65			6.70	66.9	18.9		0.0	0.0	0.1	0.1	0.1
110	2344	b	2786400	6373500	11	91-05	86	6.45			6.12	89.4	17.0		0.0	0.0	0.2	0.0	0.0
111	2362	a,b	2791500	6384200	12	84-05	210	0.43			6.98	115.0	30.8	164.0	0.1	0.0	0.0	0.2	0.3
112	2372	a	2769100	6406700	2	87-88	402				6.25						0.0		
113	2380	a	2771100	6396800	1	2-Sep-87	300				8.50			210.0					
114	2393	b	2784400	6385100	8	91-98	228	3.85			7.20	97.0	28.9		0.0	0.0	0.2	0.1	0.1
115	2407	a	2781900	6394000	2	Jan-Nov 86	462				7.15			355.0					
116	2426	a	2770600	6369500	1	3-Feb-86	99				6.40			70.0					
117	2442	a	2807100	6370300	1	31-Jan-90	143				5.70			100.0					
118	2443	a	2793500	6379300	1	7-Mar-90	242				7.10			169.0					
119	2444	a	2822500	6370400	1	8-Mar-90	445				6.10			312.0					
120	2452	a	2770100	6404500	4	85-90	226				6.62			152.5			0.5		
121	2458	a	2770600	6396400	2	84-85	233				8.13			161.5			1.0		
122	2459	a	2769900	6393900	3	84-87	1400				8.30			789.8			0.0		
123	2542	a	2769200	6397000	2	83-87	263				7.82			182.0					
124	2543	a	2768100	6395300	2	86-87	201				7.45			140.0			1.0		
125	2551	a	2774100	6382500	1	4-Sep-90	114				6.50			80.0					
126	2552	a	2782400	6394600	1	11-Sep-90	170				5.90			119.0					
127	2553	a	2824300	6370500	1	22-Jun-90	519				6.70			363.0					
128	2555	a	2785300	6385500	1	16-Nov-90	222				7.40			155.4					
129	2556	a	2785600	6379500	1	13-Dec-90	171				6.70			120.0					
130	2557	a	2781000	6365700	1	28-Dec-90	81				6.50			57.0					
131	2558	a	2795600	6378700	1	3-Jan-91	217				5.00			152.0					
132	2561	a	2789700	6378700	1	29-Jan-91	188				6.80			132.0					
133	2570	a	2799800	6381800	1	15-Apr-91	231				7.40			162.0					
134	2571	a	2781100	6378700	1	18-Apr-91	181				7.10			127.0					
135	2578	a	2771800	6386400	1	27-Jun-91	152				7.20			106.4					
136	2580	a	2786500	6388700	1	13-Aug-91	706				7.50			494.0					
137	2581	a	2791900	6378400	1	21-Mar-91	123				6.50			86.0					
138	2590	a	2809400	6372700	1	9-Jan-92	229	1			6.10		18.9	160.0					
139	2592	a	2771600	6379000	1	17-Feb-92	78				6.00			55.0					

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
			Coordinates				Field and Miscellaneous Data								Nutrients				
ID	EBOP Well Number	Data Source	Easting	Northing	Sam	Date	Cond	DO	Entero	FC	pH	SiO_2	Temp	TDS	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP
140	2595	a	2786700	6388700	1	19-Mar-92	250				6.20		19.3	154.0					
141	2596	a	2788400	6369000	1	3-Apr-92	95				5.90			67.0					
142	2600	a	2790100	6374500	1	-	96				6.20			67.0					
143	2612	a	2792500	6390100	1	22-Jun-87					6.70			39200.0					
144	2707	b	2807600	6379500	11	91-05	926	2.85	1.0	0.5	7.75	36.2	16.1		0.0	0.0	2.2	0.0	0.0
145	2729	b	2794100	6382100	6	91-96	193	4.35			6.65		19.8		0.0		0.1	0.2	0.2
146	2822	b	2816200	6368100	11	91-05	341	3.2			6.60	91.2	18.1		0.032	0.001	0.005	0.183	0.244
147	2827	a	2799800	6369400	1	-					6.40								
148	2829	a,b	2770650	6414140	13	83-05	230	5.15			8.30	70.5	31.1	114.0	0.0	0.0	0.1	0.2	0.2
149	2832	a	2769600	6411500	1	3-Nov-87	156	1			6.04		19.2	99.0					
150	2838	a	2773200	6397200	2	83	810				8.15			530.0					
151	2847	b	2792400	6388100	12	91-05	232	0.23	0.5	0.5	5.80	42.0	19.7		1.6	0.0	0.0	0.0	0.0
152	3002	a	2771000	6416100	1	13-Dec-85	165				6.10			109.0			6.0		
153	3004	a	2816100	6368500	1	10-Mar-87	125				7.00			80.0			1.0		
154	3008	a	2795600	6368700	1	4-Apr-86	40				6.90			28.0					
155	3013	a	2804500	6371400	1	2-Feb-87	267	2			6.10		18.4	212.0					
156	3015	a	2803800	6374100	2	74-76					7.35						0.0		
157	3034	b	2811900	6374600	11	91-05	292	2.75	0.8	0.5	6.50	84.7	18.2		0.0	0.0	4.9	0.2	0.2
158	3044	b	2785700	6383700	15	91-05	1771	0.40			7.40	83.0	41.8		0.2	0.0	0.0	0.1	0.1
159	3045	c	2811000	6374300	36	91-05	261	4.60	0.8	1.0	6.41	83.0	15.8		0.0	0.0	0.6	0.0	0.0
160	3272	b	2794350	6388150	4	97-05	27300				6.85	94.0	35.9		1.0	0.0	0.0	0.0	0.1
161	3287	a	2817700	6355600	2		89				6.40			56.5					
162	3460	a	2787270	6388440	1	2-Nov-87	1550				7.70			1085.0					
163	3464	a	2786500	6388700	1	3-Nov-86	555				7.50			389.0					
164	3566	b	2816600	6366200	5	97-05	185		6	1	6.90	84.6	15.1		0.010	0.001	9.250	0.172	0.172
165	4011	a	2788920	6385290	1	9-Sep-98	265				7.69			185.5					
166	4132	a	2782700	6387500	1	24-Aug-82	35				8.15		40					2.0	
167	4261	a	2777600	6388500	1	18-Feb-80	142				7.40			100.0					
168	4364	c	2785700	6383680	27	96-05	877	0.70			7.50	74.0	36.4		0.0	0.0	0.0	0.1	0.1
169	4582	b	2793850	6381050	4	97-05	211				6.75	107.0	23.9		0.0	0.0	0.1	0.2	0.2
170	4677	a	2798700	6368100	1	31-Aug-83	124				7.15			85.0					
171	4968	b	2817400	6365100	3	02-05	212				6.60	88.4	16.4		0.020	0.001	5.115	0.157	0.156
Min							20	0	1	1	5.00	36.2	15.1	11.0	0.0	0.001	0.001	0.008	0.009
Median							211	3	1	1	6.80	88.8	21.7	138.0	0.0	0.001	0.032	0.116	0.117
Mean							482	3	3	1	6.94	86.5	23.7	532.4	0.1	0.002	0.612	0.233	0.197
Max							27,300	8	18	4	9.00	137.0	41.8	39,200.0	1.6	0.011	9.250	2.580	2.420
Stdev							2,144	2	6	1	0.73	20.9	7.4	3,539.7	0.3	0.002	1.516	0.517	0.399
Count					583		163	33	8	8	168	32	39	122	35	32	74	36	35
Fraction							0.95	0.19	0.05	0.05	0.98	0.19	0.23	0.71	0.20	0.19	0.43	0.21	0.20

1. *ID is the well ID assigned in this report for the analysis of groundwater chemistry. Data source indicates origin of data (a means original catchment data, b means NERMN data, c means NGMP data). Coordinates are easting and northing New Zealand Map Grid. "Sam" is number of samples involved. "Date" is time frame well sampled. Variables concentrations are calculated median values for all available data of any given well. "Cond" is conductivity in units of uS/cm. "Entero" and "FC" are enterococcus and faecal coliform bacteria in units of MPN/100 mL. pH is in standard units. "Temp" is temperature in units of °C. Units for other variables are mg/L.*

2. *Statistics are calculated minimum (Min), median, mean, and maximum (Max) values and standard deviation (Stdev). "Count" means number of data points out of 167 maximum wells. "Fraction" is fraction of wells with data for the variable of concern (e.g., median conductivity data is available for 95% of the 172 wells but DO data is only available for 19% of the wells.*

APPENDIX 4 GROUNDWATER CHEMISTRY DATA, MAJOR CATIONS AND MAJOR ANIONS

Western Bay of Plenty Groundwater Quality Data Summary[1,2]								
		Major Cations				Major Anions		
ID	EBOP Well Number	Ca	Mg	K	Na	HCO_3	Cl	SO_4
1	66	2.9	1.1	5.4	64.3	128.3	37.8	2.0
2	68	5.0	2.3	1.9	22.5	75.6	8.8	1.8
3	70	0.4	0.5	2.9	6.4		21.0	
4	71	0.3	0.1	6.4	98.5		99.0	
5	76	0.2	0.1	4.6	53.0		32.0	
6	77	3.3	4.3	5.7	29.5		42.3	
7	86	0.8	0.3	9.5	149.0	307.0	40.1	
8	90	0.0	0.0	3.1	72.0		83.0	
9	94	5.1	4.7	3.2	31.0	96.4	16.4	2.6
10	303	6.9	5.5	4.0	16.1	92.0	9.5	
11	410	5.5	3.4	3.4	24.0	102.5	10.0	6.6
12	413	4.3	11.5	7.3	85.7		47.8	5.0
13	432	2.4	1.4	5.6	21.2		21.3	
14	552	0.9	1.8	4.3	49.0		35.0	1.0
15	556	5.3	4.1	8.8	20.6		25.0	
16	604	6.9	12.0	19.2	42.6		54.1	
17	643	15.9	10.2	5.7	59.3	234.9	28.1	14.4
18	647	8.5	4.5	2.6	23.0	83.0	22.5	2.0
19	649	6.3	2.1	3.8	22.0	56.0	24.8	3.0
20	837	1.0	1.2	6.3	27.6		35.5	
21	840	2.8	2.1	2.4	15.1	60.0	18.4	5.0
22	851	6.6	5.7	4.1	14.9	79.9	10.6	2.2
23	951	28.9	10.1	2.6	64.0	289.1	21.8	0.3
24	955	3.1	2.9	2.2	28.5	92.0	14.6	
25	956	0.4	0.2	2.4	38.0		8.6	2.0
26	1018	16.2	11.5	8.8	105.0	346.5	40.5	0.9
27	1019	1.1	1.4	4.0	60.0		21.0	
28	1072	1.8	1.3	2.5	36.2	99.0	13.4	
29	1074	1.0	7.5			157.0	52.0	
30	1077	1.9	3.0	2.3	2.0		7.0	
31	1079	21.5	0.5	2.2	4.9		30.1	
32	1081	2.9	4.2	4.3	22.0		21.0	
33	1084	0.1	0.0	3.5	13.6		21.2	
34	1085	0.1	1.2	2.2	20.8		31.7	
35	1087	0.2	1.1	2.5	12.8		35.3	
36	1092	1.9	5.1	363.0	37.5		45.8	
37	1094	0.2	0.8	3.9	14.5		3.5	
38	1095	1.5	2.5	6.9	15.9		75.8	
39	1107	0.3	0.3	3.5	50.0	105.0	25.4	4.0
40	1111	0.7	0.4	1.6	11.0		14.0	10.0
41	1114	1.6	2.0	5.8	76.8	189.0	28.4	
42	1115	0.1	0.1	8.4	77.2	248.0	24.6	
43	1119	86.0	1.0			22.0	50.0	
44	1123	1.2	0.3	9.4	560.0		709.0	
45	1131	6.0	2.0	4.0	25.0	82.0	15.0	
46	1138	9.2	9.7	4.0	32.0		18.0	
47	1304	2.2	3.1	4.6	16.2		26.5	
48	1325	8.0	4.6	2.5	30.0	107.0	22.1	
49	1354	0.3	0.7	3.7	14.4		24.7	
50	1359	0.0	0.2	4.0	26.6		35.0	
51	1360	0.2	0.3	2.9	6.7		28.2	
52	1371	1.2	3.4	4.9	14.0		25.0	
53	1374						34.0	
54	1376	0.3	1.4	1.1	30.9		28.4	
55	1384	2.4	0.4	2.1	7.8		8.0	
56	2728	9.1	4.0	10.8	79.7	133.0	84.3	12.4
57	1393	0.3	0.1	2.6	34.9	83.1	9.0	1.4
58	1436	2.1	0.8	17.8	110.0		6.0	
59	1445	2.5	0.7	11.1	214.0		113.0	
60	1448	1.6	0.9	4.3	12.6		7.1	
61	1449	3.6	2.6	4.9	9.4		3.5	
62	1463	1.0	0.6	33.1	89.0		43.0	
63	1469	7.3	3.2	3.7	39.6		14.0	

Western Bay of Plenty Groundwater Quality Data Summary[1,2]								
		Major Cations				Major Anions		
ID	EBOP Well Number	Ca	Mg	K	Na	HCO_3	Cl	SO_4
64	1470	7.0	3.1	4.9	18.9		10.6	
65	1471	5.2	2.9	2.8	13.7		7.0	
66	1472	10.2	4.5	10.1	26.5		10.6	
67	1473	12.2	3.8	1.5	39.0		9.0	
68	1474	6.8	28.2	5.3	13.9		7.0	
69	1475	5.8	3.4	2.3	14.3		10.6	
70	1501	8.0	3.0	12.0	12.0		7.0	
71	1510	11.2	7.6	1.8	18.0	90.0	7.3	1.0
72	1516	0.9	1.2	3.1	24.3		28.4	
73	1520	8.0	6.1	7.9	48.6	133.0	26.8	2.2
74	1535	4.0	2.0	3.0	25.0		11.0	
75	1555	5.5	3.4	7.3	86.0	198.0	50.9	2.0
76	1566	1.2	4.0		17.2		24.8	
77	1569	7.9	3.8	3.4	23.0	62.0	23.9	5.5
78	1570	2.1	1.5	5.4	48.9		49.5	1.0
79	1577	3.1	2.1	6.9	57.8	192.0		1.0
80	1586	3.1	2.0	3.5	12.3	35.7	8.6	5.0
81	1652							
82	1665	0.9	2.5	2.6	17.5		21.0	
83	1677	6.5	3.1	3.9	24.0		15.0	
84	1684	0.5	0.6	5.3	40.0		28.4	12.0
85	1686	1.3	1.4	3.8	74.5	114.7	56.0	5.0
86	1690	16.9	8.2	6.2	58.0	241.0	19.4	0.4
87	2001	2.7	0.1	4.2	76.3		21.3	
88	2008	3.5	2.2	4.8	20.5		12.4	
89	2018	7.5	0.8	9.6	108.0			
90	2045	35.3	8.2	5.2	38.5		30.2	
91	2055	1.0	9.0				9.0	
92	2056	1.0	0.7	5.5	30.0	78.5	13.3	2.0
93	2057	3.7	2.1	5.7	17.5		11.5	
94	2058	6.3	4.0	7.9	78.0		44.0	
95	2106	12.0	5.0			67.0	26.0	
96	2093	25.0	2.9	7.7	233.0	92.7	310.0	32.0
97	2303	1.1	0.6	9.6	107.0	279.4	12.9	0.8
98	2304	3.3	1.9	1.9	108.0	176.0	67.4	1.0
99	2309	5.4	3.4	4.4	24.0	107.0	25.5	4.0
100	2310	0.0	0.1	1.5	27.0		35.0	
101	2323	1.0	0.1	7.8	433.0		702.0	
102	2324	10.0	2.0	3.0	9.0		9.0	
103	2326	0.6	0.2	2.6	41.0	90.0	17.3	2.0
104	2328	2.0	6.1	3.8	68.0	73.5	28.0	12.0
105	2329	7.0	6.7	1.1	262.0		8.5	
106	2330	6.0	2.4	5.5	20.9	53.7	23.4	5.0
107	2331	5.9	2.7	5.3	19.9	55.5	17.7	4.5
108	2342	8.3	6.0	4.2	19.1	75.3	20.5	4.6
109	2343	4.6	1.6	3.0	13.0	42.7	10.0	2.3
110	2344	2.8	1.5	5.0	9.6	34.0	7.1	2.5
111	2362	6.7	3.2	5.1	28.0	96.3	16.9	3.4
112	2372	7.8	4.5	6.1	79.5	200.5	30.3	
113	2380	0.2	0.1	4.1	55.8		12.4	
114	2393	5.2	4.5	5.2	33.0	100.1	19.6	2.5
115	2407	0.5	0.2	7.7	83.5		106.5	10.0
116	2426	0.2	2.5	2.1	8.8		28.0	
117	2442	3.8	1.9	4.9	14.3		3.5	
118	2443	13.4	3.8	4.5	25.4		7.1	
119	2444	22.2	8.2	4.3	28.0		25.0	
120	2452	4.6	1.8	5.5	38.0	100.0	24.6	
121	2458	2.2	0.3	0.8	50.3		8.6	
122	2459	0.6	0.1	14.8	340.4	348.0	361.6	
123	2542	4.2	2.7	3.7	28.0		40.3	
124	2543	6.3	6.0	2.4	17.6		7.7	
125	2551	4.5	1.1	29.0	9.7		3.5	
126	2552	3.4	1.6	3.8	18.0		11.0	
127	2553	16.3	9.5	12.0	85.9		14.0	
128	2555	10.1	5.1	9.0	20.7		12.4	

Western Bay of Plenty Groundwater Quality Data Summary[1,2]								
		Major Cations				Major Anions		
ID	EBOP Well Number	Ca	Mg	K	Na	HCO_3	Cl	SO_4
129	2556	4.5	5.2	3.1	21.6		16.0	
130	2557	2.1	1.2	4.2	10.3		7.1	
131	2558	11.8	4.5	7.4	18.7		8.9	
132	2561	5.8	4.4	4.2	19.3		10.6	
133	2570	6.0	6.4	7.0	24.1	*	21.3	
134	2571	6.5	3.8	3.8	18.8		14.0	
135	2578	7.1	3.7	3.2	13.9		10.6	
136	2580	1.8	1.1	22.4	16.6		83.0	
137	2581	6.2	2.4	6.4	13.2		10.6	
138	2590	14.4	3.6	7.7	21.4		17.7	
139	2592	3.9	1.0	2.2	7.6		18.9	
140	2595	5.9	2.7	9.4	25.5		35.6	
141	2596	0.1	0.5	3.9	7.4		8.9	
142	2600	3.0	1.0	3.0	11.0		7.0	
143	2612	0.7	1.1	0.2	8.0		16.4	
144	2707	81.5	14.8	5.3	66.8	157.4	170.0	48.6
145	2729	8.6	4.6	3.6	22.0	82.0	16.8	3.9
146	2822	7.9	7.7	4.2	49.5	178.1	19.8	0.6
147	2827			2.0	14.0		14.0	
148	2829	0.4	0.3	3.9	47.5	103.5	18.6	4.0
149	2832	30.0	5.0			58.0	20.0	
150	2838	0.3	0.1	11.7	139.5		85.0	22.0
151	2847	18.5	7.5	7.8	29.6	59.8	55.0	24.0
152	3002	4.0	6.0	2.0	21.0		18.0	
153	3004	4.4	1.8	2.3	16.0		10.0	
154	3008	0.5	0.3	1.8	5.5		28.0	
155	3013	4.4	4.9	7.7	28.0		57.0	11.0
156	3015	3.5	3.5				25.0	
157	3034	2.8	1.4	7.1	47.5	65.5	20.3	20.0
158	3044	12.2	7.3	12.6	260.0	255.0	398.5	0.3
159	3045	12.8	5.6	9.4	23.0	67.0	36.0	8.4
160	3272	546.0	616.0	267.0	4,460.0	100.5	9,790.0	995.0
161	3287	8.0	5.0			23.0	19.0	
162	3460	13.6	7.4	35.0	265.0		227.0	
163	3464	2.6	1.4	2.0	103.4		56.7	
164	3566	7.1	3.3	7.1	15.8	34.0	15.7	4.0
165	4011	1.8	1.5	3.5	72.2		14.2	
166	4132	0.0	0.0	2.1	44.2		28.4	
167	4261	1.6	3.4	3.2	20.7		17.7	
168	4364	9.6	6.9	6.9	154.0	136.0	198.0	0.3
169	4582	8.3	4.9	4.1	23.5	83.4	22.3	4.0
170	4677	0.8	1.2	3.8	11.1		24.8	
171	4968	7.5	3.3	3.5	18.5	25.9	20.1	6.3
Min		0.0	0.0	0.2	2.0	22.0	3.5	0.3
Median		3.9	2.5	4.2	25.5	96.3	21.1	4.0
Mean		9.5	7.0	9.5	77.9	120.5	100.6	23.3
Max		546.0	616.0	363.0	4,460.0	348.0	9,790.0	995.0
Stdev		42.9	47.4	35.1	354.0	79.3	757.4	130.1
Count		168	168	161	162	65	168	58
Fraction		0.98	0.98	0.94	0.95	0.38	0.98	0.34

1. *ID is the well ID assigned in this report for the analysis of groundwater chemistry. Data source indicates origin of data (a means original catchment data, b means NERMN data, c means NGMP data). Coordinates are easting and northing New Zealand Map Grid. "Sam" is number of samples involved. "Date" is time frame well sampled. Variables concentrations are calculated median values for all available data of any given well. "Cond" is conductivity in units of uS/cm. "Entero" and "FC" are enterococcus and faecal coliform bacteria in units of MPN/100 mL. pH is in standard units. "Temp" is temperature in units of °C. Units for other variables are mg/L.*

2. *Statistics are calculated minimum (Min), median, mean, and maximum (Max) values and standard deviation (Stdev). "Count" means number of data points out of 167 maximum wells. "Fraction" is fraction of wells with data for the variable of concern (e.g., median conductivity data is available for 95% of the 172 wells but DO data is only available for 19% of the wells.*

APPENDIX 5 GROUNDWATER CHEMISTRY DATA, OTHER ELEMENTS

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
		Other Elements																	
ID	EBOP Well Number	Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Tant	Zn
1	66	0.005	0.033	1.560		0.000		0.000	0.001	0.350	0.017	0.001		0.065			0.001	240.000	0.138
2	68	0.002	0.003	0.019		0.000	0.000	0.003	0.000	0.110	0.018	0.000	0.022	0.000	0.000	0.000	0.001	63.000	0.058
3	70			0.350					0.080		0.350			0.010				60.000	0.650
4	71													0.050				220.000	0.050
5	76								0.100		0.100			0.100				120.000	0.100
6	77			0.100					0.008		0.042			0.016				100.000	0.030
7	86			0.190							0.205							242.000	
8	90			0.560							1.455			0.020				106.500	0.020
9	94									0.330									
10	303			0.100							6.100							75.000	
11	410	0.0015	0.0030	0.0415		0.0002	0.0008	0.0003	0.0003	0.2800	0.2850	0.0006	0.0293	5.0900	0.0012	0.0003	0.0005		0.3690
12	413			0.470					0.100		3.400			0.350				280.000	0.600
13	432								0.020		0.040			0.010				60.000	0.220
14	552			0.350							1.730			0.150				130.000	0.335
15	556			0.010					0.010		0.090			0.100				34.000	0.020
16	604			0.050					0.055		0.390			0.540				179.000	0.060
17	643	0.0070	0.0296	0.1490		0.0000	0.0008	0.0002	0.0032	0.3300	8.7550	0.0000	0.1630	12.7000	0.0012	0.0005	0.0005		0.0027
18	647			0.080							2.300							68.000	
19	649			0.050							0.040							46.000	
20	837										0.100			0.070				32.600	0.310
21	840			0.110							1.135							49.000	
22	851	0.002	0.001	0.013		0.000	0.000	0.000	0.000	0.090	5.780	0.000	0.006	0.160	0.000	0.001	0.001	78.000	0.043
23	951	0.002	0.010	0.183		0.000	0.000	0.000	0.000	0.260	1.010	0.000	0.126	1.730	0.001	0.000	0.001	243.000	0.011
24	955			0.060					0.010		0.245			0.050				74.000	0.200
25	956			0.130							0.100							69.000	
26	1018	0.002	0.001	0.505		0.000	0.000	0.000	0.000	0.350	1.800	0.000	0.222	0.274	0.001	0.000	0.001		0.128
27	1019			0.850					0.020		0.440			0.070				128.000	1.080
28	1072			0.060							1.100			0.050				90.500	0.300
29	1074			0.250														158.000	
30	1077			0.270					0.070		0.050							100.000	0.300
31	1079			0.150														40.000	
32	1081			0.150							0.050			0.020				70.000	
33	1084			0.140							0.040			0.040				70.000	0.070
34	1085			0.100					0.020		0.410			0.010				80.000	
35	1087			0.100					0.020		0.150			0.050				60.000	0.140
36	1092			0.500					0.010					0.020				140.000	0.490
37	1094			0.160					0.020		0.870							60.000	0.090
38	1095			0.100					0.010		0.080			0.010				24.000	0.085
39	1107			0.130							0.060							86.000	
40	1111			0.240					0.100		0.100			0.100				40.000	0.140
41	1114			1.500					0.010		1.310			0.115				169.500	0.350
42	1115			0.340							0.930							211.500	0.715
43	1119																	23.000	
44	1123			9.600							0.600			0.100				250.000	0.010
45	1131			0.160					0.010		0.010			0.010					0.060

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
		Other Elements																	
ID	EBOP Well Number	Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Tant	Zn
46	1138			0.290					0.020		21.000			30.000				141.000	5.050
47	1304			0.100					0.010		0.870			0.135				51.000	0.135
48	1325			0.080							2.040							88.000	
49	1354			0.100							0.370			0.020				55.000	0.220
50	1359			0.100							0.570			0.020				76.000	
51	1360			0.010							0.010							20.000	0.010
52	1371								0.100		0.330			0.100				50.000	0.100
53	1374										0.920			0.160				62.000	
54	1376			0.100										0.160				80.000	0.230
55	1384			0.100					0.470		0.100							17.000	0.070
56	2728	0.002	0.010	0.101	ND	0.000	0.000	0.000	0.000	0.135	7.730	0.000	0.011	0.220	0.001	0.000	0.001		0.130
57	1393	0.026	0.010	0.056		0.000	0.000	0.000	0.001	0.350	0.020	0.000	0.042	0.004	0.002	0.000	0.001		0.039
58	1436			0.730					0.010		0.010			0.010				28.000	0.010
59	1445			2.400							0.120							134.000	
60	1448			0.180					0.010		0.050			0.010				22.000	0.310
61	1449			0.080							0.450							26.000	0.150
62	1463			0.800					0.010		2.910			0.040				86.000	0.020
63	1469			0.160							0.020			0.020				80.000	0.010
64	1470			0.120					0.001		0.050			0.060				48.000	0.040
65	1471			0.170					0.001		0.040			0.030				30.000	0.040
66	1472			0.080							0.004			0.006				88.000	
67	1473			0.040					0.010		0.160			0.040				94.000	0.010
68	1474			0.020							1.700			0.045				36.000	0.017
69	1475			0.310							1.190			0.001				40.000	0.006
70	1501			0.100					0.030		1.600			2.900				27.000	0.530
71	1510			0.085					1.540		7.200			0.580				48.000	4.410
72	1516								0.020		0.030			0.030				50.000	0.490
73	1520	0.002	0.001	0.231		0.000	0.000	0.000	0.000	0.150	0.010	0.000	0.037	0.000	0.000	0.000	0.001		0.024
74	1535			0.100					0.010		3.250			0.570				70.000	0.170
75	1555			1.220							6.300							162.000	
76	1566																		0.560
77	1569			0.060							0.055							50.500	
78	1570			0.070					0.070		1.770			0.145				69.000	2.300
79	1577			0.115					0.010		0.330			0.030				146.500	4.000
80	1586	0.002	0.001	0.016		0.000	0.000	0.000	0.000	0.135	0.022	0.000	0.003	0.184	0.001	0.000	0.001		0.080
81	1652										3.350							257.000	
82	1665													0.030				100.000	0.260
83	1677								0.100		0.050			0.020				65.000	0.020
84	1684			0.500					0.058		0.300			0.040				100.000	0.137
85	1686	0.580	0.019	0.498		0.000	0.000	0.000	0.001	0.590	0.620	0.002	0.097	0.045	0.010	0.000	0.001		0.029
86	1690	0.002	0.001	0.220		0.000	0.000	0.000	0.000	0.350	1.015	0.000	0.115	0.592	0.001	0.001	0.001	215.000	0.016
87	2001			0.540					0.010		0.300			0.030				146.000	0.090
88	2008			0.090					0.010		0.330			0.010				50.000	0.010
89	2018			0.710					0.010		9.830			0.290				98.000	0.010
90	2045			0.045					0.045		0.016			0.050				106.500	0.050
91	2055										0.200							66.000	

Western Bay of Plenty Groundwater Quality Data Summary[1,2]

ID	EBOP Well Number	Other Elements																	
		Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Tant	Zn
92	2056			0.100					0.010		0.050			0.010				66.000	
93	2057			0.010					0.010		0.035			0.010				30.000	0.015
94	2058			2.200					0.020		3.000			0.230				151.000	0.020
95	2106			0.500							1.200							68.000	
96	2093	0.002	0.022	0.056		0.000	0.000	0.000	0.001	0.065	0.025	0.001	0.003	0.003	0.001	0.001	0.001		0.003
97	2303	0.122	0.034	0.086		0.000	0.000	0.000	0.002	0.535	0.120	0.000	0.112	0.075	0.001	0.001	0.001	212.000	0.011
98	2304			1.300							0.100							144.000	
99	2309			0.090							14.700							88.000	
100	2310			0.160					0.010		0.300							110.000	0.010
101	2323													0.030				240.000	0.150
102	2324								0.250		0.110			0.010				36.000	0.880
103	2326			0.090							0.060			0.200				74.000	
104	2328			0.500					0.010		0.200			0.435				94.000	0.190
105	2329			0.010					0.020		1.115			0.060				84.000	0.090
106	2330	0.010	0.001	0.016		0.000	0.000	0.002	0.001	0.060	0.040	0.000	0.005	0.001	0.000	0.000	0.001		0.125
107	2331			0.010					0.010		0.280			0.010				43.000	0.110
108	2342	0.002	0.001	0.020		0.000	0.000	0.000	0.000	0.075	0.010	0.000	0.013	0.001	0.000	0.000	0.001		0.033
109	2343	0.002	0.001	0.013		0.000	0.000	0.000	0.000	0.060	0.018	0.000	0.008	0.000	0.000	0.001	0.001		0.278
110	2344	0.025	0.001	0.011		0.000	0.000	0.000	0.001	0.075	0.025	0.000	0.007	0.002	0.000	0.000	0.001		0.023
111	2362	0.002	0.004	0.078		0.000	0.000	0.000	0.000	0.220	0.220	0.000	0.039	0.551	0.001	0.000	0.001	120.000	0.295
112	2372			1.160							8.650							164.500	
113	2380			0.010					0.010		0.010			0.010				128.000	0.010
114	2393	0.002	0.004	0.149		0.000	0.000	0.000	0.000	0.230	0.025	0.000	0.053	0.000	0.002	0.001	0.001		0.063
115	2407			0.900					0.100		4.000			0.100				155.000	0.100
116	2426			0.100							0.030			0.010				60.000	0.040
117	2442			0.080							0.170			0.040				4.000	0.030
118	2443										1.000			0.200				36.000	0.030
119	2444			0.080							2.100			0.230				40.000	
120	2452			0.425					0.020		0.100			0.120				81.500	0.580
121	2458			0.100					0.020		0.320			0.045				98.500	0.115
122	2459			1.860							0.100			0.050				285.000	0.050
123	2542			0.010					0.040		0.015			0.020				113.000	0.080
124	2543			0.010					0.015		0.030			0.015				81.500	1.105
125	2551			0.310							0.090							24.000	0.280
126	2552			0.030							0.010							22.000	0.100
127	2553			0.360							0.370			1.820				244.000	0.300
128	2555			0.150					0.010		0.080			0.540				73.000	0.060
129	2556			0.210					0.030		6.000			0.010				61.000	0.100
130	2557			0.060					0.020		0.220			0.001				22.000	0.115
131	2558			0.240					0.020		0.860			0.030				12.000	0.120
132	2561			0.470					0.040		4.300			0.100				65.000	0.890
133	2570			0.050					0.010		0.070			0.130				56.000	0.040
134	2571			0.150					0.100		0.740			2.230				66.000	0.100
135	2578			0.040					0.010		0.080			0.010				42.000	0.010
136	2580			0.960					0.010		0.050			0.010				87.000	0.140
137	2581			0.150					0.010		1.280			0.010				34.000	0.570

Western Bay of Plenty Groundwater Quality Data Summary[1,2]																			
		Other Elements																	
ID	EBOP Well Number	Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Tant	Zn
138	2590			0.030					0.010		0.030			0.010				30.000	0.010
139	2592			8.900					0.050		0.200			0.350				16.000	0.010
140	2595			19.500					0.020		0.040			0.080				34.000	0.010
141	2596			0.020					0.010		0.040			0.010				10.000	0.080
142	2600			0.140					0.010		0.570			0.040				24.000	0.040
143	2612			20.000					0.100		6.200			27.000				100.000	4.900
144	2707	0.002	0.001	0.033		0.000	0.000	0.000	0.000	0.027	0.010	0.000	0.006	0.027	0.000	0.001	0.003		0.011
145	2729	0.002	0.001	0.016		0.000		0.000	0.002	0.210	0.070	0.000		0.002			0.001		
146	2822	0.0015	0.0035	0.2170		0.0000	0.0006	0.0003	0.0003	0.3850	4.6600	0.0000	0.1930	0.9490	0.0003	0.0003	0.0005		0.0146
147	2827										0.900								0.500
148	2829	0.078	0.014	0.129		0.000	0.000	0.000	0.001	0.190	0.310	0.001	0.011	0.020	0.002	0.001	0.001	63.000	0.021
149	2832			0.100														59.000	
150	2838			0.400					0.070		0.305			0.040				430.000	0.040
151	2847	0.294	0.001	0.059		0.000	0.000	0.000	0.001	0.080	6.825	0.000	0.001	0.175	0.000	0.001	0.001		0.074
152	3002								0.010									24.000	0.030
153	3004			0.100					0.220		0.050			0.020				46.000	0.220
154	3008			0.100					0.010		0.130							20.000	0.010
155	3013								0.100		0.100			0.100				60.000	0.100
156	3015																	73.000	
157	3034	0.007	0.001	0.146		0.000	0.000	0.000	0.000	0.160	0.010	0.000	0.005	0.001	0.001	0.000	0.001		0.002
158	3044	0.004	0.023	9.510	0.380	0.000	0.000	0.000	0.001	1.050	0.370	0.000	0.744	0.282	0.005	0.000	0.001		0.003
159	3045	0.002	0.001	0.009	0.060	0.000	0.000	0.000	0.002	0.130	0.027	0.001	0.006	0.015	0.000	0.001	0.001		0.043
160	3272	0.007	0.001	0.857			0.001	0.002	0.003	0.070	4.300	0.001	1.430	5.400	0.003	0.002			0.040
161	3287										0.050							24.000	
162	3460			1.650					0.010		0.010			0.020				82.000	0.220
163	3464			0.880					0.010		0.050			0.010				84.000	0.010
164	3566	0.0085	0.0010	0.0180		0.0000	0.0001	0.0003	0.0005	0.1850	0.0250	0.0000	0.0072	0.0009	0.0004	0.0003	ND		0.0240
165	4011			0.060					0.112		0.283			0.004					0.030
166	4132										0.040			0.010					0.020
167	4261			1.000							0.170			0.130				60.000	0.300
168	4364	0.002	0.007	2.850	0.605	0.000	0.000	0.000	0.000	0.460	0.410	0.000	0.242	0.530	0.002	0.001	0.001		0.002
169	4582	0.002	0.001	0.020		0.000	0.000	0.000	0.000	0.100	0.030	0.000	0.018	0.004	0.000	0.001	0.001		0.399
170	4677								0.010		0.170							50.000	0.100
171	4968	0.0060	0.0040	0.0620		0.0000	0.0001	0.0003	0.0003	0.1300	0.0400	0.0000	0.0137	0.0010	ND	0.0003	0.0005		0.0400
Min		0.002	0.001	0.009	0.060	0.000	0.000	0.000	0.000	0.027	0.004	0.000	0.001	0.000	0.000	0.000	0.001	4.000	0.002
Median		0.002	0.002	0.115	0.380	0.000	0.000	0.000	0.010	0.185	0.200	0.000	0.020	0.040	0.001	0.000	0.001	70.000	0.080
Mean		0.036	0.007	0.753	0.348	0.000	0.000	0.000	0.043	0.237	1.251	0.000	0.118	0.762	0.001	0.000	0.001	89.583	0.301
Max		0.580	0.034	20.000	0.605	0.000	0.001	0.003	1.540	1.050	21.000	0.002	1.430	30.000	0.010	0.002	0.003	430.000	5.050
Stdev		0.110	0.010	2.623	0.274	0.000	0.000	0.001	0.154	0.201	2.742	0.000	0.277	3.685	0.002	0.000	0.000	69.248	0.798
Count		34	34	147	3	33	32	34	113	35	158	34	32	133	31	32	32	139	138
Fraction		0.20	0.20	0.86	0.02	0.19	0.19	0.20	0.66	0.20	0.92	0.20	0.19	0.78	0.18	0.19	0.19	0.81	0.81

1. *ID is the well ID assigned in this report for the analysis of groundwater chemistry. Data source indicates origin of data (a means original catchment data, b means NERMN data, c means NGMP data). Coordinates are easting and northing New Zealand Map Grid. "Sam" is number of samples involved. "Date" is time frame well sampled. Variables concentrations are calculated median values for all available data of any given well. "Cond" is conductivity in units of uS/cm. "Entero" and "FC" are enterococcus and faecal coliform bacteria in units of MPN/100 mL. pH is in standard units. "Temp" is temperature in units of °C. Units for other variables are mg/L.*

2. *Statistics are calculated minimum (Min), median, mean, and maximum (Max) values and standard deviation (Stdev). "Count" means number of data points out of 167 maximum wells. "Fraction" is fraction of wells with data for the variable of concern (e.g., median conductivity data is available for 95% of the 172 wells but DO data is only available for 19% of the wells.*

APPENDIX 6 GROUNDWATER CHEMISTRY, WELLS WITH COMPLETE ANALYSIS OF EIGHT MAJOR IONS

Western Bay of Plenty Major Ion Data[1]																					
		EBOP	NZMG Coordinates				Other Variables			Cations					Anions					Calculated	Type
Order	ID	well number	Easting	Northing	Sam	Date	Cond	pH	TDS	Ca	Fe	Mg	K	Na	HCO3	Cl	NO_3-N	SO4	CBE	TDS	Water
1	1	66	2771800	6392300	7	79-96	362	7.4	692	2.9	0.02	1.1	5.4	64.3	128.3	37.8	0.013	2.0	-0.64	242	Na-HCO3-Cl
2	2	68	2766700	6402500	14	82-05	148	7.6	119	5.0	0.02	2.3	1.9	22.5	75.6	8.8	0.065	1.8	-2.00	118	Na-HCO3
3	9	94	2780200	6387500	6	91-95	198	7.3		5.1		4.7	3.2	31.0	96.4	16.4	0.561	2.6	-0.82	160	Na-HCO3-Cl
4	11	410	2811200	6367000	7	1994-2005	205	6.80		5.5	0.2850	3.4	3.4	24.0	102.5	10.0	0.004	6.6	-10.95	156	Na-HCO3
5	17	643	2819600	6371600	10	1991-2004	435	6.60		15.9	8.7550	10.2	5.7	59.3	234.9	28.1	0.009	14.4	-6.28	377	Na-HCO3
6	18	647	2771400	6407300	1	9-Mar-88	188	6.5		8.5	2.30	4.5	2.6	23.0	83.0	22.5	0.010	2.0	-4.50	148	Na-Ca-HCO3-Cl
7	19	649	2770700	6405600	1	9-Mar-88	162	6.2		6.3	0.04	2.1	3.8	22.0	56.0	24.8	0.100	3.0	-4.35	118	Na-HCO3-Cl
8	21	840	2769600	6405000	2	83-87	129	6.6		2.8	1.14	2.1	2.4	15.1	60.0	18.4	0.010	5.0	-21.84	107	Na-HCO3-Cl
9	22	851	2768800	6394900	13	87-04	163	6.8	91	6.6	5.78	5.7	4.1	14.9	79.9	10.6	0.002	2.2	-3.21	130	Na-Mg-Ca-HCO3
10	23	951	2810900	6371200	12	81-05	486	6.9	320	28.9	1.01	10.1	2.6	64.0	289.1	21.8	0.001	0.3	-2.25	418	Na-Ca-HCO3
11	26	1018	2812000	6374600	11	91-05	637	6.7		16.2	1.80	11.5	8.8	105.0	346.5	40.5	0.009	0.9	-2.19	531	Na-HCO3
12	39	1107	2770600	6414200	1	10-Mar-88	230	8.8		0.3	0.06	0.3	3.5	50.0	105.0	25.4	0.010	4.0	-4.49	189	Na-HCO3-Cl
13	56	1393	2768600	6404700	11	91-05	165	8.0		0.3	0.02	0.1	2.6	34.9	83.1	9.0	0.036	1.4	-1.16	132	Na-HCO3
14	71	1510	2768600	6399800	3	Feb-Nov 87	184	6.9	139	11.2	7.20	7.6	1.8	18.0	90.0	7.3	0.010	1.0	8.38	144	Na-Mg-Ca-HCO3
15	73	1520	2814700	6373800	10	91-05	313	6.5		8.0	0.01	6.1	7.9	48.6	133.0	26.8	1.782	2.2	3.32	234	Na-HCO3-Cl
16	75	1555	2769900	6406100	1	9-Mar-88	410	6.3		5.5	6.30	3.4	7.3	86.0	198.0	50.9	0.010	2.0	-2.62	359	Na-HCO3-Cl
17	77	1569	2772400	6407200	2	87-88	192	6.1		7.9	0.06	3.8	3.4	23.0	62.0	23.9	0.235	5.5	-0.40	130	Na-Ca-HCO3-Cl
18	80	1586	2804300	6373500	11	91-05	107	6.4		3.1	0.02	2.0	3.5	12.3	35.7	8.6	0.222	5.0	0.45	70	Na-HCO3-Cl
19	85	1686	2777500	6391400	10	91-05	378	7.7		1.3	0.62	1.4	3.8	74.5	114.7	56.0	0.002	5.0	-0.65	257	Na-HCO3-Cl
20	86	1690	2810500	6374700	11	85-05	422	6.9	297	16.9	1.01	8.2	6.2	58.0	241.0	19.4	0.007	0.4	-3.51	351	Na-HCO3
21	92	2056	2767600	6405100	2	85-88	156	8.0	97	1.0	0.05	0.7	5.5	30.0	78.5	13.3	0.260	2.0	-4.74	131	Na-HCO3-Cl
22	96	2093	2791300	6388700	7	91-02	1,198	6.5		25.0	0.03	2.9	7.7	233.0	92.7	310.0	1.760	32.0	3.77	705	Na-Cl
23	97	2303	2770200	6399000	14	80-87	474	7.4	280	1.1	0.12	0.6	9.6	107.0	279.4	12.9	0.002	0.8	0.45	412	Na-HCO3
24	98	2304	2771200	6393500	1	16-Nov-87	455	8.0		3.3	0.10	1.9	1.9	108.0	176.0	67.4	0.010	1.0	2.64	360	Na-HCO3-Cl
25	99	2309	2770100	6406800	1	9-Mar-88	189	6.4		5.4	14.70	3.4	4.4	24.0	107.0	25.5	0.010	4.0	-19.96	188	Na-HCO3-Cl
26	103	2326	2769000	6405500	1	10-Mar-88	177	7.8		0.6	0.06	0.2	2.6	41.0	90.0	17.3	0.360	2.0	-2.92	154	Na-HCO3-Cl
27	104	2328	2766400	6396600	3	83-87	250	7.2	139	2.0	0.20	6.1	3.8	68.0	73.5	28.0	0.010	12.0	23.90	194	Na-HCO3-Cl
28	106	2330	2772800	6405300	11	91-05	178	6.4		6.0	0.04	2.4	5.5	20.9	53.7	23.4	0.075	5.0	-3.10	117	Na-HCO3-Cl
29	107	2331	2772400	6405400	5	87-88	190	6.3	137	5.9	0.28	2.7	5.3	19.9	55.5	17.7	0.035	4.5	0.48	112	Na-HCO3-Cl
30	108	2342	2795800	6382100	11	91-05	197	7.0		8.3	0.01	6.0	4.2	19.1	75.3	20.5	0.116	4.6	-1.70	138	Na-Mg-Ca-HCO3-Cl
31	109	2343	2775400	6390600	11	91-05	106	6.7		4.6	0.02	1.6	3.0	13.0	42.7	10.0	0.083	2.3	-1.36	77	Na-Ca-HCO3-Cl
32	110	2344	2786400	6373500	11	91-05	86	6.1		2.8	0.03	1.5	5.0	9.6	34.0	7.1	0.180	2.5	-0.24	63	Na-HCO3-Cl
33	111	2362	2791500	6384200	12	84-05	210	7.0	164	6.7	0.22	3.2	5.1	28.0	96.3	16.9	0.018	3.4	-4.42	160	Na-HCO3-Cl
34	114	2393	2784400	6385100	8	91-98	228	7.2		5.2	0.03	4.5	5.2	33.0	100.1	19.6	0.198	2.5	-1.13	170	Na-HCO3-Cl
35	144	2707	2807600	6379500	11	91-05	926	7.8		81.5	0.01	14.8	5.3	66.8	157.4	170.0	2.180	48.6	-0.57	547	Ca-Na-Cl-HCO3
36	145	2729	2794100	6382100	6	91-96	193	6.6		8.6	0.07	4.6	3.6	22.0	82.0	16.8	0.117	3.9	-1.18	142	Na-Ca-Mg-HCO3-Cl
37	146	2822	2816200	6368100	11	1991-2005	341	6.60		7.9	4.6600	7.7	4.2	49.5	178.1	19.8	0.005	0.6	-2.97	272	Na-HCO3
38	148	2829	2770650	6414140	13	83-05	230	8.3	114	0.4	0.31	0.3	3.9	47.5	103.5	18.6	0.112	4.0	-2.11	179	Na-HCO3-Cl
39	151	2847	2792400	6388100	12	91-05	232	5.8		18.5	6.83	7.5	7.8	29.6	59.8	55.0	0.010	24.0	-0.07	209	Na-Ca-Mg-Cl-HCO3
40	157	3034	2811900	6374600	11	91-05	292	6.5		2.8	0.01	1.4	7.1	47.5	65.5	20.3	4.895	20.0	7.77	170	Na-HCO3-Cl
41	158	3044	2785700	6383700	15	91-05	1,771	7.4		12.2	0.37	7.3	12.6	260.0	255.0	398.5	0.001	0.3	-9.14	946	Na-Cl-HCO3
42	159	3045	2811000	6374300	36	91-05	261	6.4		12.8	0.03	5.6	9.4	23.0	67.0	36.0	0.560	8.4	0.93	163	Na-Ca-HCO3-Cl
43	160	3272	2794350	6388150	4	97-05	27,300	6.9		546.0	4.30	616.0	267.0	4,460.0	100.5	9,790.0	0.030	995.0	-3.42	16779	Na-Cl
44	164	3566	2816600	6366200	5	1997-2005	185	6.90		7.1	0.0250	3.3	7.1	15.8	34.0	15.7	9.250	4.0	9.61	96	Na-Ca-HCO3-Cl
45	169	4364	2785700	6383680	27	96-05	877	7.5		9.6	0.41	6.9	6.9	154.0	136.0	198.0	0.010	0.3	0.65	512	Na-Cl-HCO3
46	170	4582	2793850	6381050	4	97-05	211	6.8		8.3	0.03	4.9	4.1	23.5	83.4	22.3	0.104	4.0	-3.39	151	Na-Ca-Mg-HCO3-Cl
47	171	4968	2817400	6365100	3	2002-2005	212	6.60		7.5	0.0400	3.3	3.5	18.5	25.9	20.1	5.115	6.3	12.20	90	Na-Ca-Cl-HCO3
			Total Samples		400												Median CBE		-1.36		

1. *ID is the well ID assigned in this report for the analysis of groundwater chemistry. "Sam" indicates number of samples from well in database. "Cond" is conductivity, "Lab TDS" is total dissolved solids as measured and reported by the analytical laboratory, standard chemical abbreviations used for cations and anions, "CBE" is charge balance error calculated ion balance in percent (i.e., sum of cations minus sum of anions divided by the total of the sum of cations plus sum of anions), "Calc TDS" is TDS calculated as the combination of all major ions, and "Type Water" is chemical water type as identified by AquaChem.*

APPENDIX 7 WATER QUALITY STATISTICS FOR WELLS GROUPED BY GEOLOGIC UNIT

Water Quality Statistics for Wells Grouped by Geologic Unit																																				
		Field and Miscellaneous Data						Nutrients					Major Cations				Major Anions			Other Elements																
	Sam	Cond	DO	pH	SiO_2	Temp	TDS	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP	Ca	Mg	K	Na	HCO3	Cl	SO4	Al	As	B	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Tant	Zn
ALL (166 wells)																																				
Min		20	0	5	36	15	11	0.003	0.001	0.001	0.008	0.009	0	0	0	2	22	4	0	0.002	0.001	0.009	0.000	0.000	0.000	0.000	0.027	0.004	0.000	0.001	0.000	0.000	0.000	0.001	4.000	0.002
Median		211	3	7	89	21	138	0.015	0.001	0.036	0.116	0.114	4	2	4	25	92	21	4	0.002	0.001	0.120	0.000	0.000	0.000	0.010	0.172	0.200	0.000	0.018	0.040	0.001	0.000	0.001	70.000	0.080
Mean		484	3	7	86	23	545	0.125	0.002	0.624	0.171	0.134	10	7	10	78	118	101	24	0.035	0.006	0.752	0.000	0.000	0.000	0.042	0.224	1.236	0.000	0.118	0.784	0.001	0.000	0.001	89.578	0.311
Max		27,300	8	25	137	42	39,200	1.590	0.011	9.250	2.000	0.425	546	616	363	4,460	348	9,790	995	0.580	0.033	20.000	0.000	0.001	0.003	1.540	1.050	21.000	0.002	1.430	30.000	0.010	0.002	0.003	430.000	5.050
Stdev		2,177	2	2	21	7	3,599	0.322	0.002	1.544	0.339	0.100	44	48	36	359	79	769	134	0.114	0.009	2.652	0.000	0.000	0.001	0.157	0.199	2.731	0.000	0.290	3.755	0.002	0.000	0.001	68.831	0.814
Count	528	158	30	164	29	36	118	32	29	71	33	32	163	163	156	157	62	163	55	31	31	143	30	29	31	107	32	153	31	29	128	28	29	29	136	132
Fraction		0.92	0.17	0.95	0.17	0.21	0.69	0.19	0.17	0.41	0.19	0.19	0.95	0.95	0.91	0.91	0.36	0.95	0.32	0.18	0.18	0.83	0.17	0.17	0.18	0.62	0.19	0.89	0.18	0.17	0.74	0.16	0.17	0.17	0.79	0.77
Aongatete (41 wells)																																				
Min		35	0	6	71	15	57	0.004	0.001	0.001	0.008	0.009	0	0	0	8	23	4	0	0.002	0.001	0.010	0.000	0.000	0.000	0.000	0.100	0.010	0.000	0.007	0.000	0.000	0.000	0.001	22.000	0.003
Median		250	1	7	87	27	200	0.035	0.001	0.036	0.150	0.159	2	1	4	46	103	25	2	0.004	0.003	0.160	0.000	0.000	0.000	0.010	0.280	0.242	0.000	0.025	0.030	0.001	0.000	0.001	98.000	0.058
Mean		459	2	8	95	27	1,635	0.063	0.001	0.682	0.319	0.141	3	2	15	86	136	80	5	0.014	0.010	1.442	0.000	0.000	0.001	0.017	0.329	1.362	0.000	0.137	2.004	0.002	0.000	0.001	122.697	0.432
Max		3,070	5	9	137	42	39,200	0.191	0.001	9.250	2.000	0.242	16	12	363	560	348	709	22	0.078	0.033	20.000	0.000	0.001	0.003	0.112	1.050	21.000	0.001	0.744	30.000	0.005	0.001	0.001	430.000	5.050
Stdev		603	2	1	22	9	7,109	0.070	0.000	2.106	0.593	0.066	4	3	58	119	99	166	6	0.025	0.012	3.912	0.000	0.000	0.001	0.029	0.288	3.875	0.000	0.255	7.018	0.002	0.000	0.000	87.192	1.191
Count	132	39	6	40	8	9	30	9	8	19	10	9	41	41	38	38	16	40	15	9	9	35	9	8	9	27	9	36	9	8	32	8	8	8	33	33
Fraction		0.95	0.15	0.98	0.20	0.22	0.73	0.22	0.20	0.46	0.24	0.22	1.00	1.00	0.93	0.93	0.39	0.98	0.37	0.22	0.22	0.85	0.22	0.20	0.22	0.66	0.22	0.88	0.22	0.20	0.78	0.20	0.20	0.20	0.80	0.80
Tauranga (76 wells)																																				
Min		94	0	5	36	16	19	0.004	0.001	0.001	0.008	0.015	0	0	1	2	22	6	0	0.002	0.001	0.009	0.000	0.000	0.000	0.000	0.027	0.010	0.000	0.001	0.000	0.000	0.000	0.001	22.000	0.002
Median		230	3	7	88	18	161	0.019	0.001	0.035	0.113	0.156	5	3	5	30	93	24	4	0.002	0.001	0.100	0.000	0.000	0.000	0.010	0.160	0.290	0.000	0.014	0.065	0.001	0.000	0.001	74.000	0.080
Mean		321	3	7	81	20	220	0.141	0.002	0.691	0.121	0.151	9	4	6	50	118	36	7	0.057	0.006	0.586	0.000	0.000	0.000	0.054	0.212	1.393	0.000	0.054	0.418	0.001	0.000	0.001	96.846	0.337
Max		1,550	8	25	115	31	1,085	1.590	0.011	6.000	0.409	0.425	86	15	35	265	307	310	49	0.580	0.030	19.500	0.000	0.001	0.002	1.540	0.590	14.700	0.002	0.193	12.700	0.010	0.001	0.003	280.000	4.410
Stdev		241	2	2	24	5	168	0.378	0.003	1.416	0.105	0.123	15	3	5	51	74	46	10	0.157	0.009	2.386	0.000	0.000	0.000	0.219	0.147	2.597	0.000	0.066	1.710	0.003	0.000	0.001	66.175	0.838
Count	292	72	19	76	15	20	48	17	15	43	17	17	74	74	70	70	39	74	34	16	16	67	16	15	16	49	17	72	16	15	56	14	15	16	61	55
Fraction		0.95	0.25	1.00	0.20	0.26	0.63	0.22	0.20	0.57	0.22	0.22	0.97	0.97	0.92	0.92	0.51	0.97	0.45	0.21	0.21	0.88	0.21	0.20	0.21	0.64	0.22	0.95	0.21	0.20	0.74	0.18	0.20	0.21	0.80	0.72
Waiteariki (38 wells)																																				
Min		20	3	5	67	17	55	0.003	0.001	0.002	0.015	0.018	0	0	1	5	34	4	2	0.002	0.001	0.011	0.000	0.000	0.000	0.000	0.060	0.004	0.000	0.006	0.000	0.000	0.000	0.001	4.000	0.010
Median		165	6	7	90	22	118	0.004	0.001	0.099	0.072	0.071	5	3	4	17	80	13	3	0.002	0.001	0.140	0.000	0.000	0.000	0.010	0.075	0.115	0.000	0.011	0.030	0.000	0.001	0.001	60.000	0.100
Mean		937	6	7	87	26	136	0.175	0.002	0.202	0.067	0.074	20	19	12	141	75	276	168	0.006	0.001	0.250	0.000	0.000	0.001	0.029	0.100	1.026	0.000	0.253	0.394	0.001	0.001	0.001	60.806	0.212
Max		27,300	8	8	97	37	697	1.004	0.005	1.000	0.126	0.134	546	616	267	4,460	101	9,790	995	0.025	0.004	2.400	0.000	0.001	0.002	0.250	0.230	6.100	0.001	1.430	5.400	0.003	0.002	0.001	134.000	0.890
Stdev		4,522	2	1	11	8	115	0.406	0.002	0.331	0.042	0.039	89	101	43	720	27	1,585	405	0.009	0.001	0.448	0.000	0.000	0.001	0.054	0.064	1.870	0.000	0.577	1.127	0.001	0.001	0.000	30.450	0.247
Count	92	36	5	37	6	7	29	6	6	8	6	6	37	37	37	38	7	38	6	6	6	32	5	6	6	24	6	34	6	6	31	6	6	5	31	33
Fraction		0.95	0.13	0.97	0.16	0.18	0.76	0.16	0.16	0.21	0.16	0.16	0.97	0.97	0.97	1.00	0.18	1.00	0.16	0.16	0.16	0.84	0.13	0.16	0.16	0.63	0.16	0.89	0.16	0.16	0.82	0.16	0.16	0.13	0.82	0.87

APPENDIX 8 GROUNDWATER TEMPERATURE DATA

The most valuable Environment Bay of Plenty temperature data are temperature logs (e.g. Babbington well, see following list of temperature measurements) where temperature measurements are made at regular depth intervals in the wells. This data is valuable because it can be reasonably assumed that well water temperatures are equilibrated with the formation temperature.

Other temperature measurements may be made at the ground surface, for example well water temperature may be measured at the ground surface while pumping the well and water may have cooled during the passage up the well. Therefore water temperature at the top of the well may not be the same as water temperature in the formation that supplies water to the well.

Temperature data includes the measurement point elevation, assuming the measurement point is equal to the well depth, for:

- Well 848, assumed elevation of measurement point is -262m
- Well 2668, assumed elevation of measurement point is -83m
- Well 4132, assumed elevation of measurement point is -346m

One well in the dataset has no measurement point depth or well depth and is therefore discarded from the data set used to model temperatures in three dimensions:

- Well 3013 is discarded from the model data set.

Temperature values used to model Western Bay of Plenty groundwater temperatures in three dimensions (Section 3.5.2) are listed in Table A8.1.

Table A8.2 lists wells that have detailed geological logs located within 10 km of Tauranga City. These wells are used to assess geology and groundwater temperatures under the City (Section 3.5.3).

Table A8.1 Temperature measurements in the Western Bay of Plenty used to model groundwater temperatures in three dimensions.

EBOP well number	Owner	Date	Depth below ground level (m)	Temperature (°C)	Ground level (m, amsl)	Elevation (m)	Bore TD (m)
54	Silver Birch Motor Camp	-	308.4	30	0	-308.4	389.4
64	Russell	-	141.85	30	27	-114.85	179.8
66	Sargent Partners	28-Jun-79	409.3	43	1	-408.3	618.7
68	Mawson E W, Hacking J A F, Jackson A W	7-Oct-82	166.4	25.5	36	-130.4	275.8
73	Grayling	-	230.65	30	0	-230.65	274.3
75	NZ Equities Ltd	-	377.95	51	28	-349.95	509
86	Miers M E	8-Jul-82	205.75	30	0	-205.75	262.1
301	Palmer	-	323.1	38	21	-302.1	381
303	Western A A	16-Nov-87	317.1	37	16	-301.1	366
305	Motor Lodge Motel	-	298.55	40	20	-278.55	335
306	Donovan	-	245.35	27	5	-240.35	274.3
307	Owens	-	347.45	43	18	-329.45	457.2
308	Van de Graaf	-	281.9	42	1	-280.9	320
413	Duggan D I (Partnership)	7-Jun-84	68.35	15.8	9	-59.35	77.7
552	Hayman P A	10-Mar-88	135.8	32.8	32	-103.8	164
848	Smart	-		35	0		262
1015	Hill-Rennie	11-May-87	33.75	20.9	5	-28.75	35
1019	Goodyear A & M	19-Jun-86	224.75	17.4	40	-184.75	244
1072	Wells B A (Te Mara Partnership)	16-May-83	45.72	15	14	-31.72	91.44
1074	Roberts K T	8-Dec-87	171.9	20	60	-111.9	195.1
1077	Brown C R & P J	30-Jul-85	147.05	25.1	20	-127.05	170.7
1079	Ferndale Orchard	9-Aug-85	106.65	18.7	160	53.35	115.8
1081	Pirihima Whanau Trust	22-Aug-85	112.02	18.4	14	-98.02	164.6
1114	Chanpego	12-Oct-84	127	30	40	-87	127
1115	Lett G & G	11-Mar-86	404.05	30.9	0	-404.05	579.1
1123	Eagle R	-	359	56	15	-344	436
1360	Poripori Development	21-Apr-86	90.5	18.8	239	148.5	129
1371	Wilberfoss R & J, & Bowden A & J	20-Jan-87	35.8	15.2	19	-16.8	39.6
1393	Babbington	12-Aug-80	37	15	40	3	326.1
1393	Babbington	12-Aug-80	50	15.5	40	-10	326.1
1393	Babbington	12-Aug-80	75	17.5	40	-35	326.1
1393	Babbington	12-Aug-80	100	20	40	-60	326.1
1393	Babbington	12-Aug-80	125	22	40	-85	326.1
1393	Babbington	12-Aug-80	150	24.5	40	-110	326.1
1393	Babbington	12-Aug-80	175	26	40	-135	326.1
1393	Babbington	12-Aug-80	200	27.5	40	-160	326.1
1393	Babbington	12-Aug-80	225	31	40	-185	326.1
1393	Babbington	12-Aug-80	250	33	40	-210	326.1
1393	Babbington	12-Aug-80	275	35.5	40	-235	326.1
1393	Babbington	12-Aug-80	300	38	40	-260	326.1
1393	Babbington	12-Aug-80	325	40.5	40	-285	326.1
1463	Morris Keith	8-May-90	304.8	20.1	20	-284.8	381
1510	Wharawhara Orchard	25-Feb-87	114.75	17.5	6	-108.75	145.7
1516	Smith I	28-Sep-83	112.9	17.2	60	-52.9	156
1659	Bateman G A	22-Mar-83	335.75	47	16	-319.75	390.1
2018	Tauranga City Council	29-Jul-87	458	19	14	-444	521
2045	Mt Maunganui Golf Club	30-Apr-91	30	33.8	5	-25	31
2106	Norfolk Orchard Partnership	10-Feb-86	59.79	33.3	16	-43.79	88.4
2326	Hedger D	10-Mar-88	169.01	16.5	22	-147.01	216.4
2329	Mayston P & J	24-Feb-87	151.32	16.8	20	-131.32	192
2339	Palmer	1-Jan-80	416.05	45	9	-407.05	416.1
2525	Salos Int	5-Apr-76	0	24.8	80	80	262.7
2525	Salos Int	5-Apr-76	25	24.8	80	55	262.7
2525	Salos Int	5-Apr-76	50	22.5	80	30	262.7
2525	Salos Int	5-Apr-76	75	22.8	80	5	262.7
2525	Salos Int	5-Apr-76	100	23	80	-20	262.7
2525	Salos Int	5-Apr-76	125	30.6	80	-45	262.7
2525	Salos Int	5-Apr-76	150	29.8	80	-70	262.7
2525	Salos Int	5-Apr-76	175	32.5	80	-95	262.7
2525	Salos Int	5-Apr-76	200	36	80	-120	262.7
2526	Yendell	1-Jan-80	177.7	39.5	20	-157.7	177.7
2530	Stack Shelf Co.	1-Mar-75	0	16.5	0	0	201.2
2530	Stack Shelf Co.	1-Mar-75	25	19	0	-25	201.2
2530	Stack Shelf Co.	1-Mar-75	50	22.5	0	-50	201.2
2530	Stack Shelf Co.	1-Mar-75	75	25	0	-75	201.2
2530	Stack Shelf Co.	1-Mar-75	100	27.5	0	-100	201.2
2530	Stack Shelf Co.	1-Mar-75	125	31.8	0	-125	201.2
2530	Stack Shelf Co.	1-Mar-75	150	35	0	-150	201.2
2530	Stack Shelf Co.	1-Mar-75	175	39	0	-175	201.2
2530	Stack Shelf Co.	1-Mar-75	200	41	0	-200	201.2
2535	Welcome Bay Hot Pools	1-Jun-76	0	16.7	24	24	239
2535	Welcome Bay Hot Pools	1-Jun-76	25	20	24	-1	239
2535	Welcome Bay Hot Pools	1-Jun-76	50	21	24	-26	239
2535	Welcome Bay Hot Pools	1-Jun-76	75	23	24	-51	239
2535	Welcome Bay Hot Pools	1-Jun-76	100	24	24	-76	239
2535	Welcome Bay Hot Pools	1-Jun-76	125	25.6	24	-101	239
2535	Welcome Bay Hot Pools	1-Jun-76	150	27.5	24	-126	239
2535	Welcome Bay Hot Pools	1-Jun-76	175	29	24	-151	239
2535	Welcome Bay Hot Pools	1-Jun-76	200	31	24	-176	239
2535	Welcome Bay Hot Pools	1-Jun-76	225	33	24	-201	239
2535	Welcome Bay Hot Pools	1-Jun-76	250	35.5	24	-226	239

EBOP well number	Owner	Date	Depth below ground level (m)	Temperature (^{o}C)	Ground level (m, amsl)	Elevation (m)	Bore TD (m)
2543	Rutherford M & M	1-Dec-86	181.375	37.8	37	-144.375	213.4
2590	Plummer B T	9-Jan-92	15.85	18.9	17	1.15	17.37
2595	Partridge B	19-Mar-92	60	19.3	2	-58	67
2668	Tseetham	20-Jan-05		29	15		98
2810	Papamoa Primary School	9-Nov-76	25	21.5	3	-22	157.9
2810	Papamoa Primary School	9-Nov-76	50	27	3	-47	157.9
2810	Papamoa Primary School	9-Nov-76	75	29.5	3	-72	157.9
2810	Papamoa Primary School	9-Nov-76	100	30	3	-97	157.9
2810	Papamoa Primary School	9-Nov-76	125	31	3	-122	157.9
2810	Papamoa Primary School	9-Nov-76	150	30	3	-147	157.9
2832	Stockley M R	3-Nov-87	46.5	19.2	36	-10.5	60
2841	Clougher	2-Jun-76	0	16	14	14	337
2841	Clougher	2-Jun-76	25	17.5	14	-11	337
2841	Clougher	2-Jun-76	50	20	14	-36	337
2841	Clougher	2-Jun-76	75	22	14	-61	337
2841	Clougher	2-Jun-76	100	23	14	-86	337
2841	Clougher	2-Jun-76	125	25	14	-111	337
2841	Clougher	2-Jun-76	150	27.5	14	-136	337
2841	Clougher	2-Jun-76	175	28	14	-161	337
2841	Clougher	2-Jun-76	200	27.8	14	-186	337
2841	Clougher	2-Jun-76	225	28.5	14	-211	337
2841	Clougher	2-Jun-76	250	30	14	-236	337
2841	Clougher	2-Jun-76	275	32.5	14	-261	337
2841	Clougher	2-Jun-76	300	35.6	14	-286	337
2841	Clougher	2-Jun-76	325	39.7	14	-311	337
3013	Weaver	2-Feb-87		18.4	72		
3098	Tauranga Girl's College	-	421.5	42.5	20	-401.5	476
3467	Glenmur Imports Ltd	25-Aug-78	10	20	0	-10	329.2
3467	Glenmur Imports Ltd	25-Aug-78	25	20	0	-25	329.2
3467	Glenmur Imports Ltd	25-Aug-78	50	23	0	-50	329.2
3467	Glenmur Imports Ltd	25-Aug-78	75	26	0	-75	329.2
3467	Glenmur Imports Ltd	25-Aug-78	100	30	0	-100	329.2
3467	Glenmur Imports Ltd	25-Aug-78	125	32.5	0	-125	329.2
3467	Glenmur Imports Ltd	25-Aug-78	150	36	0	-150	329.2
3467	Glenmur Imports Ltd	25-Aug-78	175	39	0	-175	329.2
3467	Glenmur Imports Ltd	25-Aug-78	200	42	0	-200	329.2
3467	Glenmur Imports Ltd	25-Aug-78	225	44.5	0	-225	329.2
3467	Glenmur Imports Ltd	25-Aug-78	250	45	0	-250	329.2
3467	Glenmur Imports Ltd	25-Aug-78	275	50	0	-275	329.2
3467	Glenmur Imports Ltd	25-Aug-78	300	51	0	-300	329.2
3467	Glenmur Imports Ltd	25-Aug-78	325	53	0	-325	329.2
3855	Baijings	25-Oct-00	400.5	46	160	-240.5	487
3875	Devitt	19-Feb-03	305	39	20	-285	305
4132	Clow M O & P J	24-Aug-82		40	20		365.76
4397	Maunder	16-Mar-79	50	18.5	40	-10	115.82
4397	Maunder	16-Mar-79	60	19	40	-20	115.82
4397	Maunder	16-Mar-79	70	19.3	40	-30	115.82
4397	Maunder	16-Mar-79	80	19.7	40	-40	115.82
4397	Maunder	16-Mar-79	90	20.2	40	-50	115.82
4397	Maunder	16-Mar-79	100	20.7	40	-60	115.82
4397	Maunder	16-Mar-79	110	21.5	40	-70	115.82
4397	Maunder	16-Mar-79	116	23	40	-76	115.82
4538	Smith	21-Aug-84	0	12.25	0	0	367.9
4538	Smith	21-Aug-84	30	18	0	-30	367.9
4538	Smith	21-Aug-84	50	21	0	-50	367.9
4538	Smith	21-Aug-84	70	24	0	-70	367.9
4538	Smith	21-Aug-84	100	28	0	-100	367.9
4538	Smith	21-Aug-84	120	31	0	-120	367.9
4538	Smith	21-Aug-84	150	37	0	-150	367.9
4538	Smith	21-Aug-84	180	35	0	-180	367.9
4538	Smith	21-Aug-84	200	39	0	-200	367.9
4538	Smith	21-Aug-84	220	39	0	-220	367.9
4538	Smith	21-Aug-84	250	39	0	-250	367.9
4538	Smith	21-Aug-84	280	42	0	-280	367.9
4538	Smith	21-Aug-84	300	43	0	-300	367.9
4538	Smith	21-Aug-84	330	45	0	-330	367.9
4538	Smith	21-Aug-84	350	45	0	-350	367.9
4538	Smith	21-Aug-84	361	47	0	-361	367.9
4539	Cranston	1-Jan-80	335.3	48	6	-329.3	335.3
4541	Ferrow	1-Jan-80	249.9	43.7	8	-241.9	249.9
4542	McGregor	1-Jun-76	0	14	20	20	213.4
4542	McGregor	1-Jun-76	25	17.5	20	-5	213.4
4542	McGregor	1-Jun-76	50	19.5	20	-30	213.4
4542	McGregor	1-Jun-76	75	22	20	-55	213.4
4542	McGregor	1-Jun-76	100	24.5	20	-80	213.4
4542	McGregor	1-Jun-76	125	27	20	-105	213.4
4542	McGregor	1-Jun-76	150	29.5	20	-130	213.4
4542	McGregor	1-Jun-76	175	32.5	20	-155	213.4
4542	McGregor	1-Jun-76	200	34	20	-180	213.4
4542	McGregor	1-Jun-76	220	36.5	20	-200	213.4
4566	Bundell	2-Nov-76	0	13	1	1	305
4566	Bundell	2-Nov-76	25	16	1	-24	305
4566	Bundell	2-Nov-76	50	18	1	-49	305

EBOP well number	Owner	Date	Depth below ground level (m)	Temperature (^{o}C)	Ground level (m, amsl)	Elevation (m)	Bore TD (m)
4566	Bundell	2-Nov-76	75	21.5	1	-74	305
4566	Bundell	2-Nov-76	100	21.7	1	-99	305
4566	Bundell	2-Nov-76	125	27	1	-124	305
4566	Bundell	2-Nov-76	150	28	1	-149	305
4566	Bundell	2-Nov-76	175	32	1	-174	305
4566	Bundell	2-Nov-76	200	31.5	1	-199	305
4566	Bundell	2-Nov-76	225	37	1	-224	305
4566	Bundell	2-Nov-76	250	40	1	-249	305
4566	Bundell	2-Nov-76	275	41.5	1	-274	305
4566	Bundell	2-Nov-76	300	42.5	1	-299	305
4567	Waler	1-Jan-80	231.6	35	20	-211.6	231.6
4569	Beamont	9-Nov-76	25	17.5	7	-18	304.8
4569	Beamont	9-Nov-76	50	19.5	7	-43	304.8
4569	Beamont	9-Nov-76	75	22	7	-68	304.8
4569	Beamont	9-Nov-76	100	25	7	-93	304.8
4569	Beamont	9-Nov-76	125	27.5	7	-118	304.8
4569	Beamont	9-Nov-76	150	28.5	7	-143	304.8
4569	Beamont	9-Nov-76	175	30	7	-168	304.8
4569	Beamont	9-Nov-76	200	32.5	7	-193	304.8
4569	Beamont	9-Nov-76	225	35	7	-218	304.8
4569	Beamont	9-Nov-76	250	37.5	7	-243	304.8
4569	Beamont	9-Nov-76	275	39.5	7	-268	304.8
4569	Beamont	9-Nov-76	300	42	7	-293	304.8
4570	Munro	20-Dec-76	0	14	1	1	271.3
4570	Munro	20-Dec-76	25	16	1	-24	271.3
4570	Munro	20-Dec-76	50	20	1	-49	271.3
4570	Munro	20-Dec-76	75	22.5	1	-74	271.3
4570	Munro	20-Dec-76	100	26	1	-99	271.3
4570	Munro	20-Dec-76	125	29	1	-124	271.3
4570	Munro	20-Dec-76	150	32.5	1	-149	271.3
4570	Munro	20-Dec-76	175	36	1	-174	271.3
4570	Munro	20-Dec-76	200	39.7	1	-199	271.3
4570	Munro	20-Dec-76	225	41.5	1	-224	271.3
4570	Munro	20-Dec-76	250	47.5	1	-249	271.3
4570	Munro	20-Dec-76	270	48	1	-269	271.3
4575	McTainsch	1-Jan-80	179.5	40	20	-159.5	
4579	Willow Park Motor Hotel	4-Oct-77	25	17.5	0	-25	
4579	Willow Park Motor Hotel	4-Oct-77	50	21	0	-50	
4579	Willow Park Motor Hotel	4-Oct-77	75	25	0	-75	
4579	Willow Park Motor Hotel	4-Oct-77	100	28	0	-100	
4579	Willow Park Motor Hotel	4-Oct-77	125	30	0	-125	
4579	Willow Park Motor Hotel	4-Oct-77	150	32.5	0	-150	
4579	Willow Park Motor Hotel	4-Oct-77	175	35	0	-175	
4579	Willow Park Motor Hotel	4-Oct-77	200	37.5	0	-200	
4579	Willow Park Motor Hotel	4-Oct-77	225	40	0	-225	
4579	Willow Park Motor Hotel	4-Oct-77	250	42.5	0	-250	
4579	Willow Park Motor Hotel	4-Oct-77	275	44	0	-275	
4579	Willow Park Motor Hotel	4-Oct-77	300	44	0	-300	
4579	Willow Park Motor Hotel	4-Oct-77	325	44.5	0	-325	
4579	Willow Park Motor Hotel	4-Oct-77	350	45	0	-350	
4580	Parklyn	4-Oct-77	25	16.5	12	-13	
4580	Parklyn	4-Oct-77	50	22	12	-38	
4580	Parklyn	4-Oct-77	75	27.5	12	-63	
4580	Parklyn	4-Oct-77	100	30	12	-88	
4580	Parklyn	4-Oct-77	125	31.5	12	-113	
4580	Parklyn	4-Oct-77	150	34	12	-138	
4580	Parklyn	4-Oct-77	175	40	12	-163	
4580	Parklyn	4-Oct-77	200	42.5	12	-188	
4580	Parklyn	4-Oct-77	225	42.5	12	-213	
4702	Springhill Orchard	15-May-80	0	15	40	40	36.6
4702	Springhill Orchard	15-May-80	25	16.5	40	15	36.6
4702	Springhill Orchard	15-May-80	50	22	40	-10	36.6
4702	Springhill Orchard	15-May-80	75	25	40	-35	36.6
4702	Springhill Orchard	15-May-80	100	28	40	-60	36.6
4702	Springhill Orchard	15-May-80	125	32	40	-85	36.6
4702	Springhill Orchard	15-May-80	150	35	40	-110	36.6
4702	Springhill Orchard	15-May-80	175	35	40	-135	36.6
4702	Springhill Orchard	15-May-80	200	35	40	-160	36.6
4702	Springhill Orchard	15-May-80	225	35	40	-185	36.6
4702	Springhill Orchard	15-May-80	250	35	40	-210	36.6
4963	Wright S.J.	-	210	27	40	-170	270
4993	Seeka Kiwifruit Ltd	-	100	29	12	-88	108
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	593	32	14	-579	754
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	653	33	14	-639	754
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	676	34	14	-662	754
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	703	30	14	-689	754
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	727	33	14	-713	754
10545	Waihi Beach Top Ten Holiday Park	17-Mar-05	752	34	14	-738	754
1445	Greenfield R A		210	16.5	20	-190	225
1472	Valley Orchard		86	16.6	30	-56	125

Table A8.2 Wells with detailed geological logs within 10km of Tauranga City.

ID	EBOP well Number	Easting	Northing	Estimated depth to top of undifferentiated volcanics (mbgl)	Reference
1	51	2794080	6382070	37.1	EBOP database, 2006
2	52	2780300	6387600	0	EBOP database, 2006
3	54	2789200	6382500	79.3	EBOP database, 2006
4	56	2779710	6388870	21.3	EBOP database, 2006
5	57	2781000	6384800	42.7	EBOP database, 2006
6	59	2782000	6376500	85.6	EBOP database, 2006
7	60	2785600	6376300	54.9	EBOP database, 2006
8	61	2784700	6384100	0	EBOP database, 2006
9	64	2781200	6386000	97.5	EBOP database, 2006
10	67	2790000	6382000	14.6	EBOP database, 2006
11	69	2786500	6388600	146.3	EBOP database, 2006
12	74	2781700	6383900	61.3	EBOP database, 2006
13	76	2791600	6385000	180	EBOP database, 2006
14	77	2793100	6382400	49	EBOP database, 2006
15	80	2785400	6380200	135.9	EBOP database, 2006
16	82	2785300	6374500	76.2	EBOP database, 2006
17	83	2782600	6379000	98.1	EBOP database, 2006
18	88	2792500	6381900	10.7	EBOP database, 2006
19	89	2791700	6389400	0	EBOP database, 2006
20	92	2780200	6387600	121.3	EBOP database, 2006
21	93	2782060	6386890	160	EBOP database, 2006
22	94	2780290	6387570	122.5	EBOP database, 2006
23	95	2781800	6387700	91.4	EBOP database, 2006
24	96	2783900	6382200	75.9	EBOP database, 2006
25	98	2783600	6382200	75.9	EBOP database, 2006
26	100	2785100	6377300	27.4	EBOP database, 2006
27	307	2788900	6383800	0	EBOP database, 2006
28	308	2785400	6387400	0	EBOP database, 2006
29	403	2783100	6379900	0	EBOP database, 2006
30	405	2784500	6375900	2.4	EBOP database, 2006
31	407	2785600	6383900	96	EBOP database, 2006
32	415	2791300	6385100	0	EBOP database, 2006
33	421	2784900	6384600	57.9	EBOP database, 2006
34	422	2791500	6380000	170.7	EBOP database, 2006
35	424	2781200	6387400	128.9	EBOP database, 2006
36	427	2780400	6385800	125	EBOP database, 2006
37	556	2792000	6384800	0	EBOP database, 2006
38	604	2792900	6385500	0	EBOP database, 2006
39	605	2784400	6382400	69	EBOP database, 2006
40	631	2793600	6388200	0	EBOP database, 2006
41	632	2797600	6383100	0	EBOP database, 2006
42	633	2797100	6384500	0	EBOP database, 2006
43	638	2795200	6381900	54	EBOP database, 2006
44	640	2794500	6382000	42	EBOP database, 2006
45	834	2782300	6375900	132.6	EBOP database, 2006
46	836	2779700	6387600	118.9	EBOP database, 2006
47	837	2794300	6386400	0	EBOP database, 2006
48	838	2789000	6379400	18.3	EBOP database, 2006
49	846	2781300	6378600	24.4	EBOP database, 2006
50	926	2784200	6386100	0	EBOP database, 2006
51	1008	2781300	6379400	0	EBOP database, 2006
52	1009	2794000	6388100	0	EBOP database, 2006
53	1010	2793400	6387600	0	EBOP database, 2006
54	1030	2794900	6379100	54	EBOP database, 2006
55	1031	2791200	6378600	90	EBOP database, 2006
56	1035	2792700	6388900	0	EBOP database, 2006
57	1039	2792800	6381400	10	EBOP database, 2006
58	1059	2780000	6385900	115.8	EBOP database, 2006
59	1064	2784600	6378400	91.4	EBOP database, 2006
60	1071	2793000	6382300	40	EBOP database, 2006
61	1078	2792200	6389400	0	EBOP database, 2006
62	1080	2786600	6381900	121.9	EBOP database, 2006
63	1081	2795200	6382200	12.19	EBOP database, 2006
64	1088	2778900	6385200	67.06	EBOP database, 2006
65	1089	2792100	6389400	0	EBOP database, 2006
66	1123	2780400	6387600	154	EBOP database, 2006
67	1128	2791500	6385400	0	EBOP database, 2006
68	1141	2793400	6387200	0	EBOP database, 2006
69	1316	2788000	6375400	10	EBOP database, 2006
70	1356	2783800	6375500	18.3	EBOP database, 2006
71	1362	2785700	6375700	18.2	EBOP database, 2006
72	1363	2785700	6375700	64	EBOP database, 2006
73	1364	2784200	6378100	96	EBOP database, 2006
74	1365	2784500	6378300	97.5	EBOP database, 2006
75	1368	2780100	6387300	136.6	EBOP database, 2006
76	1375	2793100	6381300	3.7	EBOP database, 2006
77	1383	2785400	6379300	88.7	EBOP database, 2006
78	1386	2788310	6382990	148.7	EBOP database, 2006
79	1389	2789500	6377500	18.3	EBOP database, 2006
80	1391	2782300	6376300	130.1	EBOP database, 2006
81	1392	2783500	6384500	9.1	EBOP database, 2006
82	1396	2786200	6380900	0	EBOP database, 2006
83	1399	2786900	6375900	36.6	EBOP database, 2006
84	1436	2786800	6388500	63	EBOP database, 2006
85	1449	2782200	6377200	30	EBOP database, 2006
86	1463	2785000	6387700	103.7	EBOP database, 2006
87	1464	2794200	6382700	36.88	EBOP database, 2006
88	1465	2793000	6388600	0	EBOP database, 2006
89	1466	2791600	6389300	0	EBOP database, 2006

ID	EBOP well Number	Easting	Northing	Estimated depth to top of undifferentiated volcanics (mbgl)	Reference
90	1467	2791600	6389600	0	EBOP database, 2006
91	1468	2785130	6388070	190.3	EBOP database, 2006
92	1470	2794600	6380400	40.23	EBOP database, 2006
93	1472	2795000	6379700	46	EBOP database, 2006
94	1473	2789500	6376300	8	EBOP database, 2006
95	1475	2795200	6377800	7	EBOP database, 2006
96	1476	2785300	6387700	125	EBOP database, 2006
97	1477	2789180	6383930	51.9	EBOP database, 2006
98	1478	2788500	6378500	25	EBOP database, 2006
99	1480	2788000	6388000	219.5	EBOP database, 2006
100	1484	2787820	6388210	100	EBOP database, 2006
101	1488	2789200	6384500	164.6	EBOP database, 2006
102	1489	2788500	6378500	21.9	EBOP database, 2006
103	1492	2788510	6378500	18.29	EBOP database, 2006
104	1494	2786090	6388720	42	EBOP database, 2006
105	1495	2792500	6379500	19.81	EBOP database, 2006
106	1497	2783760	6376170	89	EBOP database, 2006
107	1504	2792300	6390000	0	EBOP database, 2006
108	1507	2791300	6379800	7.6	EBOP database, 2006
109	1515	2781300	6378600	9	EBOP database, 2006
110	1517	2791600	6379700	45	EBOP database, 2006
111	1557	2794300	6386400	0	EBOP database, 2006
112	1559	2791200	6385000	0	EBOP database, 2006
113	1565	2792900	6385500	0	EBOP database, 2006
114	1571	2791500	6389700	0	EBOP database, 2006
115	1572	2795200	6381900	54	EBOP database, 2006
116	1573	2785890	6388540	61	EBOP database, 2006
117	1578	2793600	6388200	0	EBOP database, 2006
118	1579	2795200	6381800	39.6	EBOP database, 2006
119	1604	2785500	6391500	8.2	EBOP database, 2006
120	1656	2784900	6383400	91.4	EBOP database, 2006
121	1657	2783600	6376700	97.5	EBOP database, 2006
122	1659	2779700	6387600	118.9	EBOP database, 2006
123	1661	2778600	6385600	91.4	EBOP database, 2006
124	1662	2780900	6384500	36.6	EBOP database, 2006
125	1663	2779400	6385500	24.4	EBOP database, 2006
126	1665	2779700	6387600	121.9	EBOP database, 2006
127	1668	2794300	6382100	48.8	EBOP database, 2006
128	1669	2794200	6381900	45.7	EBOP database, 2006
129	1670	2796700	6383220	73.2	EBOP database, 2006
130	1671	2797600	6383100	91.4	EBOP database, 2006
131	1672	2781300	6388400	140.2	EBOP database, 2006
132	1673	2785300	6378800	109.7	EBOP database, 2006
133	1674	2781500	6376600	109.7	EBOP database, 2006
134	1678	2778400	6383300	17.1	EBOP database, 2006
135	1679	2782600	6378000	24.4	EBOP database, 2006
136	1681	2792100	6389400	0	EBOP database, 2006
137	1682	2791500	6390300	0	EBOP database, 2006
138	1684	2791900	6384300	136.2	EBOP database, 2006
139	1688	2784900	6379400	3	EBOP database, 2006
140	1693	2785100	6379800	9.1	EBOP database, 2006
141	1695	2784700	6379600	121.9	EBOP database, 2006
142	1697	2783600	6382200	12.2	EBOP database, 2006
143	2001	2789500	6381200	80	EBOP database, 2006
144	2004	2793000	6388600	0	EBOP database, 2006
145	2007	2781500	6378200	27.5	EBOP database, 2006
146	2014	2782700	6387200	190	EBOP database, 2006
147	2018	2788300	6384600	190	EBOP database, 2006
148	2026	2791300	6391800	0	EBOP database, 2006
149	2028	2787700	6388200	40	EBOP database, 2006
150	2029	2784600	6375400	65	EBOP database, 2006
151	2035	2782800	6383500	30	EBOP database, 2006
152	2036	2795000	6386700	0	EBOP database, 2006
153	2037	2795100	6382500	30	EBOP database, 2006
154	2042	2795900	6381900	20	EBOP database, 2006
155	2043	2785290	6380180	125	EBOP database, 2006
156	2045	2793600	6388200	0	EBOP database, 2006
157	2046	2793600	6388200	103	EBOP database, 2006
158	2050	2793600	6387800	0	EBOP database, 2006
159	2301	2788370	6380900	28.04	EBOP database, 2006
160	2305	2791400	6382600	88.39	EBOP database, 2006
161	2306	2787100	6388500	151.2	EBOP database, 2006
162	2307	2784300	6376300	79.2	EBOP database, 2006
163	2313	2789300	6384500	94.49	EBOP database, 2006
164	2318	2787900	6378400	33.53	EBOP database, 2006
165	2321	2779100	6385400	14.63	EBOP database, 2006
166	2322	2787400	6385100	176.8	EBOP database, 2006
167	2323	2780400	6388200	125	EBOP database, 2006
168	2332	2792800	6378300	62.48	EBOP database, 2006
169	2336	2785400	6387700	115.2	EBOP database, 2006
170	2337	2788670	6377830	25.91	EBOP database, 2006
171	2338	2789300	6383000	85.34	EBOP database, 2006
172	2339	2785100	6388000	176.2	EBOP database, 2006
173	2342	2795870	6382190	75.9	EBOP database, 2006
174	2352	2793200	6381200	11.58	EBOP database, 2006
175	2353	2788300	6380000	46.33	EBOP database, 2006
176	2356	2782400	6376900	115.8	EBOP database, 2006
177	2357	2789900	6377000	7.62	EBOP database, 2006
178	2360	2787700	6374100	27.43	EBOP database, 2006
179	2362	2791630	6384220	94.49	EBOP database, 2006

ID	EBOP well Number	Easting	Northing	Estimated depth to top of undifferentiated volcanics (mbgl)	Reference
180	2363	2794100	6382600	75.59	EBOP database, 2006
181	2364	2790000	6376800	10.67	EBOP database, 2006
182	2365	2789100	6379000	21.34	EBOP database, 2006
183	2366	2782900	6378400	63.4	EBOP database, 2006
184	2388	2789100	6378700	21.95	EBOP database, 2006
185	2389	2782700	6379200	102.1	EBOP database, 2006
186	2390	2788100	6379400	48.77	EBOP database, 2006
187	2391	2788200	6379900	73.15	EBOP database, 2006
188	2392	2784990	6385140	102.1	EBOP database, 2006
189	2393	2784480	6385120	125	EBOP database, 2006
190	2396	2779800	6387000	140.8	EBOP database, 2006
191	2397	2780100	6386600	153.9	EBOP database, 2006
192	2398	2779200	6385000	9.1	EBOP database, 2006
193	2399	2779800	6384900	0	EBOP database, 2006
194	2403	2789800	6376500	24	EBOP database, 2006
195	2413	2796500	6382300	38	EBOP database, 2006
196	2415	2796600	6382600	45	EBOP database, 2006
197	2416	2796400	6382100	42	EBOP database, 2006
198	2443	2793500	6379300	27	EBOP database, 2006
199	2455	2783700	6384800	107.9	EBOP database, 2006
200	2457	2784100	6384800	94.49	EBOP database, 2006
201	2526	2786100	6388500	150.9	EBOP database, 2006
202	2527	2785980	6388560	150.9	EBOP database, 2006
203	2532	2786200	6386500	98	EBOP database, 2006
204	2534	2780000	6388700	32.9	EBOP database, 2006
205	2535	2793100	6381300	76.2	EBOP database, 2006
206	2555	2785300	6385500	60	EBOP database, 2006
207	2556	2785600	6379500	15	EBOP database, 2006
208	2558	2795600	6378700	35	EBOP database, 2006
209	2571	2781100	6378700	13.5	EBOP database, 2006
210	2577	2793600	6381500	30	EBOP database, 2006
211	2580	2786500	6388700	80	EBOP database, 2006
212	2581	2791900	6378400	10	EBOP database, 2006
213	2582	2791200	6378800	45	EBOP database, 2006
214	2595	2788450	6388020	0	EBOP database, 2006
215	2600	2790100	6374500	20	EBOP database, 2006
216	2612	2792440	6389980	125	EBOP database, 2006
217	2652	2794640	6382290	131	EBOP database, 2006
218	2654	2785970	6386270	158	EBOP database, 2006
219	2659	2780810	6388300	12	EBOP database, 2006
220	2660	2795910	6379730	243	EBOP database, 2006
221	2663	2779560	6388720	182	EBOP database, 2006
222	2666	2780120	6387170	210	EBOP database, 2006
223	2667	2780830	6387280	140	EBOP database, 2006
224	2670	2782410	6378900	195	EBOP database, 2006
225	2675	2794770	6386750	127	EBOP database, 2006
226	2676	2794790	6386770	127	EBOP database, 2006
227	2677	2781180	6387450	0	EBOP database, 2006
228	2678	2785510	6379750	122	EBOP database, 2006
229	2679	2791540	6379800	5	EBOP database, 2006
230	2683	2793050	6385710	0	EBOP database, 2006
231	2684	2793050	6385710	0	EBOP database, 2006
232	2685	2788870	6383550	115.5	EBOP database, 2006
233	2706	2792760	6389650	120	EBOP database, 2006
234	2729	2794400	6381800	0	EBOP database, 2006
235	2732	2795600	6385400	0	EBOP database, 2006
236	2784	2794800	6381800	0	EBOP database, 2006
237	2793	2782300	6377000	0	EBOP database, 2006
238	2798	2790700	6391600	43	EBOP database, 2006
239	2801	2793500	6388900	128	EBOP database, 2006
240	2842	2791700	6390800	0	EBOP database, 2006
241	2843	2791390	6390910	0	EBOP database, 2006
242	2844	2791200	6390800	0	EBOP database, 2006
243	2845	2792500	6389600	0	EBOP database, 2006
244	2846	2791500	6389300	0	EBOP database, 2006
245	2847	2792370	6387990	0	EBOP database, 2006
246	2848	2791300	6388100	0	EBOP database, 2006
247	2849	2792200	6389300	0	EBOP database, 2006
248	2982	2791100	6389000	0	EBOP database, 2006
249	2983	2784700	6377500	0	EBOP database, 2006
250	3098	2787600	6382900	130	EBOP database, 2006
251	3116	2778900	6383000	28	EBOP database, 2006
252	3125	2792400	6379800	9	EBOP database, 2006
253	3141	2789300	6377500	24	EBOP database, 2006
254	3151	2790500	6382400	0	EBOP database, 2006
255	3273	2794270	6388210	0	EBOP database, 2006
256	3312	2797700	6384600	0	EBOP database, 2006
257	3318	2789800	6387700	0	EBOP database, 2006
258	3322	2791000	6388300	0	EBOP database, 2006
259	3353	2797500	6381900	36	EBOP database, 2006
260	3354	2796600	6381700	6	EBOP database, 2006
261	3355	2791100	6374600	26	EBOP database, 2006
262	3454	2796800	6385400	112.9	EBOP database, 2006
263	3455	2790600	6391600	45	EBOP database, 2006
264	3456	2790600	6391700	40	EBOP database, 2006
265	3457	2790400	6391600	40	EBOP database, 2006
266	3458	2790400	6391700	30	EBOP database, 2006
267	3459	2790500	6391700	40	EBOP database, 2006
268	3467	2788830	6387550	61	EBOP database, 2006
269	3503	2796990	6385200	0	EBOP database, 2006

ID	EBOP well Number	Easting	Northing	Estimated depth to top of undifferentiated volcanics (mbgl)	Reference
270	3508	2784500	6375300	0	EBOP database, 2006
271	3512	2792900	6385100	0	EBOP database, 2006
272	3671	2793500	6387900	0	EBOP database, 2006
273	3673	2793000	6388500	0	EBOP database, 2006
274	3709	2779420	6380350	5.5	EBOP database, 2006
275	3853	2787030	6376040	27.4	EBOP database, 2006
276	3864	2786280	6380920	92	EBOP database, 2006
277	3866	2787050	6388530	138	EBOP database, 2006
278	3869	2787370	6380760	22.25	EBOP database, 2006
279	3870	2787370	6380760	25	EBOP database, 2006
280	3875	2786160	6388420	115	EBOP database, 2006
281	3884	2796520	6382940	158	EBOP database, 2006
282	3885	2787340	6388360	51	EBOP database, 2006
283	3886	2796650	6383260	92	EBOP database, 2006
284	3892	2780810	6388300	142	EBOP database, 2006
285	3895	2787360	6388360	70	EBOP database, 2006
286	3900	2794640	6382290	90.5	EBOP database, 2006
287	4011	2788920	6385290	210	EBOP database, 2006
288	4028	2795200	6386700	0	EBOP database, 2006
289	4055	2781700	6386200	115.9	EBOP database, 2006
290	4271	2785000	6382600	81	EBOP database, 2006
291	4286	2787800	6376900	32	EBOP database, 2006
292	4388	2784700	6384700	0	EBOP database, 2006
293	4389	2796600	6383900	0	EBOP database, 2006
294	4397	2782700	6382800	6.1	EBOP database, 2006
295	4477	2791100	6389900	15	EBOP database, 2006
296	4489	2793800	6382100	91.4	EBOP database, 2006
297	4504	2795500	6381900	0	EBOP database, 2006
298	4514	2789200	6382900	48.8	EBOP database, 2006
299	4520	2794500	6385500	170.7	EBOP database, 2006
300	4529	2788610	6377910	12.2	EBOP database, 2006
301	4538	2792370	6390040	175.3	EBOP database, 2006
302	4539	2787600	6388320	65.5	EBOP database, 2006
303	4540	2785100	6388000	128.6	EBOP database, 2006
304	4541	2786650	6388620	146.3	EBOP database, 2006
305	4566	2793700	6388700	213.3	EBOP database, 2006
306	4567	2785200	6387600	1	EBOP database, 2006
307	4569	2794100	6382400	4.6	EBOP database, 2006
308	4570	2791700	6381600	1.8	EBOP database, 2006
309	4572	2791700	6385200	341.4	EBOP database, 2006
310	4575	2787200	6388300	3	EBOP database, 2006
311	4577	2789170	6385230	201.2	EBOP database, 2006
312	4579	2789600	6386600	6.1	EBOP database, 2006
313	4580	2787100	6388500	79.2	EBOP database, 2006
314	4756	2780400	6384800	0	EBOP database, 2006
315	4880	2778670	6385810	91.4	EBOP database, 2006
316	10012	2785400	6391710	0	EBOP database, 2006
317	10017	2784600	6375600	72	EBOP database, 2006
318	10058	2793100	6388500	0	EBOP database, 2006
319	10061	2778500	6384500	6	EBOP database, 2006
320	10080	2784700	6380100	18	EBOP database, 2006
321	10094	2794700	6385800	0	EBOP database, 2006
322	10095	2795600	6381100	0	EBOP database, 2006
323	10113	2791100	6387900	0	EBOP database, 2006
324	10165	2793000	6387500	0	EBOP database, 2006
325	10182	2791300	6385400	72	EBOP database, 2006
326	10185	2795600	6381100	0	EBOP database, 2006
327	10215	2779990	6380740	6	EBOP database, 2006
328	10375	2785600	6376100	12	EBOP database, 2006
329	10391	2785600	6376100	12	EBOP database, 2006
330	10415	2797300	6383300	22	EBOP database, 2006
331	10496	2793300	6385900	18	EBOP database, 2006
332	10513	2784800	6376900	3	EBOP database, 2006
333	10515	2786900	6378300	36	EBOP database, 2006
334	10516	2782200	6383300	42	EBOP database, 2006
335	10519	2781100	6378500	12	EBOP database, 2006
336	10528	2791300	6389300	0	EBOP database, 2006
337	10536	2797200	6385300	0	EBOP database, 2006
338	10822	2786600	6377600	35	EBOP database, 2006
339	10827	2787100	6375700	25	EBOP database, 2006
340	10839	2794000	6388000	0	EBOP database, 2006
341	10842	2786800	6378100	57	EBOP database, 2006
342	10855	2794000	6388000	0	EBOP database, 2006
343	10859	2781500	6379600	24	EBOP database, 2006
344	10880	2794400	6381900	58	EBOP database, 2006
345	10895	2794200	6382200	36	EBOP database, 2006
346	10898	2794500	6382000	33	EBOP database, 2006
347	Ohourere	2779420	6380348	5	CH2M Beca Ltd, November 2000
348	N	2782276	6384826	122	Groundwater Consultants (N.Z) Ltd, 1984
349	64	2781200	6386000	102	Groundwater Consultants (N.Z) Ltd, 1984
350	52	2780300	6387600	133	Groundwater Consultants (N.Z) Ltd, 1984
351	56	2779710	6388870	144	Groundwater Consultants (N.Z) Ltd, 1984

APPENDIX 9 DIGITAL TERRAIN MODELS

Terrain and Bathymetry

A digital terrain model (DTM) of the EBOP region is derived using Earth Vision software.

A model of the terrain, and the sea bed in the EBOP region, is derived as follows:

1. EBOP file elevation_xyz_35m.dat is a regularised grid of point values at a 35m interval over the terrestrial and marine areas of the EBOP region.
2. This data set contains 34 million values which is beyond the 2.1 million Earth Vision limit for values.
3. Null values are deleted.
4. The file of non-null values is processed to produce 1.9 million data set values by filtering the original data. The x and y intervals of this data are:
    - x interval 35m
    - y interval 70m
5. EV software is used to produce a 2d grid:
    - input data file short1.dat
    - minimum x 2757892.6
    - minimum y 6238159.4
    - maximum x 2961292.6
    - maximum y 6451259.4
    - z range - 1454 to 1707 (2d grid)
    - grid spacing x 100m
    - grid spacing y 100m
    - File name: EBOPr1.2grd
6. EV software is used to produce a z grid:
    - input data file short2.dat
    - minimum and maximum x, y as above
    - z range – 995 to 1661 (2d grid)
    - grid spacing x 50m
    - gird spacing y 50m
    - File name: EBOPr2.2grd

Terrain

The 20m contour data of the New Zealand map grid is gridded in the area:

- minimum x 2750000
- minimum y 6339950
- maximum x 2819950
- maximum y 6430050
- grid spacingx 100m
- grid spacingy 100m
- File name: tgadtm1.2grd

This model has sea level = 0m

New Zealand map grid data is gridded with:

- minimum x 2749950
- minimum y 6339950
- maximum x 2819950
- maximum y 6430050
- grid spacingx 100m
- grid spacingy 100m
- File name: taurangadtm1.2grd

This model has sea level = 0m and sea level = -9999. Sea level = -9999m where, it is presumed, the data is outside the bound of New Zealand map grid.

APPENDIX 10 WESTERN BAY OF PLENTY GEOLOGICAL MODEL DATASETS WITH A 500 M GRID GEOLOGICAL MODEL

10.1 Layer thickness

Unit name	Thickness data name	Thickness grid name
Tauranga sediments	TGA-thick.dat	TGA_thicksmooth5.2grd
Mamaku Ignimbrite	Mamaku.dat	mam7_smooth.2grd
Waimakariri Ignimbrite	Waimak.dat	Waimak2_smooth.2grd
Waiteariki Ignimbrite	Waite1.dat	Waite2_smooth.2grd
Aongatete Ignimbrite	Aongatete.dat	Aongatete_smooth.2grd

10.2 Polygon files

File Name	Description
bound.ply	boundary of model area.
TGA.ply	Tauranga sediments in model area.
TGA1.ply	Tauranga sediments in whole grid area.
Mamaku1.ply	Mamaku outcrop in model area.
Waimak2.ply	Waimakariri outcrop and subsurface extent in model area.
Waite2.ply	Waiteariki outcrop in whole grid area – note this is a concatenation of other polygon files.
Minden_Otawa.ply	Minden Rhyolite and Otawa Volcanics. Note two rhyolite outcrops in Mamaku Ignimbrite (Briggs et al. 2005) are included in this polygon but are not included in the geological map (Figure 2.1).
Coromandel.ply	Andesite-Kaimai Subgroup and dacite exposed on the Kaimai Range (Figure 2.1).

10.3 Elevation grids to build geological model on 500 m grid

dtm500.2grd	Elevation on a 500 m grid with sea level = 0.
tga_topo5.2grd	Area within TGA1.ply set to ground elevation +100 m. Area outside TGA1.ply stepped down to –1000 m.
mam_top3.2grd	Area within Mamaku1.ply set to ground elevation +100 m. Area outside Mamaku1.ply set to -900 m.
Waimak_top7.2grd	• set to 2x elevation for area where Waimakariri exposed; • set to mam7.2grd-Waimak2.smooth.2grd where under the Mamaku Ignimbrite; mam7.2grd is a smoothed DTM; • stepped down to -900 m; • set to -900 m (mostly) outside Waimak2.ply.
Waite_top11.2grd	• set to 2x elevation for area where Waiteariki exposed; • set to 0 m inside Minden_Otawa.ply; • set to dtm-Tauranga where Tauranga is over Waiteariki; • set to dtm-Mamaku where Mamaku is over Waiteariki; • set to dtm-Waimakariri where Waimakariri is over Waiteariki;

	• set to dtm-Mamaku-Waimakariri where Mamaku and Waimakariri are over Waitearikі; • set to -1000 m outside the 20 m thickness contour; • stepped down to -1000 m on the South East area.
Minden_Otawa_top4.2grd	• set to elevation +300 m inside Minden_Otawa.ply; • set to -800 m and -1000 m mostly outside Minden-Otawa.ply; • outside of domes to be stepped.
Aong_top1.2grd	• set to top of Waiteariki – thickness of Waiteariki. Note the grid file used for the Waiteariki base is an early version; • set to 2x elevation in the area of Coromandel.ply.
Aong_base3.2grd	• this is the top of the Kaimai Subgroup; • set to Aongatete top – thickness of the Aongatete; • set to 2x elevation in the area of Coromandel.ply.

10.4 Model generation

tgamodel1.seq	• sequence file for the model; • all layers are depositional except: Aong_top1.2grd unconformity

tgamodel7.faces is generated by this sequence file.
tgamodel8.unsliced faces is tgamodel7.unsliced.faces cut by dtm500.2grd.
tgamodel9.unsliced faces is tgamodel8.unsliced.faces cut by bound.ply.

APPENDIX 11 WESTERN BAY OF PLENTY GEOLOGICAL MODEL DATASETS WITH A 100 M GRID GEOLOGICAL MODEL

This 100m grid geological model is built from the 500m grid geological model. Modifications are incorporated to the grids generated for the 500m grid geological model. Major modifications concern the portion of grids corresponding to geological layer outcrops.

11.1 Layer thicknesses

Layer thickness files are identical to the ones described in Appendix 10.

11.2 Polygon files

Polygon files are identical to the ones described in Appendix 10, with the addition of the following polygon files:

File name	Description
Waimak_outcrop.ply	Waimakariri outcrop in model area
Waite_outcrop.ply	Waiteariki outcrop in model area
Waite_outcrop_dome.ply	hole in Waiteariki outcrop, where a rhyolite dome outcrops

11.3 Elevation grids to build geological model on 100m grid

File name	Description
dtm100.2grd	Elevation on a 100m grid with sea level=0
tga_top11.2grd	Area within TGA1.ply set to ground elevation + 100m. Area outside TGA1.ply set as tga_top5.2grd
dtm100inmam3.2grd	Area within Mamaku1.ply set to ground elevation + 1000m. Area outside Mamaku1.ply set to -900m
Waimak_top10.2grd	Area within Waimak_outcrop.ply set to 2x ground elevation. Area outside Waimak_outcrop.ply set as Waimak_top7.2grd
Waite_top10dome.2grd	Area within Waite_outcrop.ply set to 2x ground elevation. Area within Waite_outcrop_dome.ply set to 0. Area outside Waimak_outcrop.ply and Waite_outcrop_dome.ply set as Waite_top11.2grd
Minden_Otawa_top10.2grd	Area within Minden_Otawa.ply set to ground elevation + 300m. Area outside Minden_Otawa.ply set as Minden_Otawa_top4.2grd
Aong_top1.2grd	same as described in Appendix 10
Aong_base10.2grd	Area within coromandel1.ply set to 2x ground elevation. Area outside coromandel1.ply set as Aong_base3.2grd

11.4 Model generation

File name	Description
tgamodel10.seq	Sequence file for the model All layers are depositional, except Aong_top1.2grd, which is in unconformity.
tgamodel10.faces	Is generated by tgamodel10.seq file
tgamodel11.unsliced.faces	Is tgamodel10.unsliced.faces cut by dtm100.2grd

APPENDIX 12 GEOLOGICAL CROSS SECTIONS AND VOLUME CALCULATIONS

12.1 Cross sections

Cross sections are drawn with the stack file and 2d grids as follows:

Stack file: tgastack.stack (Appendix 11, A11.1).

Layers, 2d grids and layer operation:

Layer	2d grid	Operation
Ground surface	dtm100.2grd	unconformity
Sediments	tga_top11.2grd	deposition
Mamaku Ignimbrite	dtm100inmam3.2grd	deposition
Waimakariri Ignimbrite	Waimak_top10.2grd	deposition
Waiteariki Ignimbrite	Waite_top10dome.2grd	deposition
Otawa and rhyolite domes	min_Ot_top10.2grd	deposition
Aongatete Ignimbrite	Aong_top1.2grd	unconformity
Basement	Aong_base10.2grd	deposition

Cross section and traverse files and completed cross sections are:

Cross section	Traverse file	Completed cross section
Waihi Beach	waihi.trv	waihi.ann
Katikati	kati.trv	kati.ann
Omokoroa	omoko.trv	omoko.ann
Tauranga	tau.trv	tau.ann
Te Puke	tepuke.trv	tepuke.ann

12.2 Volume calculations

Volumetric estimates are made with grids and polygon files as follows:

Stack file: tgastack.stack.

- Layer volumetrics;
- calculated km^3 (i.e. 10^{-9} x m^3);
- polygon files from following list:

Aongatete
Kaitemako
Kopurererua
Mamaku 1 (area where Mamaku Ignimbrite exposed)
Mangorewa
Maungatawa
Omanawa
Ongare
Otumoetai
Tahawai

Apata
Kaituna
Maketu
Mangapapa
Matakana
Minden-Otawa (14 domes exposed at the ground surface)
Otawa
Oturu
Tauranga

Te-Mania
Te-Puna
Tuapiro
Waiau
Waimak 2 (all Waimakariri Ignimbrite)
Waimapu
Wainui
Waiora-Ngawahine
Waiora-Waiora
Waitao
Waite-outcrop (area where Waiteariki Ignimbrite exposed)
Whatako
Te-Puna-area
Te Rereatukahia
Uretara
Waihi
Waimak-outcrop (area where Waimakariri Ignimbrite exposed)
Waione
Waiora-Ohourere
Waipapa
Waitekohe
Welcome

12.3 Estimated groundwater elevation in the Mamaku Ignimbrite

Groundwater elevation in the Mamaku Ignimbrite is estimated using observations of ground level and groundwater elevation in the Lake Rotorua catchment. Reeves et al. (2005) identified where Mamaku Ignimbrite is the surface exposure (Table A12.1).

Table A12.1 Location of wells where Mamaku Ignimbrite is the surface exposure in the Lake Rotorua catchment.

Easting	Northing	Well depth (m)	Well elevation (m)	Groundwater elevation (m)	Well number (Reeves et al. 2005)
2789500	6348400	250	441	353	429
2780700	6333300	242	658	468	171
2795576	6349310	225	479.3	307	10092
2794800	6350400	220	435	283	10089
2786300	6347900	180	503	418	458
2786200	6347800	180	504	419	456
2793200	6350600	153.6	385	296	10091
2788703	6346607	150	416.5	357	10111
2786000	6347000	147.5	499	425	301
2785000	6347500	137	529	451	165
2788000	6347000	134.1	447	370	125
2786500	6347500	134.1	500	426	124
2784400	6343200	128	483	423	312
2786500	6343000	124	414	348	290
2788000	6347200	124	459	387	284
2784000	6347000	124	533	470	164
2775100	6339600	122	547	462	811
2790510	6346760	118.5	365	305	665
2779790	6340730	113	579	524	278
2778200	6342300	110	559	494	326
2788200	6344700	102	377	311	689
2780200	6341800	99.06	587	529	144
2779710	6340670	96.4	579	532	279
2788600	6346600	95	418	354	445
2779510	6341510	91.44	581	535	137
2785000	6350000	89	539	482	814
2782000	6340800	87.5	555	503	427
2776900	6342800	85.5	560	499	71
2780100	6341600	79.2	581	541	133
2788824	6349343	76	470	382	10062
2779200	6339700	75	579	524	813
2789606	6345975	65	365	321	10105

Groundwater elevation (GW_e) and ground elevation (G_e) (Figure A12.1) are related by the simple equation: $GW_e = 0.98\ G_e\ -65$

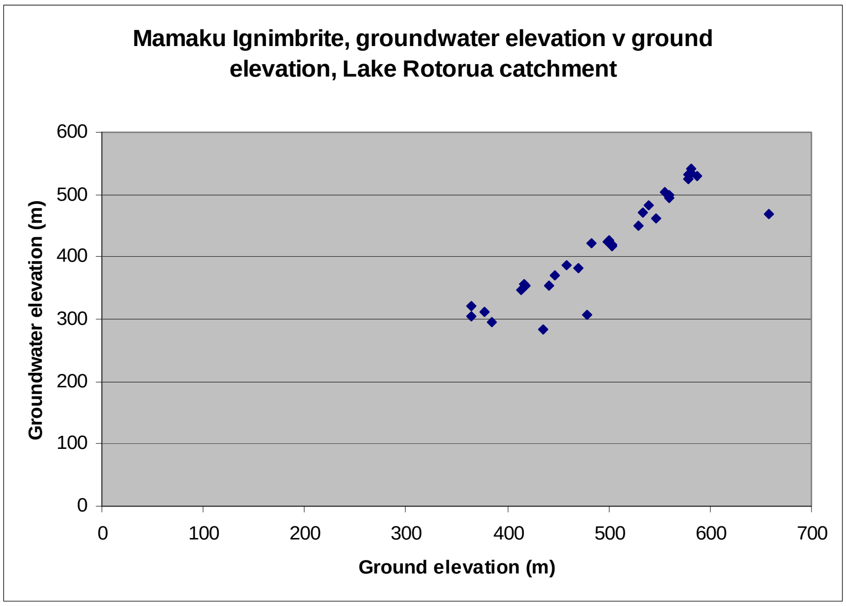


Figure A12.1 Mamaku Ignimbrite, groundwater elevation v ground elevation, Lake Rotorua catchment.

12.4 Saturated rock calculations

Stack file: tgastack.stack
calculated km^3
polygon files as in Appendix 12.2
Top layer: estimated groundwater table from the following:

Layer	Estimated groundwater level
Sediments	Tauranga_gwl.2grd (Figure 3.3)
Mamaku Ignimbrite	Mamig_gw_level.2grd* (Appendix 12.3)
Waimakariri Ignimbrite	Waite_gwl.2grd (Figure 3.4)
Waiteariki Ignimbrite	Waite_gwl.2grd (Figure 3.4)
Otawa and rhyolite domes	Waite_gwl.2grd (Figure 3.4)
Aongatete Ignimbrite	Assume fully saturated

* Mamig_gw_level.2grd = 0.98*dtm100.2grd - 65

Tauranga_gwl.2grd - generated from the Tauranga Group Sediments groundwater elevation data in Appendix 2 with below sea level elevations removed and with zero metre elevation data at the coast and offshore.

Waite_gwl.2grd - generated from the Waiteariki Ignimbrite groundwater elevation data in Appendix 2 with below-sea level elevations removed and with zero metre elevation data at the coast and offshore.

Saturated layer volumes are calculated with a stack file (Appendix 12.1) using the estimated groundwater level as the top layer, e.g. the volume of saturated Mamaku is estimated with the top grid representing the groundwater level (Mamig_gw_level.2grd) in place of dtm100.2grd in the stack.

APPENDIX 13 HYDROLOGICAL DATA HELD BY ENVIRONMENT BAY OF PLENTY IN THE WESTERN BAY OF PLENTY – ROTORUA AREA

Meteorological stations

Tauranga:
1. wind velocity and wind direction are measured at Tauranga Airport
2. start of record: December 1969

Rotorua Airport
1. wind speed and wind direction are measured
2. start of record; January 1991

Rainfall – manual sites

Site	Start of record
Katikati	January 1963
Upper Kaimai	July 1994
Tauranga City	January 1970
Kaimai hydro, McLarens Falls	October 1967
Te Maunga Road	January 1980
Ohauiti Road	January 1980
Sewell, McLarens Falls Road	January 1968
Te Puke	December 1979
Rangiuru Road	January 1980
Mangatoi Road	August 1968
Kaharoa	January 1968
Okere Falls Road	September 1974
Lake Okareka	January 1966

Rainfall – automatic sites

Site	Start of record
Tuapiro	May 1993
Waipapa	November 1991
Te Puna	September 1990
Kaituna (Te Matai)	July 1989
Mangorewa (Mangorewa)	September 1985
Mangorewa (Kaharoa)	September 1985
Kaituna (Whakarewarewa)	January 1990
Pongokawa	June 1996

River flow – sites in current operation

Site	Start of record	TIDEDA Site Numbers
Kauri Point tributary	May 1990	13309
Tuapiro	January 1984	13310
Waipapa	May 1983	13805
Mangawhai	July 1971	13901

Wairoa (above Ruahihi)	September 1990	14130
Wairoa (Power station)	July 1993	14132
Kopurereroa	October 1980	14302
Waimapu	June 1990	14410
Raparapahoe	March 1992	1114651
Waiari	November 1966	14627
Mangorewa	July 1967	14628
Kaituna (Te Matai)	May 1955	14614 (data from 1 Jan 1968)
Kaituna (Taaheke)	October 1981	1114609
Ngongotaha	May 1975	1014641
Utuhina	September 1967	14610
Puarenga (FRI)	May 1975	14625
Puarenga (Hemo Gorge)	August 1982	1114613
Tamaheke	February 1984	1114610
Te Kokonga	June 1984	1114615

Groundwater level

Site	**Start of record**
Duncan at Lund Road	June 1987
Stannetts at Matahiwi Road	July 1990
Otumoetai at Beach Road Reserve	February 1983
Stewart at Maketu Road	September 1990

Note: "Start of record" dates are from EBOP (2001). These dates sometimes differ from the start dates of the data sets.

APPENDIX 14 WESTERN BAY OF PLENTY RAINFALL DATA

Manual site number:	755903
Location:	Kauri Point Road
Period of full year records:	1963 – 2001
Annual rainfall low and year (mm, year)	941, 1982
Annual rainfall high and year (mm, year)	2021, 1971
Average of annual rainfall (mm):	1592
Standard deviation of annual rainfall (mm):	243

Manual site number:	758905
Location:	Wallingford, Upper Kamai
Period of full year records:	1995 – 2004
Annual rainfall low and year (mm, year):	1776, 2002
Annual rainfall high and year (mm, year):	2431, 1998
Average of annual rainfall (mm):	2231
Standard deviation of annual rainfall (mm):	304

Manual site number:	766101
Location:	Tauranga sewage treatment plant
Period of full year record:	1970 – 2004
Annual rainfall low and year (mm, year):	858, 1982
Annual rainfall high and year (mm, year):	1731, 1979
Average of annual rainfall (mm):	1232
Standard deviation of annual rainfall (mm):	232

Manual site number:	767201
Location:	Tauranga
Period of full year records:	1980 – 2002, with gaps
Annual rainfall low and year (mm, year):	863, 1993
Annual rainfall high and year (mm, year):	1818, 1995
Average of annual rainfall (mm):	1285
Standard deviation of annual rainfall (mm):	239

Manual site number:	767304
Location:	Te Puke
Period of full year record:	1980 – 2004
Annual rainfall low and year (mm, year):	931, 1993
Annual rainfall high and year (mm, year):	1906, 1995
Average of annual rainfall (mm):	1413
Standard deviation of annual rainfall (mm):	243

Manual site number:	768002
Location:	Kaimai hydropower
Period of full year records:	1968 – 1994
Annual rainfall low and year (mm, year)	1419, 1993
Annual rainfall high and year (mm, year)	2417, 1971
Average of annual rainfall (mm):	1953
Standard deviation of annual rainfall (mm):	271

Manual site number:	768003
Location:	Tauranga, Wairoa catchment
Period of full year records:	1968 – 1999, with gaps
Annual rainfall low and year (mm, year):	1536, 1980
Annual rainfall high and year (mm, year):	2491, 1971
Average of annual rainfall (mm):	2076
Standard deviation of annual rainfall (mm):	271

Manual site number:	768103
Location:	Tauranga harbour
Period of full year record:	1980 – 2004
Annual rainfall low and year (mm, year):	1331, 1993
Annual rainfall high and year (mm, year):	2573, 1995
Average of annual rainfall (mm):	2059
Standard deviation of annual rainfall (mm):	336

Manual site number:	768307
Location:	Te Puke
Period of full year records:	1980 - 2004
Annual rainfall low and year (mm, year)	1350, 2002
Annual rainfall high and year (mm, year)	2649, 1995
Average of annual rainfall (mm):	2009
Standard deviation of annual rainfall (mm):	359

Manual site number:	769203
Location:	Tauranga, Kaituna River catchment
Period of full year records:	1969 – 2004, with gaps
Annual rainfall low and year (mm, year):	1406, 1982
Annual rainfall high and year (mm, year):	3031, 1971
Average of annual rainfall (mm):	2133
Standard deviation of annual rainfall (mm):	400

Manual site number:	769302
Location:	Kaharoa
Period of full year record:	1968 – 1985, with gaps
Annual rainfall low and year (mm, year):	1509, 1982
Annual rainfall high and year (mm, year):	2835, 1971
Average of annual rainfall (mm):	2142
Standard deviation of annual rainfall (mm):	378

Manual site number:	860303
Location:	Rotorua, Kaituna River catchment
Period of full year records:	1975 – 2004, with gaps
Annual rainfall low and year (mm, year)	1292, 2002
Annual rainfall high and year (mm, year)	2681, 1995
Average of annual rainfall (mm):	1903
Standard deviation of annual rainfall (mm):	341

Manual site number:	861302
Location:	Lake Okareka
Period of full year records:	1966 – 2004, with gaps
Annual rainfall low and year (mm, year):	1100, 1993
Annual rainfall high and year (mm, year):	2013, 1995
Average of annual rainfall (mm):	1535
Standard deviation of annual rainfall (mm):	201

Automatic site number:	755811
Location:	Tuapiro at Woodlands Road
Period of full year record:	1994 – 2004, with gaps
Annual rainfall low and year (mm, year):	1480, 2002
Annual rainfall high and year (mm, year):	2266, 1995
Average of annual rainfall (mm):	1893
Standard deviation of annual rainfall (mm):	253

Automatic site number:	757901
Location:	Waipapa at Goodalls Road
Period of full year records:	1992 – 2004, with gaps
Annual rainfall low and year (mm, year)	1560, 1993
Annual rainfall high and year (mm, year)	2436, 2001
Average of annual rainfall (mm):	2022
Standard deviation of annual rainfall (mm):	315

Automatic site number:	766002
Location:	Stannetts at Matahiwi Road
Period of full year records:	1991 – 2004, with gaps
Annual rainfall low and year (mm, year):	883, 1993
Annual rainfall high and year (mm, year):	1679, 1995
Average of annual rainfall (mm):	1287
Standard deviation of annual rainfall (mm):	256

Automatic site number:	768301
Location:	Te Matai
Period of full year record:	1990 – 2004
Annual rainfall low and year (mm, year):	928, 1993
Annual rainfall high and year (mm, year):	1928, 1995
Average of annual rainfall (mm):	1288
Standard deviation of annual rainfall (mm):	274

Automatic site number:	768310
Location:	Mangarewa at Saunders
Period of full year records:	1986 – 2004, with many gaps
Annual rainfall low and year (mm, year)	1345, 1991
Annual rainfall high and year (mm, year)	2146, 2004
Average of annual rainfall (mm):	1756
Standard deviation of annual rainfall (mm):	272

Automatic site number:	769402
Location:	Pongakawa
Period of full year records:	1997 – 2004
Annual rainfall low and year (mm, year):	1084, 2002
Annual rainfall high and year (mm, year):	1807, 2004
Average of annual rainfall (mm):	1405
Standard deviation of annual rainfall (mm):	282

Automatic site number:	860205
Location:	Kaharoa
Period of full year record:	1986 – 2004, with gaps
Annual rainfall low and year (mm, year):	1238, 2002
Annual rainfall high and year (mm, year):	2178, 1995
Average of annual rainfall (mm):	1786
Standard deviation of annual rainfall (mm):	637

Automatic site number:	861204
Location:	Whakarewarewa
Period of full year record:	1899 – 2004, with gaps
Annual rainfall low and year (mm, year):	823, 1914
Annual rainfall high and year (mm, year):	2580, 1962
Average of annual rainfall (mm):	1430 (1963 to 2004 inclusive)
Standard deviation of annual rainfall (mm):	207 (1963 to 2004 inclusive)

Rainfall data is held by NIWA for the following sites located in the Western Bay of Plenty – Rotorua area.

767010	1971 – 1994
768102	1980 -
860206	1985 – 1989
860116	1975 – 1978
860112	1975 – 1983
862212	1981 – 1986
861114	1975 – 1978
861218	1975 – 1978
861315	1981 – 1986
861313	1975 – 1978

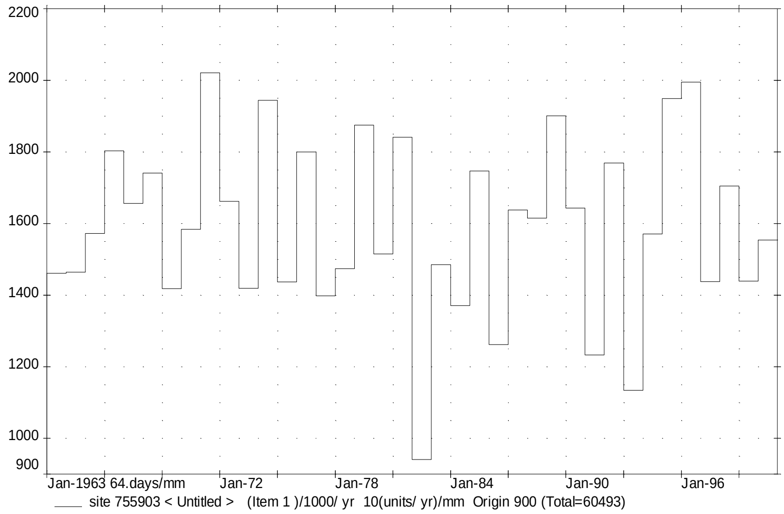
Climate Stations	B 86133	Rotorua Aero AWS start Oct 1991
	B 86131	Rotorua Aero Apr 1964 – Dec 1991
	B 76921	Te Ranga start Oct 1990
	B 76838	Te Puke EWS start Jan 1996
	B 76836	Te Puke EDR Feb 1986 – Sep 1996
	B 76621	Tauranga Aero Jan 1986 – Jan 1996
	B 76624	Tauranga Aero AWS start May 1992
	B 76603	Whakamaramara EDR May 1985 – Jun 1986
	B 75382	Waihi Barry Road EWS start Dec 1989
	B 75381	Waihi Jan 1986 – Dec 1989

Source: Walter (2000).

APPENDIX 15 WESTERN BAY OF PLENTY AND ROTORUA RAINFALL – ANNUAL RAINFALL PLOTS AND STATISTICS

The Min Mean and Max of Annual means are for complete years only.

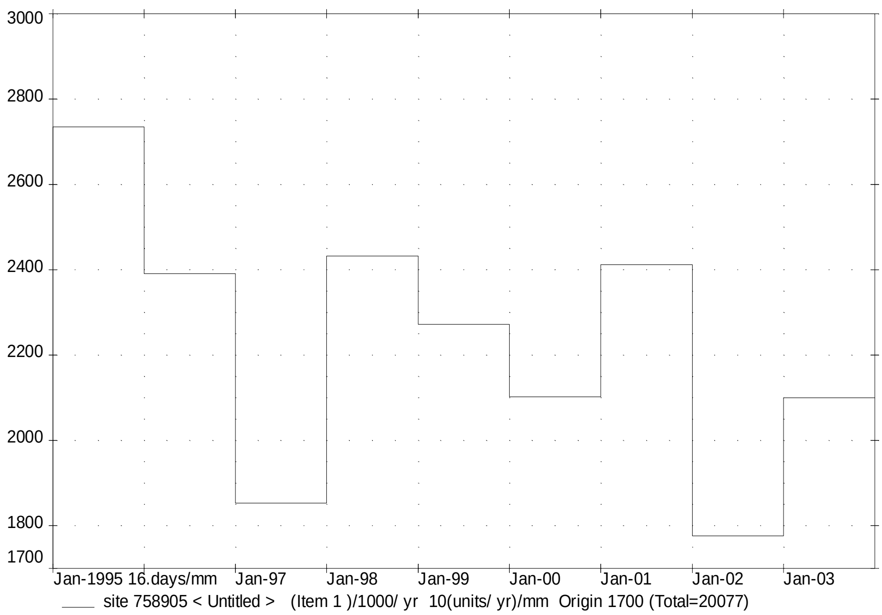
Site 755903



Monthly totals 1963 to 2000 site 755903

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	12	6	17	41	30	45	37	28	35	15	28	18	941
Mean	99	111	152	135	130	172	163	153	131	110	114	123	1592
Max.	352	320	461	385	293	369	391	295	249	298	281	339	2021

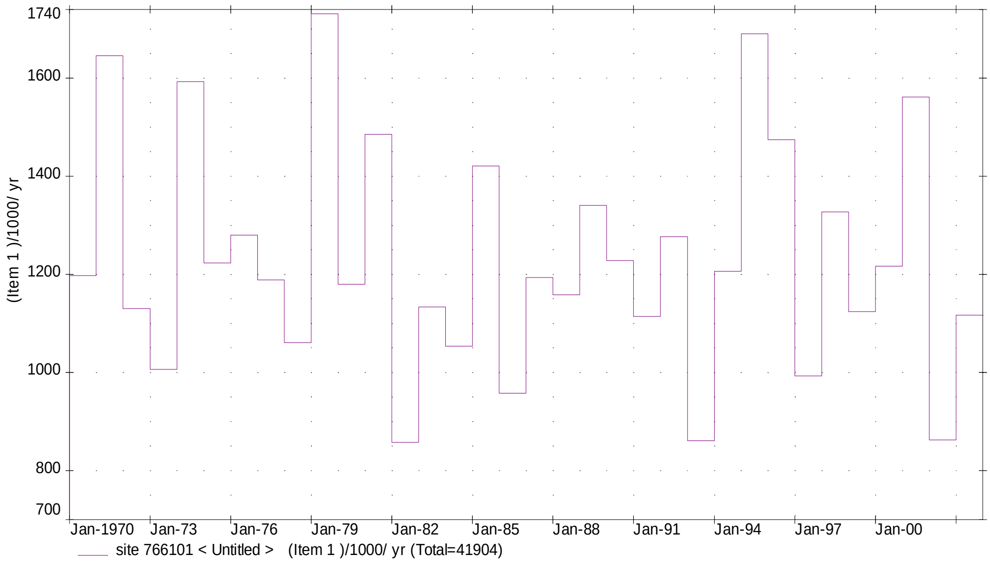
Site 758905



Monthly totals 1995 to 2003 site 758905

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	50	16	52	79	157	92	68	102	91	91	104	94	1776
Mean	120	126	147	223	208	203	237	194	197	170	199	207	2231
Max.	215	290	239	436	387	295	500	303	326	241	601	449	2734

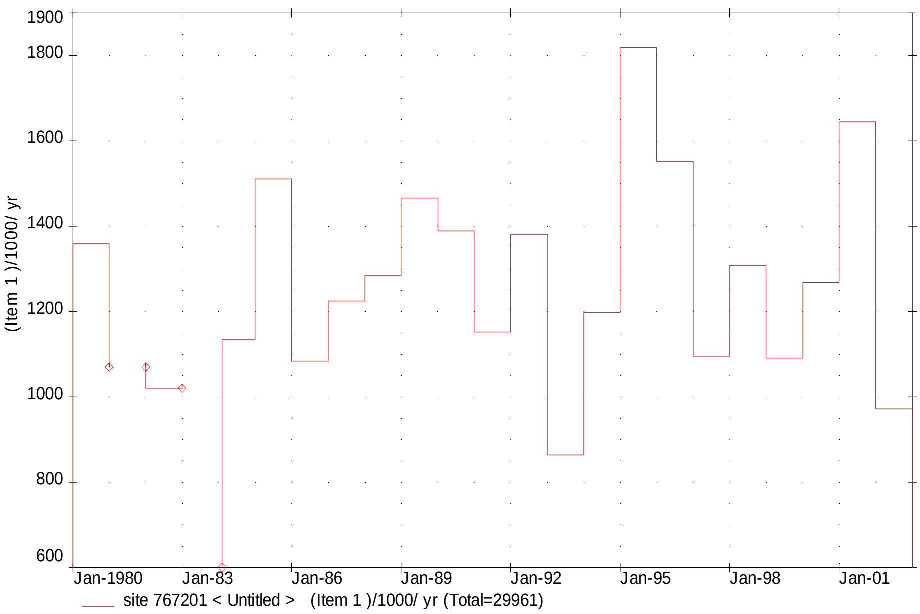
Site 766101



Monthly totals 1970 to 2003 site 766101

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	9	7	33	28	30	37	25	39	37	11	22	18	858
Mean	76	78	123	121	95	123	126	117	102	91	85	97	1232
Max.	255	252	487	386	203	234	320	216	262	244	223	265	

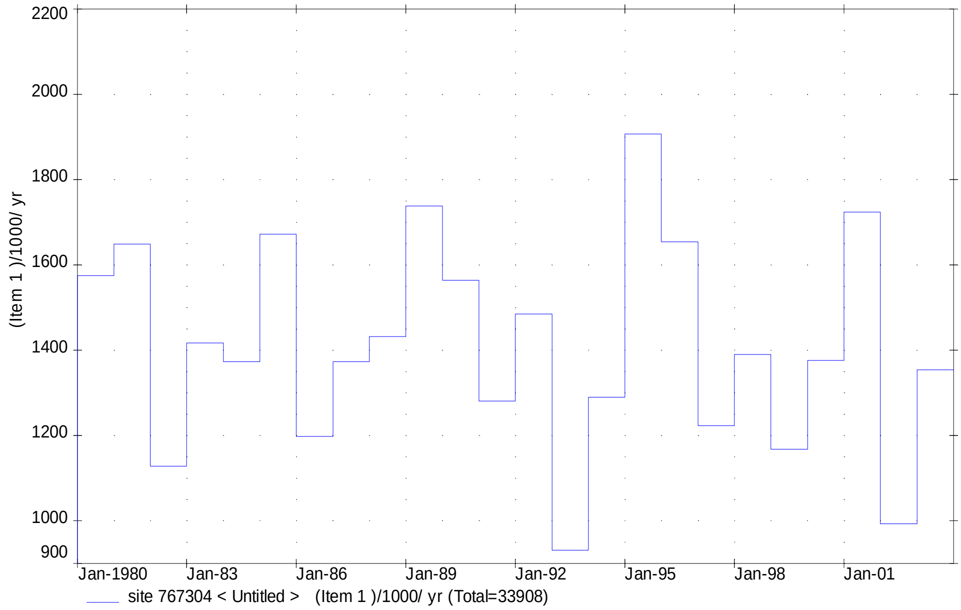
Site 767201



Monthly totals 1980 to 2002 site 767201

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	9	4	35	21	45	39	28	32	24	15	29	19	863
Mean	92	81	108	137	92	125	133	121	95	99	92	106	1285
Max.	262	285	300	341	243	281	337	218	183	262	209	257	1818

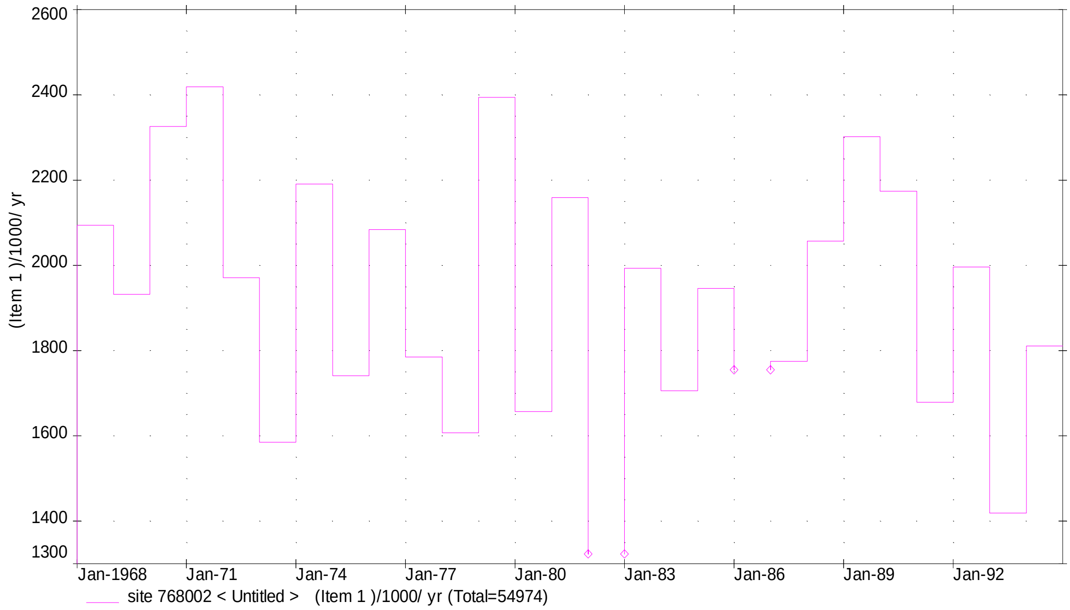
Site 767304



Monthly totals 1980 to 2003 site 767304

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	13	14	39	31	52	57	25	50	46	16	26	17	931
Mean	101	87	125	140	101	144	145	129	108	111	104	117	1413
Max.	325	262	339	364	218	340	364	291	227	309	220	290	

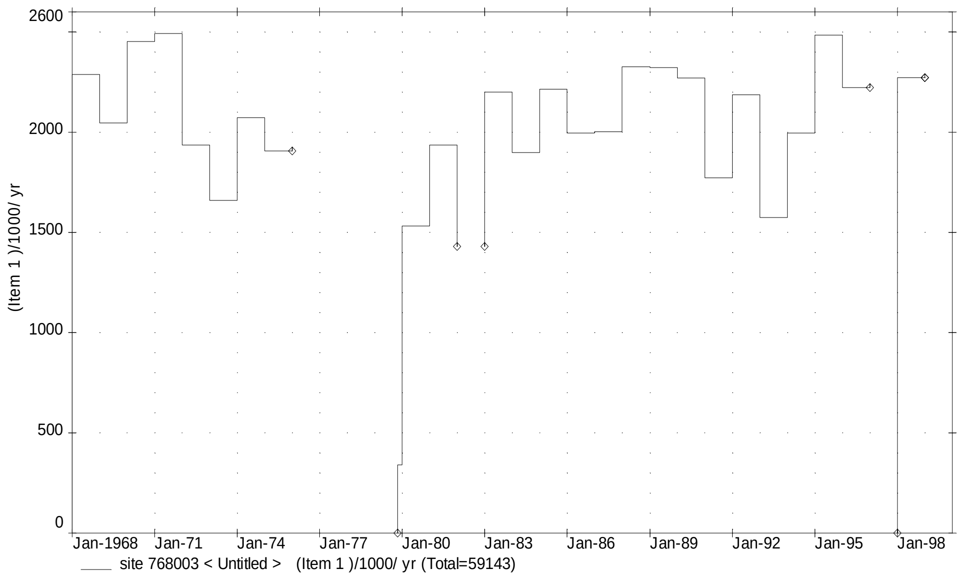
Site 768002



Monthly totals 1968 to 1994 site 768002

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	14	10	29	61	34	87	47	34	65	30	44	17	1419
Mean	111	119	174	155	154	195	169	199	172	168	145	149	1953
Max.	331	361	526	291	293	367	316	424	349	516	346	299	2417

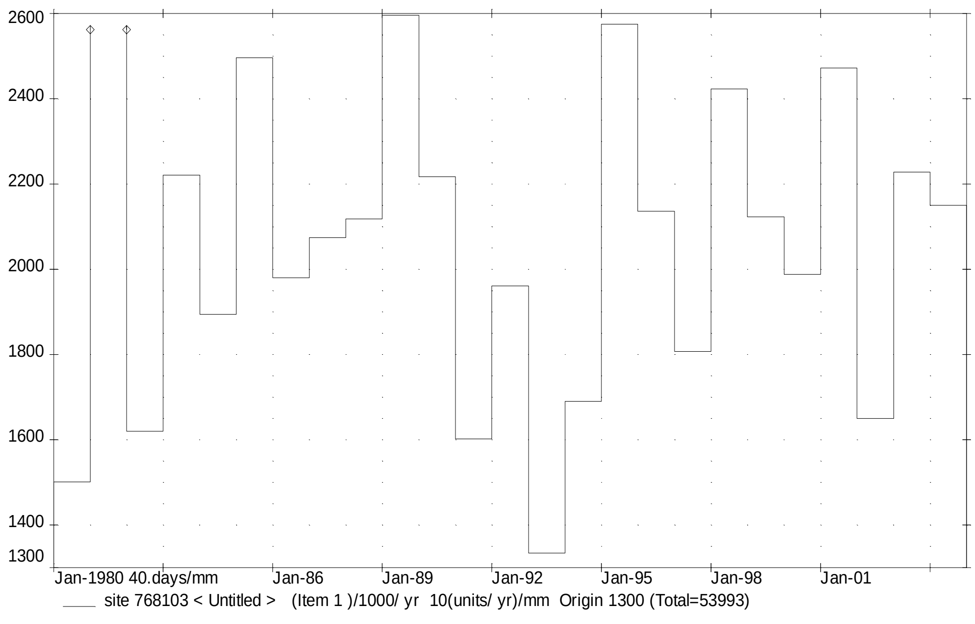
Site 768003



Monthly totals 1968 to 1999 site 768003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	15	10	38	64	24	94	57	57	67	28	57	37	1536
Mean	137	117	168	168	161	204	181	218	188	179	166	173	2075
Max.	515	323	457	401	336	381	519	433	349	554	508	328	2491

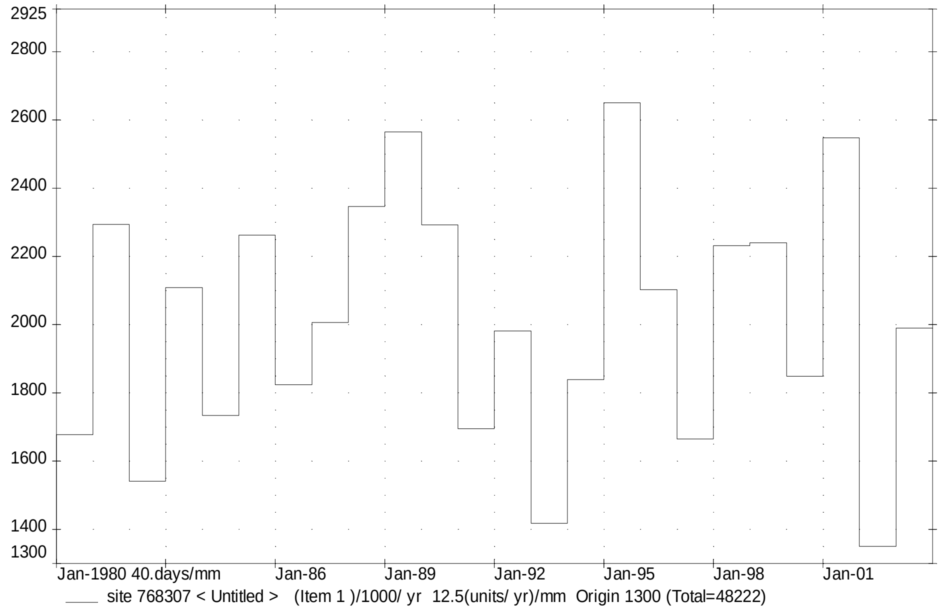
Site 768103



Monthly totals 1980 to 2004 site 768103

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	7	20	13	54	49	66	10	50	0	35	54	23	1331
Mean	144	151	158	183	157	199	197	185	171	182	168	181	2059
Max.	466	371	474	495	417	436	588	432	526	572	509	432	2573

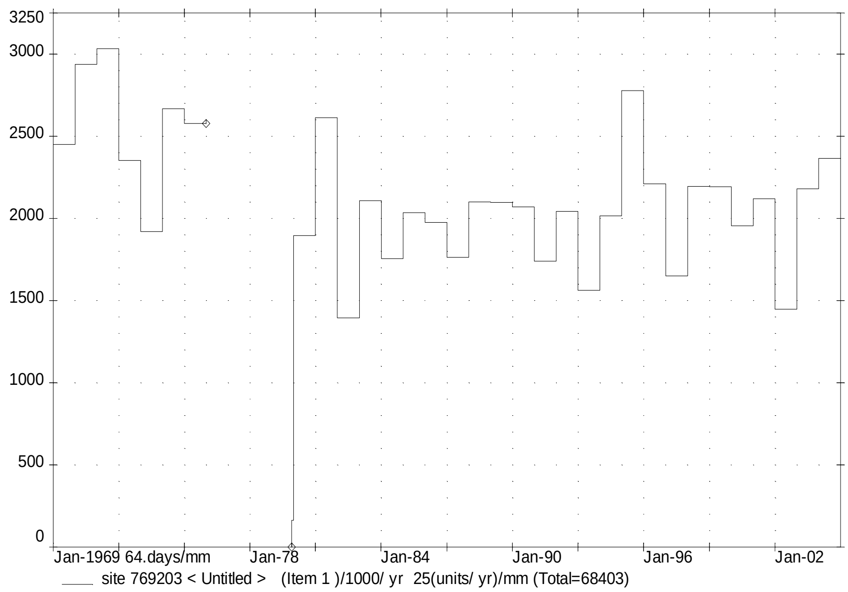
Site 768307



Monthly totals 1980 to 2003 site 768307

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	12	17	48	37	46	79	52	62	74	36	28	36	1350
Mean	135	127	163	183	153	199	189	203	167	170	158	162	2009
Max.	439	381	380	434	422	414	589	482	317	566	523	363	2649

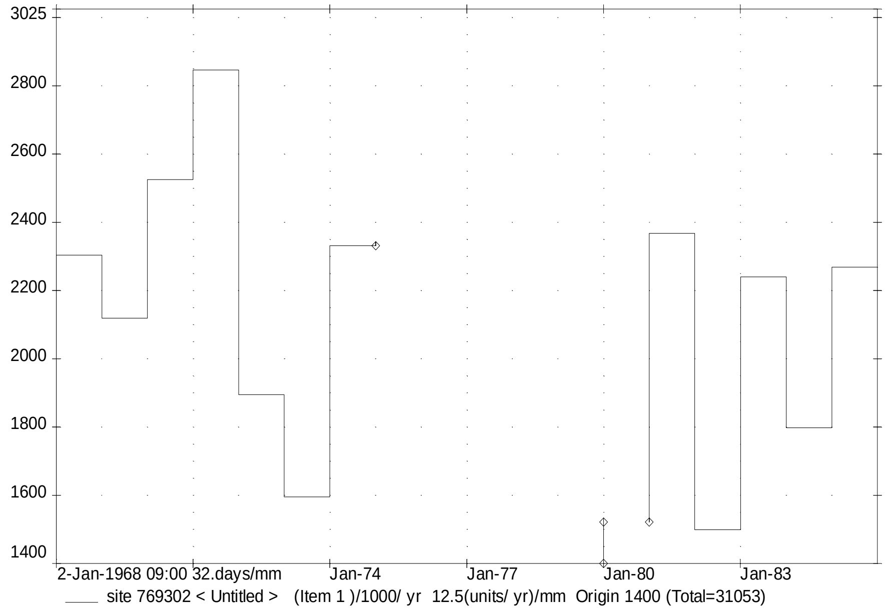
Site 769203



Monthly totals 1969 to 2004 site 769203

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	8	15	20	58	55	74	57	47	62	41	51	52	1406
Mean	131	142	173	178	167	221	188	211	195	185	158	181	2133
Max.	316	454	592	539	348	399	475	594	513	495	492	482	3031

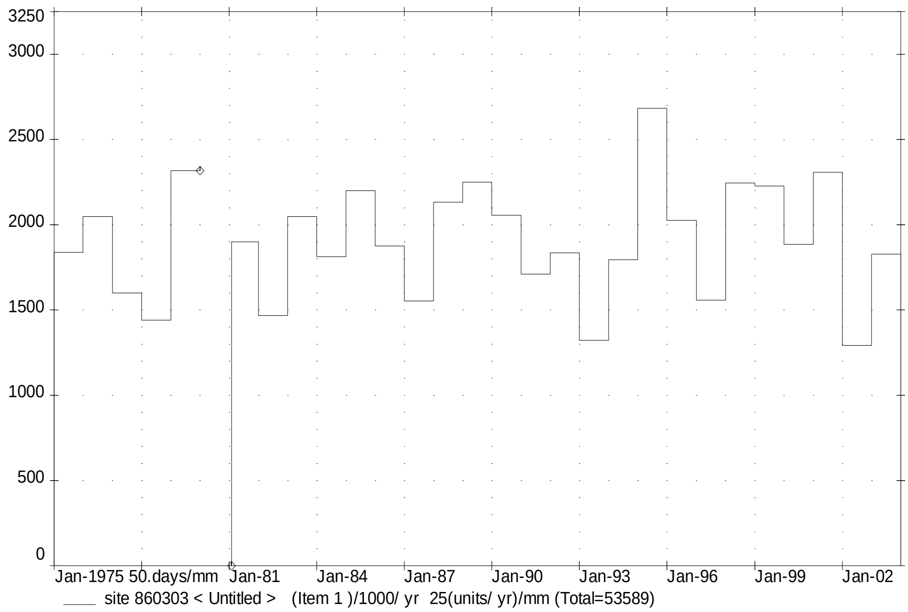
Site 769302



Monthly totals 1968 to 1985 site 769302

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	29	23	29	60	73	77	53	39	89	25	34	61	1509
Mean	131	114	196	193	158	255	149	230	202	181	150	179	2141
Max.	224	283	541	405	283	439	255	547	418	612	392	334	2835

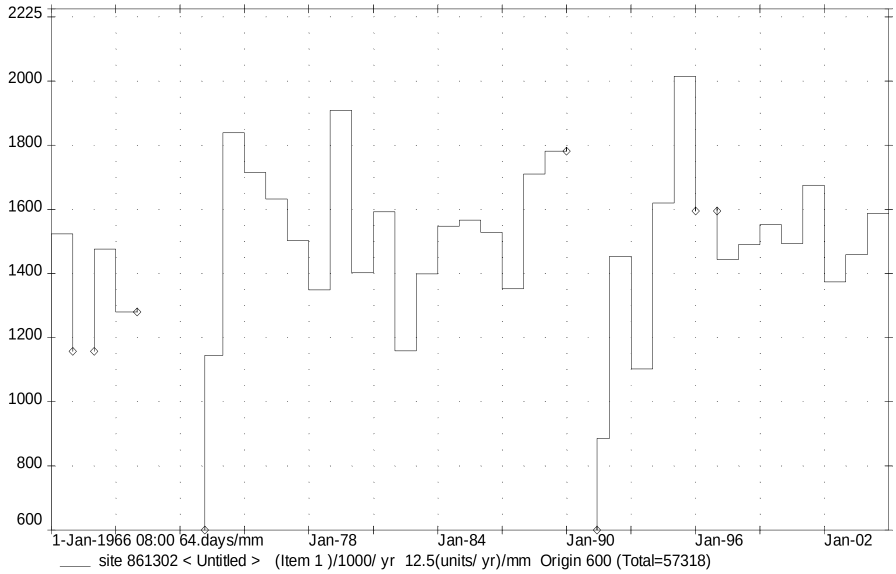
Site 860303



Monthly totals 1975 to 2003 site 860303

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	3	14	36	46	38	88	47	52	66	28	37	38	1292
Mean	119	128	152	158	145	189	191	179	159	167	153	165	1903
Max.	396	391	512	407	437	384	554	397	301	532	596	361	2681

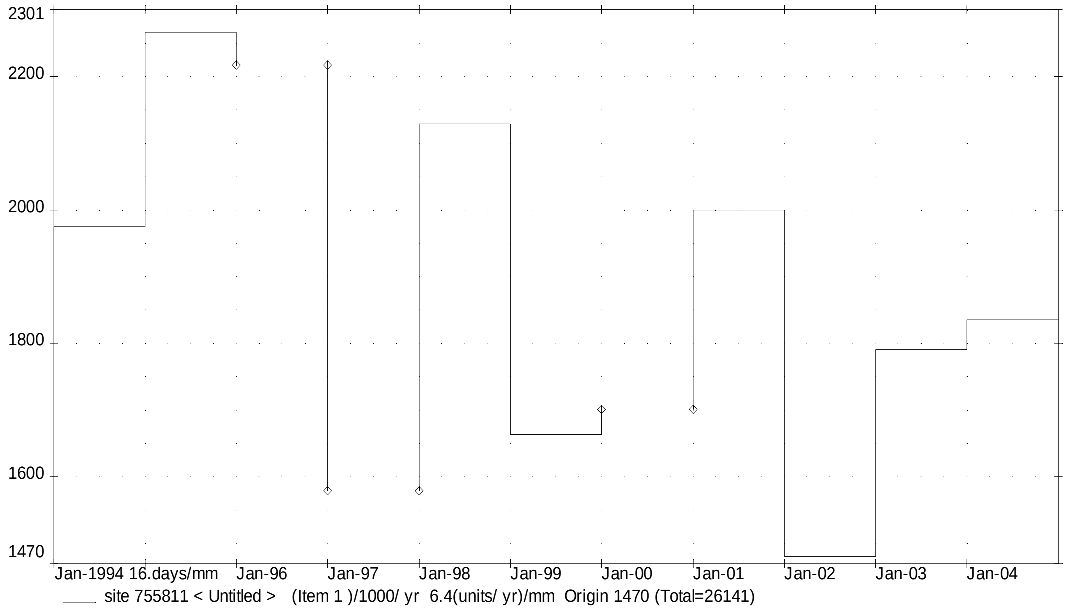
Site 861302



Monthly totals 1966 to 2004 site 861302

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	9	3	5	32	41	46	17	34	53	37	45	57	1100
Mean	99	107	114	119	132	152	147	139	136	125	112	143	1534
Max.	340	279	359	269	315	260	292	270	255	339	253	292	2013

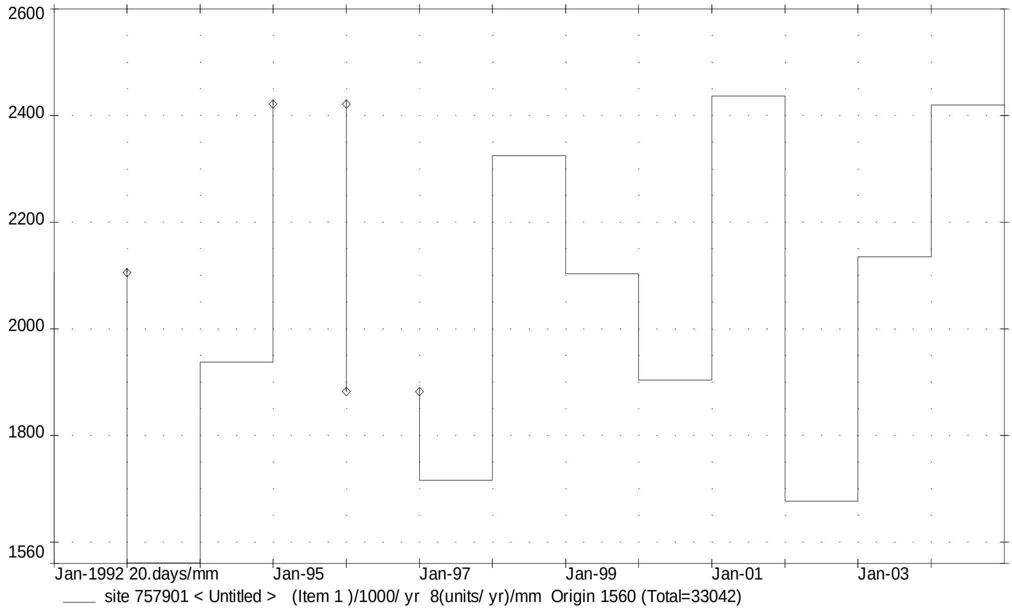
Site 755811



Monthly totals 1994 to 2004 site 755811

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	25	21	10	111	86	76	70	94	67	75	48	26	1480
Mean	121	159	138	202	145	165	230	162	151	139	159	149	1892
Max.	215	432	306	429	251	248	439	292	332	226	353	366	2266

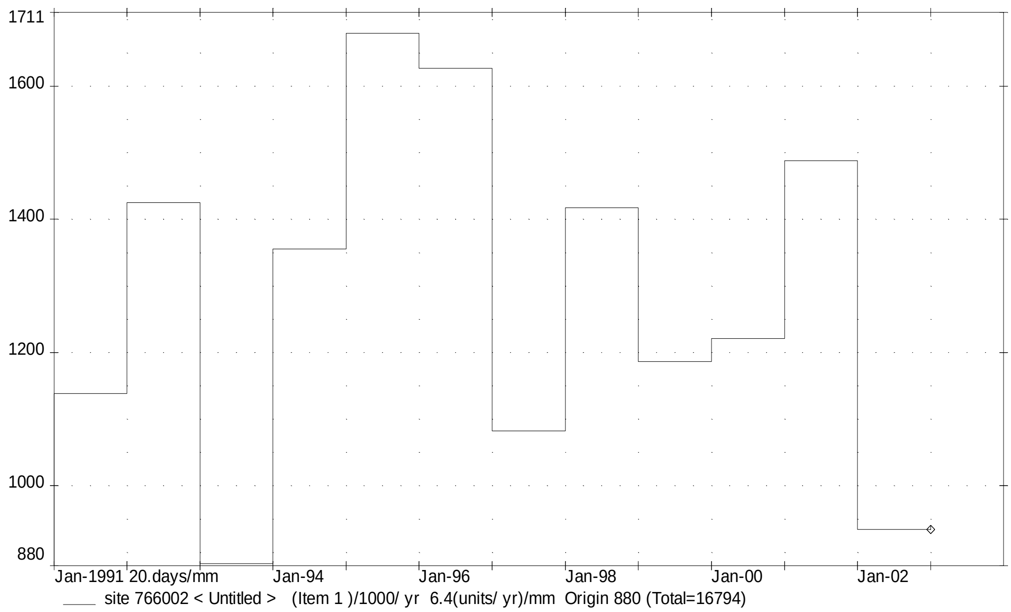
Site 757901



Monthly totals 1992 to 2004 site 757901

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	26	17	14	82	122	87	62	97	83	77	58	31	1560
Mean	120	159	136	215	194	196	219	177	167	174	148	180	2022
Max.	248	452	347	454	331	305	486	287	314	348	455	467	2436

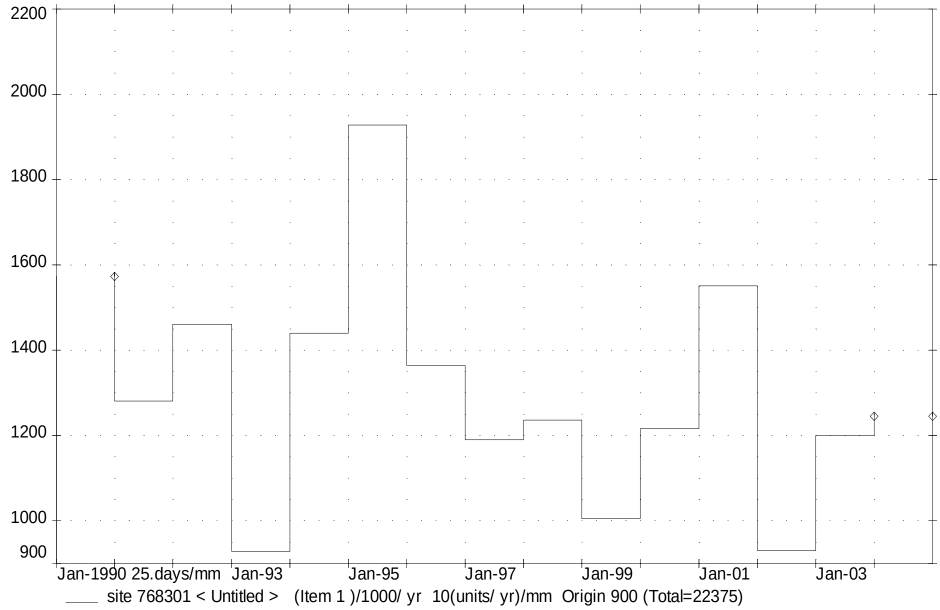
Site 766002



Monthly totals 1991 to 2003 site 766002

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	28	17	42	37	35	31	46	65	38	26	39	13	883
Mean	83	99	96	144	98	121	148	111	106	91	92	108	1287
Max.	149	260	206	318	184	185	327	208	206	228	224	253	1679

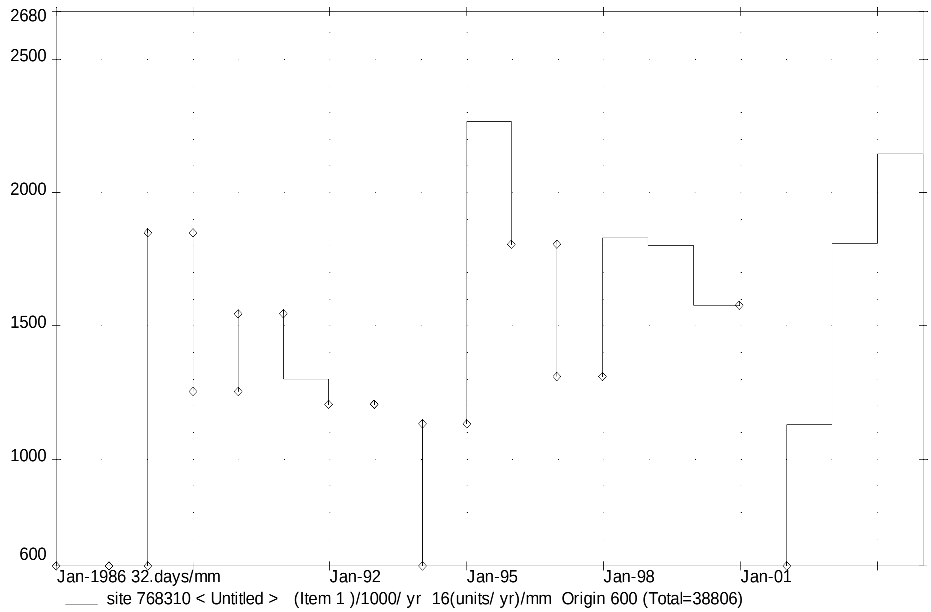
Site 768301



Monthly totals 1990 to 2004 site 768301

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	25	13	10	42	32	35	42	51	52	40	28	13	928
Mean	77	85	97	149	102	131	168	133	104	100	83	97	1287
Max.	182	236	204	401	201	266	350	325	209	201	186	271	1928

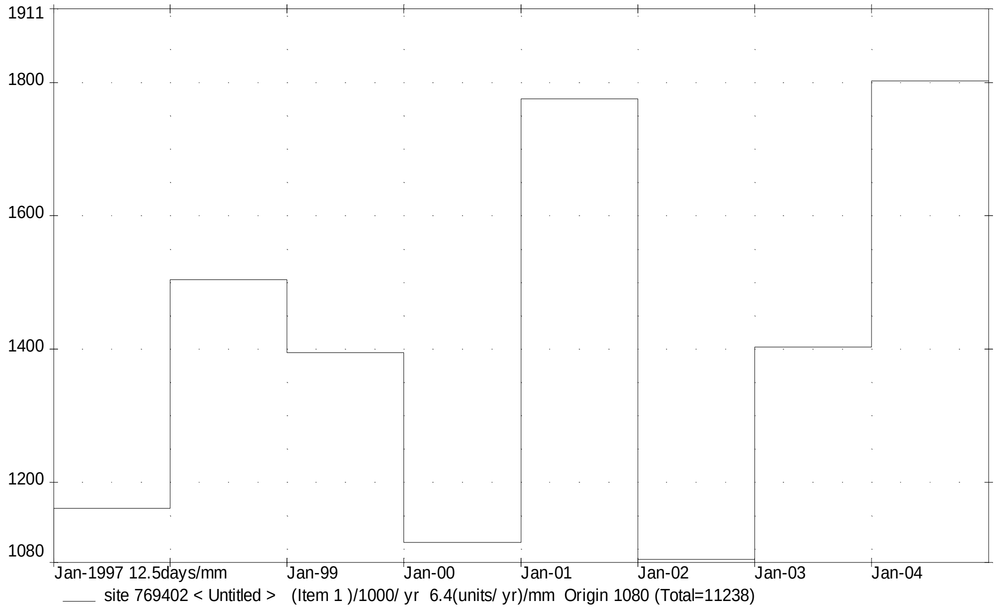
Site 768310



Monthly totals 1986 to 2004 site 768310

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	7	18	15	44	12	12	59	67	68	45	42	23	1345
Mean	99	128	110	168	139	138	183	156	146	152	135	107	1755
Max.	185	371	237	394	298	232	529	385	258	294	402	247	2146

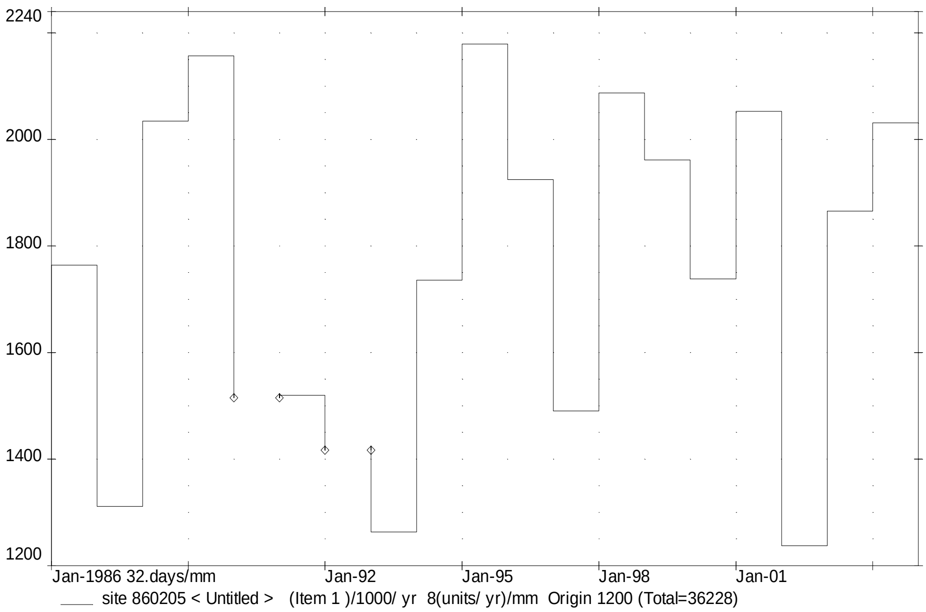
Site 769402



Monthly totals 1997 to 2004 site 769402

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	27	0	15	39	53	67	47	44	63	42	30	65	1084
Mean	73	92	103	140	142	152	158	97	120	111	94	125	1405
Max.	148	288	173	211	272	220	399	160	194	214	181	273	1807

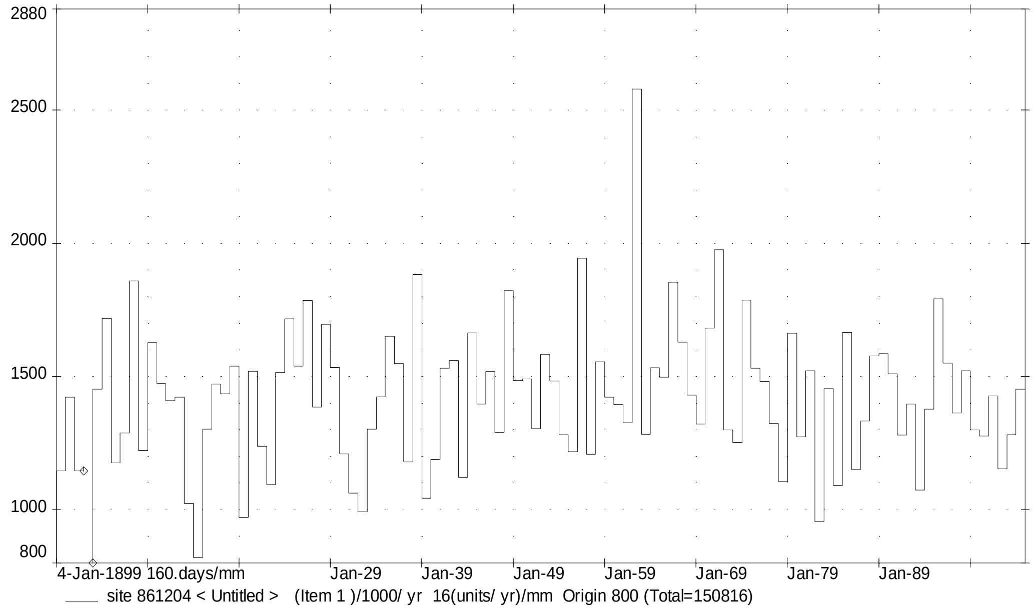
Site 860205



Monthly totals 1986 to 2004 site 860205

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	13	16	15	30	41	14	37	61	54	53	57	24	1238
Mean	119	141	123	160	160	157	172	157	151	142	136	154	1786
Max.	429	468	299	401	427	278	540	264	307	348	438	315	2178

Site 861204



Monthly totals 1899 to 2004 site 861204

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min.	1	2	7	13	0	29	15	17	23	25	15	12	823
Mean	104	102	105	117	131	136	131	128	117	125	106	120	1429
Max.	352	313	400	487	464	324	369	305	308	336	267	351	2580

APPENDIX 16 RAINFALL MODEL

The NIWA rainfall model (Section 5.1.2) is used to represent rainfall in the region. Data from this model was supplied by EBOP.

Data file: ev_annual_0050P_xyz.dat – NIWA data of mean rainfall is the EBOP region.

Processing steps on this data:

1. remove header
2. remove null values and created short 1.dat.
3. gridded rainfall values:
    - minimum x 2748050
    - minimum y 622900
    - maximum x 2972550
    - maximum y 6432500
    - grid spacing (x and y) 500
    - File name: rain1.2grd
    - Boundary polygon (approximate boundary): rain1.ply

APPENDIX 17 ESTIMATES OF 'DEEP' GROUNDWATER FLOW, BY AQUIFER AND BY SURFACE WATER CATCHMENT

Tauranga Group Sediments catchment number	Catchment	Estimated deep groundwater recharge (L/s)
1	Aongatete	206
2	Apata	104
3	Kaitemako	45
4	Katikati Streams	66
5	Kopurererua	162
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	512
7	Maketu	14
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	495
11	Maungatawa area	251
12	Omanawa	0
13	Ongare/Tanners Point	158
14	Otumoetai area	2
15	Oturu	70
16	Tahawai	100
17	Tauranga city area	46
18	Te Mania	61
19	Te Puna	0
20	Te Puna area	463
21	Te Rereatukahia	212
22	Tuapiro	201
23	Uretara	245
24	Waiau	144
25	Waihi Beach	249
26	Waimapu	195
27	Wainui	0
28	Waione	90
29	Waipapa	155
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	0
32	Wairoa_Wairoa	48
33	Waitao area	165
34	Waitekohe	162
35	Welcome Bay area	52
36	Whatakao	186
	Sum (L/s)	4858
	Sum (m^3/s)	4.9
Mamaku/Waimakariri Ignimbrite catchment number	**Catchment**	**Estimated deep groundwater recharge (L/s)**
1	Aongatete	0
2	Apata	0
3	Kaitemako	0
4	Katikati Streams	0
5	Kopurererua	185
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	0
7	Maketu	0
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	0
11	Maungatawa area	0
12	Omanawa	0
13	Ongare/Tanners Point	0
14	Otumoetai area	0
15	Oturu	0
16	Tahawai	0
17	Tauranga city area	0
18	Te Mania	0
19	Te Puna	0
20	Te Puna area	0
21	Te Rereatukahia	0
22	Tuapiro	0
23	Uretara	0
24	Waiau	0
25	Waihi Beach	0
26	Waimapu	682
27	Wainui	0
28	Waione	0
29	Waipapa	0
30	Wairoa_Ngamawahine	0

Mamaku/Waimakariri Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
31	Wairoa_Ohourere	0
32	Wairoa_Wairoa	48
33	Waitao area	0
34	Waitekohe	0
35	Welcome Bay area	0
36	Whatakao	0
	Sum (L/s)	915
	Sum (m^3/s)	0.9

OTP Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
1	Aongatete	0
2	Apata	0
3	Kaitemako	45
4	Katikati Streams	0
5	Kopurererua	46
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	0
7	Maketu	0
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	0
11	Maungatawa area	100
12	Omanawa	0
13	Ongare/Tanners Point	0
14	Otumoetai area	0
15	Oturu	0
16	Tahawai	0
17	Tauranga city area	25
18	Te Mania	0
19	Te Puna	0
20	Te Puna area	0
21	Te Rereatukahia	0
22	Tuapiro	0
23	Uretara	0
24	Waiau	0
25	Waihi Beach	0
26	Waimapu	0
27	Wainui	0
28	Waione	0
29	Waipapa	0
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	80
32	Wairoa_Wairoa	0
33	Waitao area	247
34	Waitekohe	0
35	Welcome Bay area	104
36	Whatakao	0
	Sum (L/s)	649
	Sum (m^3/s)	0.6

Waiteariki Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
0		
1	Aongatete	343
2	Apata	130
3	Kaitemako	102
4	Katikati Streams	53
5	Kopurererua	46
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	256
7	Maketu	7
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	141
11	Maungatawa area	100
12	Omanawa	0
13	Ongare/Tanners Point	0
14	Otumoetai area	1
15	Oturu	23
16	Tahawai	60
17	Tauranga city area	8
18	Te Mania	20
19	Te Puna	0
20	Te Puna area	231
21	Te Rereatukahia	30

Waiteariki Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
22	Tuapiro	151
23	Uretara	98
24	Waiau	144
25	Waihi Beach	0
26	Waimapu	487
27	Wainui	0
28	Waione	26
29	Waipapa	466
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	400
32	Wairoa_Wairoa	290
33	Waitao area	330
34	Waitekohe	121
35	Welcome Bay area	52
36	Whatakao	293
	Sum (L/s)	4409
	Sum (m^3/s)	4.4

Minden Rhyolite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
1	Aongatete	0
2	Apata	0
3	Kaitemako	0
4	Katikati Streams	0
5	Kopurererua	0
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	0
7	Maketu	0
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	0
11	Maungatawa area	0
12	Omanawa	0
13	Ongare/Tanners Point	0
14	Otumoetai area	0
15	Oturu	12
16	Tahawai	0
17	Tauranga city area	0
18	Te Mania	0
19	Te Puna	0
20	Te Puna area	0
21	Te Rereatukahia	0
22	Tuapiro	0
23	Uretara	0
24	Waiau	96
25	Waihi Beach	0
26	Waimapu	292
27	Wainui	0
28	Waione	0
29	Waipapa	78
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	240
32	Wairoa_Wairoa	48
33	Waitao area	0
34	Waitekohe	0
35	Welcome Bay area	0
36	Whatakao	0
	Sum (L/s)	765
	Sum (m^3/s)	0.8

Aongatete Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
1	Aongatete	137
2	Apata	26
3	Kaitemako	34
4	Katikati Streams	13
5	Kopurererua	23
6 part	Lower Kaituna (hills)	0
6 part	Lower Kaituna (plain)	85
7	Maketu	2
8	Mangapapa/Opuiaki	0
9	Mangorewa	0
10	Matakana Island	71
11	Maungatawa area	50
12	Omanawa	0
13	Ongare/Tanners Point	18

Aongatete Ignimbrite catchment number	Catchment	Estimated deep groundwater recharge (L/s)
14	Otumoetai area	0
15	Oturu	12
16	Tahawai	40
17	Tauranga city area	4
18	Te Mania	20
19	Te Puna	0
20	Te Puna area	77
21	Te Rereatukahia	61
22	Tuapiro	151
23	Uretara	147
24	Waiau	96
25	Waihi Beach	249
26	Waimapu	292
27	Wainui	0
28	Waione	13
29	Waipapa	78
30	Wairoa_Ngamawahine	0
31	Wairoa_Ohourere	80
32	Wairoa_Wairoa	48
33	Waitao area	82
34	Waitekohe	121
35	Welcome Bay area	52
36	Whatakao	53
	Sum (L/s)	2136
	Sum (m^3/s)	2.1

APPENDIX 18 GROUNDWATER CONSENTS IN TAURANGA CITY AND WESTERN BAY OF PLENTY DISTRICT, JANUARY 2009

The following steps outline the processing of Environment Bay of Plenty groundwater allocation data:

- Environment Bay of Plenty records 688 groundwater consents in the area covered by Western Bay of Plenty District Council and Tauranga City (Ellis Miller, Environment Bay of Plenty pers. comm. 22 January 2009);
- 60 groundwater consents appear as duplicate entries, having the same consent number, same holder name, same use, same allocation, same well number and same location etc, for example consent 20468. The duplicates are removed from the dataset;
- five groundwater consents have no data on water allocation rates in consent locations, for example consent 24421. These are removed from the dataset.
- seven consents have no location information in the dataset; locations are estimated from street locations for consent numbers: 60999, 61516, 61773, 63250, 63255, 64869 and 64966;
- 623 consents are listed in the following table.

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
20019	1	GENERAL SALEYARD USES & WASHING DOWN	UNC	2807500	6374600
20059	0	WATERING OF GOLF COURSE	UNC	2785400	6381700
20071	0	LAYING DUST DURING DRY WEATHER	UNC	2791000	6388400
20073	0	SPRAY IRRIGATION OF GREENS & FAIRWAYS	UNC	2793600	6387300
20115	1	USE IN THERMAL SWIMMING POOL	UNG	2785600	6383800
20131	0	HORTICULTURAL & PASTURE IRRIGATION	UNC	2781300	6378200
20132	0	IRRIGATION OF PLAYING FIELD TURF	UNC	2793600	6387900
20147	0	IRRIGATING PLAYING FIELDS	UNC	2795000	6386600
20148	0	IRRIGATING PLAYING FIELDS	UNC	2792100	6389500
20152	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2809200	6371900
20157	0	IRRIGATING PLAYING FIELDS	UNC	2794200	6387300
20193	1	ORNAMENTAL PONDS	UNC	2770200	6398000
20204	1	USE IN PRIVATE SWIMMING POOL	UNG	2779900	6388600
20239	0	IRRIGATING PLAYING FIELDS	UNC	2795300	6386700
20244	1	CULTIVATING FISH & AQUATIC PLANTS	UNG	2788600	6380000
20245	0	DOMESTIC, STOCK AND WASHING PIGGERY	UNC	2773900	6383000
20246	0	DOMESTIC USE AND STOCK WATERING	UNC	2772900	6370000
20265	1	TAKE WATER FOR SWIMMING POOLS	UNG	2778500	6391000
20273	0	DRINKING WATER, ABLUTIONS & IRRIGATION	UNC	2802300	6382700
20286	1	HEATING, OTUMOETAI SWIMMING POOL	UNG	2786300	6386500
20294	1	TAKE FROM BORE FOR IRRIGATION & DOMESTIC	UNG	2773100	6397100
20298	0	ORCHARD IRRIGATION & GENERAL FARM USE	UNC	2824600	6368200
20311	0	TAKE FROM BORE FOR ORCHARD IRRIGATION	UNC	2781800	6386400
20328	1	PUBLIC POOL HEATING	UNG	2793100	6381500
20342	0	DOMESTIC & POOL HEATING	UNG	2789600	6386600
20362	0	TAKE FOR PROCESSING & COOLING	UNC	2789600	6386600
20367	0	IRRIGATION OF HORTICULTURAL CROPS	UNC	2802400	6370300
20399	1	SUPPLY WARM WATER TO SWIMMING POOL	UNG	2786500	6381800
20418	0	TAKE WATER FROM BORES FOR IRRIGATION	UNC	2770700	6412500
20428	0	ORCHARD IRRIG, FARMING & DOMESTIC USE	UNC	2777600	6384900
20447	0	ORCHARD & NURSERY IRRIGATION	UNC	2770700	6414100
20449	1	TAKE FROM BORE FOR A SWIMMING POOL	UNG	2788800	6387600
20454	1	ORCHARD IRRIGATION	UNC	2773200	6397500
20468	0	ORCHARD IRRIGATION	UNC	2815300	6368200
20471	0	IRRIGATING PLAYING FIELD	UNC	2793000	6388600
20474	0	ORCHARD IRRIGATION	UNC	2806800	6369600
20479	0	TAKE WATER FROM WELL-ORCHARD IRRIGATION	UNC	2817900	6367200
20483	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2781200	6386000
20486	0	IRRIG GOLF COURSE GREENS, TEES & TREES	UNC	2777500	6391300
20487	0	TAKE FOR IRRIGATION & DOMESTIC USE	UNC	2810000	6372100
20490	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2777200	6387200
20498	0	ORCHARD IRRIGATION	UNC	2786300	6373400
20500	0	TAKE GEOTHERMAL & DIS TO TGA HARBOUR	UNG	2779800	6388800
20510	1	OPERATING FISH HOLDING AND BREEDING TANK	UNC	2785300	6374100
20516	0	TAKE & DISCHARGE GEO FLUID FOR POOL	UNG	2789100	6382600
20550	0	IRRIGATION, SPRAYING, STOCK & DOMESTIC	UNC	2785200	6373100
20577	1	SUPPLYING WARM WATER TO SWIMMING POOLS	UNG	2785100	6388000
20587	0	ORCHARD IRRIGATION	UNC	2766200	6399700
20588	0	ORCHARD IRRIGATION	UNC	2773100	6397100
20594	0	IRRIGATION & DOMESTIC USE	UNC	2782200	6394100
20596	0	ORCHARD IRRIGATION	UNC	2771800	6392300
20598	0	IRRIGATING PLAYING FIELD	UNC	2793000	6388400
20619	0	ORCHARD IRRIGATION	UNC	2766000	6399700
20621	0	ORCHARD & NURSERY IRRIGATION	UNC	2809800	6374700
20622	0	TAKE WATER WAIPAPA RIVER FOR IRRIGATION	UNC	2775100	6389100
20639	0	NURSERY, ORCHARD, GREENHOUSE IRRIGATION	UNC	2788400	6368800
20644	0	ORCHARD IRRIGATION	UNC	2781700	6393900
20645	1	IRRIG, DOMESTIC & GENERAL FARM USE	UNC	2797700	6381800
20648	0	ORCHARD, SHELTER & VEGETABLE IRRIGATION	UNC	2810600	6374200
20651	0	TAKE FROM BORE FOR HORT IRRIGATION	UNC	2771500	6394100
20654	0	ORCHARD IRRIGATION	UNC	2801100	6374400
20669	0	ORCHARD & NURSERY IRRIGATION	UNC	2770700	6396200
20688	0	ORCHARD AND SHELTER BELT IRRIGATION	UNC	2784300	6378700
20695	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2780100	6386700
20707	3	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2806000	6370000
20707	2	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2807100	6371000
20710	1	USE IN HOT POOLS & IN CENTRAL HEATING	UNG	2790100	6382000
20713	1	USE IN DOMESTIC SWIMMING POOL	UNG	2787000	6388500
20716	0	Horticultura Irrigation	UNC	2782300	6376300
20720	1	WARM WATER FOR POOL HEAT EXCHANGER	UNG	2786200	6380900
20745	1	WARM WATER FOR PRIVATE POOL	UNG	2793400	6389000
20749	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2807400	6369800
20753	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2784100	6378200
20768	0	ORCHARD IRRIGATION	UNC	2777700	6388600
20772	0	TAKE FROM BORE FOR DOMESTIC & STOCK	UNC	2789700	6378700
20774	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2771300	6393500
20779	1	WARM WATER FOR SWIM POOL HEAT EXCHANGE	UNG	2789200	6384500
20783	0	ORCHARD IRRIGATION	UNC	2792900	6385600
20789	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2792400	6384500
20793	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2784400	6376200
20796	1	WARM WATER FOR POOL & BATH HOUSE	UNG	2810100	6371100
20799	1	USE IN HEAT EXCHANGER, NURSERY OPERATION	UNG	2768100	6399200
20801	0	IRRIGATING PLAYING FIELD	UNC	2791700	6389600
20811	0	HORTICULTURAL IRRIGATION	UNC	2780200	6387700
20813	0	HORTICULTURAL IRRIGATION	UNC	2770600	6412300

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20814	0	HORTICULTURAL IRRIGATION	UNC	2811300	6366500
20816	0	HORTICULTURAL IRRIGATION	UNC	2771400	6393300
20831	0	ORCHARD IRRIGATION	UNC	2767800	6399400
20838	1	ORCHARD IRRIGATION	UNC	2792200	6384300
20839	0	STOCK, DOMESTIC USES & IRRIGATION	UNC	2814000	6366700
20844	1	HOUSEHOLD, POOL & GREENHOUSE HEATING	UNG	2786400	6388600
20848	0	IRRIGATION & STOCK WATERING	UNC	2786400	6372700
20855	1	WARM WATER FOR MOTEL PLUNGE POOLS	UNG	2789300	6383000
20861	0	ORCHARD IRRIGATION	UNC	2774900	6390500
20866	0	DOMESTIC USE & IRRIGATION	UNC	2778800	6385700
20869	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2784600	6376000
20875	0	IRRIGATION, STOCK & DOMESTIC USE	UNC	2771200	6387100
20885	0	ORCHARD IRRIGATION	UNC	2766700	6402600
20889	0	IRRIGATION & DOMESTIC USE	UNC	2810100	6373800
20891	0	ORCHARD IRRIGATION	UNC	2769200	6396000
20899	0	TAKE WATER FROM WELL FOR IRRIGATION	UNC	2810400	6372200
20911	0	ORCHARD IRRIGATION	UNC	2779100	6395800
20918	0	IRRIGATING A BOWLING GREEN	UNC	2791800	6389600
20922	0	ORCHARD IRRIGATION	UNC	2801400	6379700
20923	0	TAKE WATER FROM BORE FOR DOMESTIC USE	UNC	2789000	6378600
20931	0	ORCHARD IRRIGATION & STOCK WATERING	UNC	2770900	6414500
20935	0	IRRIGATION, STOCK WATER & DOMESTIC USE	UNC	2809100	6367200
20936	0	ORCHARD IRRIGATION	UNC	2811600	6367700
20968	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2787800	6377000
20971	1	HEATING A THERAPY POOL	UNG	2788900	6383500
20973	0	ORCHARD IRRIGATION	UNC	2779900	6387000
20986	0	ORCHARD IRRIGATION	UNC	2811900	6372000
21005	0	ORCHARD IRRIGATION	UNC	2771500	6394200
21006	1	TAKE FROM BORE FOR HORT IRRIGATION	UNC	2770300	6397300
21006	2	FROST PROTECTION	UNC	2770300	6397300
21017	1	WARM WATER FOR SWIMMING POOL	UNG	2802500	6374000
21018	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2817900	6366900
21034	0	ORCHARD IRRIGATION	UNC	2768400	6406300
21039	0	ORCHARD IRRIGATION	UNC	2764500	6398500
21042	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2773800	6385000
21050	1	IRRIGATION & STOCK WATER SUPPLY	UNC	2767300	6398800
21050	2	ORCH IRRIG, SWIM POOL & HSHOLD HTG	UNG	2767300	6398800
21053	0	DOM USE, ORCHARD SPRAYING & IRRIGATION	UNC	2785500	6374100
21057	0	ORCHARD IRRIGATION	UNC	2786500	6373200
21069	0	ORCHARD IRRIGATION	UNC	2791600	6384200
21074	0	ORCHARD IRRIGATION	UNC	2784200	6376200
21076	0	ORCHARD IRRIGATION	UNC	2782200	6377400
21091	0	ORCHARD IRRIGATION	UNC	2781300	6386600
21092	1	IRRIGATION & USE IN SWIMMING POOL	UNG	2780100	6387300
21098	1	NURSERY & ORCHARD IRRIGATION	UNG	2782700	6387500
21109	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2780600	6372400
21114	0	ORCHARD IRRIGATION	UNC	2765200	6394000
21119	0	ORCHARD IRRIGATION	UNC	2770700	6414100
21120	0	ORCHARD IRRIGATION	UNC	2770500	6415100
21127	0	ORCHARD IRRIGATION	UNC	2800700	6367800
21131	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2785700	6375800
21133	0	ORCHARD IRRIGATION	UNC	2766500	6396600
21136	0	ORCHARD IRRIGATION	UNC	2784300	6378000
21147	0	ORCHARD IRRIGATION	UNC	2777600	6388600
21154	0	ORCHARD IRRIGATION	UNC	2778400	6389200
21161	0	ORCHARD IRRIGATION	UNC	2810500	6370700
21162	0	IRRIGATION, STOCK & FARM USE	UNC	2810600	6371900
21166	0	IRRIGATION, STOCK & DOMESTIC USE	UNC	2785400	6375900
21176	0	ORCHARD IRRIGATION	UNC	2771300	6397300
21183	0	ORCHARD IRRIGATION	UNC	2777100	6389400
21186	0	ORCHARD IRRIGATION	UNC	2768800	6408100
21189	0	ORCHARD IRRIGATION	UNC	2778800	6389400
21190	0	IRRIGATION, DOMESTIC & STOCK USE	UNC	2814500	6368200
21222	0	ORCHARD IRRIGATION	UNC	2768800	6396100
21228	0	HORTICULTURAL IRRIGATION	UNC	2767000	6397100
21238	0	IRRIGATION, DOMESTIC & STOCK USE	UNC	2783600	6382400
21244	0	ORCHARD IRRIGATION	UNC	2769300	6391500
21247	0	ORCHARD IRRIGATION	UNC	2782400	6377000
21255	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2785100	6378400
21261	1	DOMESTIC, HEATING & USE IN SPA POOL	UNG	2780500	6388200
21268	0	ORCHARD IRRIGATION	UNC	2782800	6379100
21277	0	ORCHARD IRRIGATION	UNC	2768600	6400200
21285	0	TAKE BORE WATER FOR HORT IRRIGATION	UNC	2809500	6374700
21287	0	ORCHARD IRRIGATION	UNC	2810500	6374700
21288	0	ORCHARD IRRIGATION	UNC	2816700	6367600
21289	0	ORCHARD IRRIGATION from a bore	UNC	2816700	6367800
21292	0	ORCHARD IRRIGATION	UNC	2782900	6378400
21302	0	ORCHARD IRRIGATION & FROST PROTECTION	UNC	2800900	6369700
21303	0	HORTICULTURAL IRRIGATION	UNC	2782300	6375900
21304	0	IRRIGATION, DOMESTIC & ORCHARD USE	UNC	2782200	6372500
21309	0	ORCHARD IRRIGATION	UNC	2810700	6374600
21310	0	ORCHARD IRRIGATION	UNC	2777900	6388400
21311	1	ORCHARD IRRIGATION	UNC	2770100	6400900
21313	0	ORCHARD IRRIGATION	UNC	2808800	6371500
21314	0	ORCHARD IRRIGATION	UNC	2779700	6397000

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
21318	0	ORCHARD IRRIGATION	UNC	2766500	6404700
21321	0	ORCHARD IRRIGATION	UNC	2783900	6382200
21322	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2809600	6368300
21323	0	IRRIGATION, GENERAL & DOMESTIC USE	UNC	2781900	6374300
21329	0	DOMESTIC, IRRIGATION & POULTRY WATER	UNC	2780800	6373700
21336	0	IRRIGATION & DOMESTIC USE	UNC	2800700	6369000
21341	0	ORCHARD IRRIGATION	UNC	2805100	6366600
21342	0	DOMESTIC USE, STOCK WATER & IRRIGATION	UNC	2771600	6388000
21343	0	ORCHARD IRRIGATION	UNC	2817800	6367100
21344	0	ORCHARD IRRIGATION	UNC	2794400	6382100
21346	0	TAKE FROM BORE FOR HORT IRRIGATION	UNC	2786600	6372800
21351	0	ORCHARD IRRIGATION & FROST PROTECTION	UNC	2786500	6373100
21352	0	ORCHARD IRRIGATION	UNC	2791500	6379500
21353	0	ORCHID IRRIGATION	UNC	2793100	6381000
21358	0	ORCHARD IRRIGATION	UNC	2792800	6381400
21360	0	ORCHARD IRRIGATION	UNC	2787400	6378100
21361	0	ORCHARD IRRIGATION	UNC	2787500	6378100
21362	0	ORCHARD IRRIGATION	UNC	2775500	6390600
21367	0	ORCHARD IRRIGATION	UNC	2770800	6393700
21373	0	ORCHARD IRRIGATION	UNC	2769400	6396900
21375	0	ORCHARD IRRIGATION	UNC	2809100	6375100
21379	0	ORCHARD IRRIGATION	UNC	2773200	6397400
21380	0	ORCHARD IRRIGATION	UNC	2798700	6368100
21382	2	USE IN SWIMMING POOL & HEATING	UNG	2779600	6387700
21382	1	ORCHARD IRRIGATION	UNC	2779700	6387600
21383	0	ORCHARD IRRIGATION	UNC	2810500	6370600
21384	0	ORCHARD IRRIGATION	UNC	2786500	6372200
21385	0	ORCHARD IRRIGATION	UNC	2787700	6374100
21391	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2784700	6376100
21398	1	TAKE WATER FOR HORTICULTURE IRRIGATION	UNC	2765600	6396700
21404	0	ORCHARD IRRIGATION	UNC	2780200	6386300
21424	0	ORCHARD IRRIGATION	UNC	2781500	6376800
21426	0	ORCHARD IRRIGATION AND DOMESTIC USE	UNC	2808100	6368200
21427	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2795600	6378800
21431	0	IRRIGATION, POND AND WATERFALL	UNC	2791200	6390700
21432	0	ORCHARD IRRIGATION	UNC	2781600	6376100
21435	0	ORCHARD IRRIGATION	UNC	2788500	6379600
21439	0	ORCHARD IRRIGATION AND DOMESTIC USE	UNC	2801200	6379700
21442	0	ORCHARD IRRIGATION	UNC	2796600	6383900
21444	0	ORCHARD IRRIGATION	UNC	2795500	6381900
21450	3	ORCHARD IRRIGATION	UNC	2778400	6387600
21455	0	ORCHARD IRRIGATION & STOCK WATERING	UNC	2772600	6387900
21461	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2784600	6383300
21464	0	ORCHARD IRRIGATION	UNC	2771300	6393900
21465	0	ORCHARD IRRIGATION	UNC	2780000	6385900
21466	0	ORCHARD IRRIGATION	UNC	2769900	6396700
21473	0	ORCHARD IRRIGATION	UNC	2809000	6373600
21474	0	ORCHARD IRRIGATION	UNC	2811200	6366900
21475	0	IRRIGATION, STOCK & DOMESTIC USE	UNC	2787400	6378200
21499	0	ORCHARD IRRIGATION	UNC	2810000	6373700
21501	1	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2793000	6381400
21501	2	FROST PROTECTION	UNC	2793000	6381400
21503	0	ORCHARD IRRIGATION	UNC	2809600	6374300
21514	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2809100	6375500
21516	0	ORCHARD IRRIGATION	UNC	2767700	6405200
21518	0	ORCHARD IRRIGATION	UNC	2813900	6368500
21524	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2807100	6369900
21531	0	DOMESTIC, FARM USES & IRRIGATION	UNC	2769300	6393500
21536	0	ORCHARD IRRIGATION	UNC	2814000	6367400
21537	0	ORCHARD IRRIGATION	UNC	2766600	6398700
21555	0	IRRIGATION, DAIRY, DOMESTIC & STOCK USE	UNC	2812400	6369400
21562	0	ORCHARD IRRIGATION	UNC	2786900	6372500
21568	0	TAKE WATER FOR HORTICULTURE IRRIGATION	UNC	2770900	6392600
21573	1	HEATING SPA & SWIMMING POOLS	UNG	2799900	6381100
21574	1	TAKE FROM BORE FOR HORT IRRIGATION	UNC	2771300	6412600
21583	0	ORCHARD IRRIGATION	UNC	2782200	6373400
21587	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2808900	6363900
21588	0	ORCHARD IRRIGATION	UNC	2779800	6387400
21594	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2812000	6374700
21595	0	ORCHARD IRRIGATION	UNC	2811500	6368100
21596	0	ORCHARD IRRIGATION	UNC	2784700	6383600
21597	1	PASTURE AND CROP IRRIGATION	UNC	2811400	6373900
21601	1	IRRIGATION & HEATING	UNG	2783600	6382200
21603	0	ORCHARD IRRIGATION	UNC	2797800	6368100
21604	0	IRRIGATION, STOCK & DOMESTIC USES	UNC	2779500	6395400
21605	0	ORCHARD IRRIGATION	UNC	2788100	6378000
21611	0	ORCHARD IRRIGATION	UNC	2814000	6367900
21614	0	DOMESTIC USE & ORCHARD IRRIGATION	UNC	2786600	6373300
21615	0	ORCHARD IRRIGATION	UNC	2810300	6373000
21623	0	ORCHARD IRRIGATION	UNC	2793200	6381200
21624	0	ORCHARD IRRIGATION ON THREE PROPERTIES	UNC	2802500	6367200
21626	0	USE IN BOTTLING	UNC	2785700	6383700
21629	0	ORCHARD IRRIGATION	UNC	2812800	6367400
21631	0	ORCHARD IRRIGATION	UNC	2810100	6375000
21635	0	ORCHARD IRRIGATION	UNC	2769500	6402300

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21636	0	HORTICULTURAL IRRIGATION	UNC	2802400	6370100
21638	0	IRRIGATION & DOMESTIC USE	UNC	2768600	6404700
21640	0	ORCHARD IRRIGATION	UNC	2801400	6372200
21642	1	HEATING GLASSHOUSES	UNG	2780200	6387600
21643	1	USE IN SPA POOL & SWIMMING POOL	UNG	2792500	6381900
21651	0	HORTICULTURAL IRRIGATION	UNC	2809600	6373300
21658	0	ORCHARD IRRIGATION	UNC	2767900	6394900
21661	0	ORCHARD IRRIGATION	UNC	2769600	6394000
21663	0	ORCHARD IRRIGATION	UNC	2786700	6372600
21667	0	ORCHARD IRRIGATION	UNC	2813000	6371600
21670	0	ORCHARD IRRIGATION	UNC	2811000	6374400
21672	0	ORCHARD IRRIGATION	UNC	2772500	6387600
21673	1	IRRIGATION AND GLASSHOUSE HEATING	UNG	2766500	6402600
21675	0	IRRIGATION, DOMESTIC & PIGGERY USE	UNC	2772200	6393500
21677	0	ORCHARD IRRIGATION	UNC	2805400	6372600
21678	0	ORCHARD IRRIGATION	UNC	2804700	6372900
21679	0	ORCHARD IRRIGATION	UNC	2809500	6373300
21682	0	ORCHARD IRRIGATION	UNC	2779000	6385700
21690	0	ORCHARD IRRIGATION	UNC	2775500	6392200
21698	0	ORCHARD IRRIGATION	UNC	2782100	6385300
21701	0	ORCHARD IRRIGATION	UNC	2785400	6374500
21707	0	ORCHARD IRRIGATION	UNC	2768700	6394900
21710	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2775600	6384800
21713	0	ORCHARD IRRIGATION & DOMESTIC USE	UNC	2817700	6367100
21717	0	ORCHARD IRRIGATION	UNC	2781800	6376400
21719	0	DOMESTIC, STOCK USE & IRRIGATION	UNC	2773200	6388300
21724	0	HORTICULTURAL IRRIGATION	UNC	2776800	6389100
21726	0	ORCHARD IRRIGATION	UNC	2774400	6389200
21731	1	TAKE FROM A BORE FOR ORCHARD IRRIGATION	UNC	2770000	6395800
21732	0	ORCHARD IRRIGATION	UNC	2768900	6396300
21733	1	BORE FOR DOMESTIC & IRRIGATION	UNC	2775600	6384500
21741	0	ORCHARD IRRIGATION	UNC	2776500	6388700
21743	0	TAKE WATER FOR HORTICULTURE IRRIGATION	UNC	2771600	6394300
21746	0	HORTICULTURAL IRRIGATION	UNC	2782700	6382800
21757	0	ORCHARD IRRIGATION	UNC	2778100	6390500
21774	0	ORCHARD IRRIGATION	UNC	2792900	6385300
21777	0	IRRIGATION, KIWIFRUIT AND SHELTER	UNC	2767700	6403300
21778	0	ORCHARD IRRIGATION	UNC	2770300	6401700
21779	0	HORTICULTURAL IRRIGATION, KIWIFRUIT	UNC	2782900	6378300
21781	0	HORTICULTURAL IRRIGATION, KIWIFRUIT	UNC	2768700	6408000
21788	1	KIWIFRUIT & AVOCADO IRRIGATION	UNC	2774000	6384400
21795	0	HORTICULTURAL IRRIGATION: VINEHAVEN ORCH	UNC	2782400	6369400
21801	1	HORTICULTURAL IRRIGATION	UNC	2810600	6368900
21805	0	HORT IRRIGATION & DOMESTIC USE	UNG	2776200	6390500
21806	0	HORTICULTURAL IRRIGATION, KIWIFRUIT	UNC	2814100	6365400
21807	0	IRRIGATION: KIWIFRUIT & NURSERY	UNC	2781200	6387400
21812	0	IRRIGATION, DOMESTIC & SPRAYING USES	UNC	2786900	6372100
21817	0	KIWIFRUIT TRICKLE IRRIGATION	UNC	2807600	6370000
21818	0	HORTICULTURAL IRRIGATION	UNC	2771400	6397300
21819	0	HORTICULTURAL IRRIGATION	UNC	2816400	6369600
21823	1	HORTICULTURAL IRRIGATION FROM BORE	UNC	2812600	6369000
21830	0	TRICKLE IRRIGATION-KIWIFRUIT	UNC	2810900	6366600
21835	0	HORTICULTURAL IRRIGATION	UNC	2809800	6361600
21836	0	IRRIGATION, DOMESTIC AND STOCK USES	UNC	2809500	6369400
21839	1	WARM WATER FOR IRRIGATION & HEATING	UNG	2771600	6412700
21841	0	HORTICULTURAL IRRIGATION	UNC	2781700	6375800
21858	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2822500	6369900
21866	0	Take water from bore for hort irrigation	UNC	2822600	6370000
21873	0	IRRIGATION, DOMESTIC & STOCK USES	UNC	2782600	6378400
21878	0	HORTICULTURAL IRRIGATION & STOCK USE	UNC	2822300	6369100
21879	0	HORTICULTURAL IRRIGATION & DOMESTIC USES	UNC	2788100	6379800
21884	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2781800	6387700
21895	0	HORTICULURAL IRRIGATION-KIWIFRUIT	UNC	2812100	6367200
21896	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2799300	6373600
21898	1	HORTICULTURAL IRRIGATION AND STOCK USES	UNC	2791200	6379200
21898	2	HORTICULTURAL IRRIGATION AND STOCK USES	UNC	2791200	6379600
21903	0	HORTICULTURAL IRRIGATION	UNC	2809500	6372000
21915	1	IRRIGATION, STOCK & DOMESTIC USES	UNC	2823200	6367400
21919	0	HORTICULTURAL IRRIGATION	UNC	2809600	6374200
21924	0	IRRIGATION ORNAMENTAL FOLIAGE CROPS	UNC	2788000	6369700
21929	0	IRRIGATION & DOMESTIC USES	UNC	2809500	6372300
21930	0	IRRIGATION, STOCK & DOMESTIC USES	UNC	2809200	6367400
21932	2	HORICULTURAL IRRIGATION, STOCK USE	UNC	2779400	6375600
21933	0	HORTICULTURAL IRRIGATION	UNC	2782500	6377300
21937	0	ORCHARD IRRIGATION-KIWIFRUIT	UNC	2808900	6375800
21941	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2782700	6386300
21946	0	ORCHARD IRRIGATION-KIWIFRUIT	UNC	2791900	6384300
21947	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2816900	6367200
21960	0	HORTICULTURAL IRRIGATION	UNC	2795200	6382200
21962	0	HORTICULTURAL IRRIGATION	UNC	2794200	6381900
21967	3	GLASSHOUSE, ORCHARD & DOMESTIC USES	UNC	2811700	6374500
21967	1	WARM WATER FOR HEATING HOT HOUSES	UNG	2812100	6374600
21969	1	HORTICULTURAL IRRIGATION	UNC	2802500	6381400
21975	0	WARM WATER FOR SWIMMING POOLS	UNC	2786400	6388700
21976	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2806600	6371600

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
21981	0	IRRIGATION, STOCK AND DOMESTIC USES	UNC	2775000	6385700
21985	0	HORTICULTURAL IRRIGATION	UNC	2793100	6382400
21986	1	SWIMMING POOL	UNG	2783500	6384500
21987	0	IRRIGATION, STOCK & DOMESTIC USES	UNC	2805300	6372700
21988	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2810900	6372000
21992	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2777700	6388200
21998	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2806500	6371600
22010	0	HORTICULTURAL IRRIGATION; DOMESTIC	UNC	2808900	6373900
22016	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2808700	6371400
22017	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2780800	6371700
22019	1	WARM WATER FOR USE IN SWIMMING POOL	UNG	2764500	6397500
22023	0	HORTICULTURAL IRRIGATION-KIWIFRUIT	UNC	2811800	6370000
22024	0	HORTICULTURAL IRRIGATION	UNC	2786800	6372300
22037	0	TAKE FROM BORE FOR DOMESTIC & IRRIGATION	UNC	2807100	6372100
22039	0	HORTICULTURAL IRRIGATION	UNC	2767900	6395200
22041	0	HORTICULTURAL IRRIGATION	UNC	2768000	6395300
22048	1	WARM WATER FOR USE IN SWIMMING POOL	UNG	2778700	6391400
22049	0	HORTICULTURAL IRRIGATION	UNC	2770500	6414000
22055	0	HORTICULTURAL IRRIGATION	UNC	2778700	6385800
22066	0	HORTICULTURAL IRRIGATION & STOCK WATER	UNC	2771300	6388100
22081	0	HORTICULTURAL IRRIGATION EX WELL	UNC	2811700	6366800
22082	0	HORTICULTURAL IRRIGATION EX BORE	UNC	2809600	6371900
22083	0	HORT IRRIG, DOM USE & STOCK WATER	UNC	2776200	6392500
22086	0	TAKE WATER FOR HORTICULTURE IRRIGATION	UNC	2769100	6395900
22099	0	HORTICULTURAL & SHELTER BELT IRRIGATION	UNC	2808900	6367600
22102	3	TAKE FROM BORE FOR IRRIGATION	UNC	2809600	6368700
22142	0	HORTICULTURAL IRRIGATION EX WELL	UNC	2816800	6367700
22150	0	HORTICULTURAL IRRIGATION & STOCK WATER	UNC	2816500	6366700
22163	0	NURSERY IRRIGATION	UNC	2779900	6385200
22172	1	SCHOOL WATER SUPPLY AND DOMESTIC USE	UNC	2802200	6253200
22201	0	TAKE WATER FROM BORES FOR IRRIGATION	UNC	2791600	6389600
23589	0	TAKE WATER FOR PUBLIC SUPPLY, ATHENREE	UNC	2769400	6411600
24728	0	TAKE GEOTHERMAL FLUID FOR DOMESTIC USE	UNG	2787300	6388400
24866	0	TAKE HOT WATER FOR GLASSHOUSE HEATING	UNG	2780300	6387500
25047	0	TAKE GEOTHERMAL WATER FOR USE IN POOLS	UNG	2772700	6412800
25126	0	TAKE WATER FROM BORE FOR ORCHARD IRRIG	UNC	2768500	6404900
60296	0	TAKE GEO FLUID FROM BORE FOR HEATING	UNG	2788600	6378400
60422	0	TAKE FROM 3 BORES FOR HORT IRRIGATION	UNC	2810930	6371220
60441	0	TAKE WARM WATER FROM BORE TO HEAT POOL	UNG	2786900	6388600
60464	0	TAKE WATER FROM A BORE FOR DUST CONTROL	UNC	2786000	6388600
60479	0	TAKE FROM BORE FOR HORT & FROST PROTECT	UNC	2771390	6405970
60520	0	L S EARTHWORKS FOR RESIDENTIAL SUBDIVISI	UNC	2790750	6379950
60580	0	TAKE FROM BORE FOR ORCHARD IRRIGATION	UNC	2809800	6370230
60634	0	TAKE FROM BORE FOR ORCHARD IRRIGATION	UNC	2769110	6409020
60656	0	TAKE FROM BORE FOR DEER PROCESSING	UNC	2769850	6367100
60759	0	TAKE FROM A BORE FOR HORT IRRIGATION	UNC	2774630	6390820
60766	0	TAKE & DIS GEOTHERMAL FLUID FOR HEATING	UNG	2785070	6387980
60767	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2786940	6376330
60772	0	TAKE & DIS GEOTHERMAL FOR HEATING POOL	UNG	2786360	6388700
60868	0	TAKE & DISCHARGE GEOTHERMAL FLUID	UNG	2793950	6382060
60880	0	TAKE & DIS GEOTHERMAL FLUID FOR DOMESTIC	UNG	2778730	6388550
60889	0	TAKE & DIS GEOTHERMAL FOR SCHOOL POOL	UNG	2802300	6382600
60907	0	TAKE WATER FROM A BORE FOR IRRIGATION	UNC	2807490	6374700
60915	0	PLACE STRUCTURE;TAKE FROM STREAM & BORE	UNC	2783000	6376870
60918	0	TAKE FROM BORE FOR IRRIG & FROST PROTECT	UNC	2812810	6373650
60928	0	TAKE WATER FROM A BORE FOR IRRIGATION	UNC	2810630	6371590
60932	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2807480	6374730
60945	0	TAKE FROM BORE FOR IRRIG & FROST PROTECT	UNC	2768430	6406470
60976	0	TAKE BORE WATER FOR HORT IRRIGATION	UNC	2821660	6362420
60999	0	TAKE GEOTHERMAL WATER FOR HEATING	UNG	2778800	6389400
61007	0	TAKE FROM BORE FOR IRRIG & FROST PROTECT	UNC	2811510	6372650
61041	0	TAKE FROM BORE FOR DOMESTIC & HORT USE	UNC	2787390	6373920
61066	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2788920	6385290
61074	0	TAKE & DIS GEO FLUID FOR DOMESTIC USE	UNG	2784960	6387710
61093	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2776900	6391170
61099	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2785200	6387700
61122	0	TAKE & DIS GEOTHERAML FLUID FOR POOL	UNG	2786850	6388360
61126	0	TAKE & DIS GEOTHERMAL FLUID FOR DOM USE	UNG	2778580	6390740
61168	0	TAKE GROUNDWATER FOR ORCHARD IRRIGATION	UNC	2772960	6405660
61191	0	TAKE FROM STREAM FOR ORCHARD IRRIGATION	UNC	2769950	6406310
61202	0	TAKE & DIS WATER FROM BORE FOR POOLS	UNG	2789380	6383900
61204	0	TAKE WATER FROM BORE FOR DOMESTIC USE	UNC	2788670	6377830
61208	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2766760	6396620
61209	0	TAKE & DIS GEO FLUID FOR GREENHOUSES	UNG	2766750	6396670
61214	0	TAKE GEOTHREMAL FLUID TO HEAT POOL	UNG	2789180	6383930
61217	0	TAKE WATER FROM A BORE FOR IRRIGATION	UNC	2812310	6373430
61222	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2788370	6380900
61226	0	GEOTHERMAL TAKE & DISCHARGE	UNG	2777590	6390990
61268	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2787530	6382870
61339	0	TAKE FOR FROST PROT & WIDEN EXISTG DRAIN	UNC	2811100	6375250
61389	0	LS EARTHWORKS; STRUCTURE; DIVERT; DIS	UNC	2793160	6376490
61422	0	TAKE & DIS WARM WATER FOR SWIMMING POOL	UNG	2777860	6390870
61431	0	TAKE FOR OMOKOROA PUBLIC WATER SUPPLY	UNC	2774960	6384660
61433	0	TAKE WARM WATER & DIS TO TGA HARBOUR	UNG	2785140	6388070
61459	0	TAKE GROUNDWATER FOR ORCHARD IRRIGATION	UNC	2771500	6392900

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
61477	0	TAKE G/WATER FOR ORCHARD IRRIG & FROST	UNC	2810270	6372980
61516	0	TAKE & DIS GEO FLUID & USE STRUCTURE	UNG	2786800	6388500
61517	0	TAKE & DIS GEOTHERMAL FOR POOL USE	UNG	2776900	6390900
61527	0	TAKE FOR OHOURERE PUBLIC WATER SUPPLY	UNC	2779980	6380770
61573	0	TAKE GROUNDWATER FOR PUBLIC WATER SUPPLY	UNC	2800570	6371790
61574	0	TAKE GROUNDWATER FOR PUBLIC WATER SUPPLY	UNC	2803100	6370600
61672	0	TAKE & DIS GEOTHERMAL FOR DOMESTIC USE	UNG	2791290	6385450
61773	0	TAKE & DIS GROUNDWATER TO LAND	UNC	2779000	6392000
61792	0	TAKE & DIS GEO FLUID FOR COMMERCIAL USE	UNG	2787980	6380730
61960	0	TAKE & DIS GEO WATER-POOL & PRIVATE USE	UNG	2786160	6388420
61964	0	TAKE & DIS GEOTHERMAL FLUID FOR POOL	UNG	2786340	6388440
61978	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2813980	6368570
62045	0	TAKE WATER FROM BORE FOR WATER SUPPLY	UNC	2770000	6417000
62052	0	TAKE & DIS GEO FLUID FOR HEATING	UNG	2786490	6388660
62108	0	TAKE & DIS GEO FLUID FOR PRIVATE USE	UNG	2786470	6388660
62109	0	TAKE WATER FROM BORES FOR IRRIGATION	UNC	2820250	6364720
62170	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2770600	6395980
62218	0	TAKE GEO WATER FOR DOMESTIC USE,SPA,DIS	UNG	2787370	6388370
62247	0	TAKE SURFACE WATER FOR FROST PROTECTION	UNC	2801190	6375630
62369	0	TAKE WATER FOR IRRIGATION & FROST PROTEC	UNC	2812910	6373380
62410	0	TAKE GEO WATER FOR POOL	UNG	2768240	6401090
62428	0	TAKE FROM BORE FOR PUBLIC WATER SUPPLY	UNC	2769010	6409800
62445	0	TAKE WATER FOR IRRIGATION/FROST	UNC	2817010	6366570
62515	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2772810	6397330
62538	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2769090	6397290
62568	0	TAKE WATER FROM BORE FOR IRRI/FROST	UNC	2810200	6375600
62583	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2788960	6383070
62590	0	TAKE WATER FROM BORE FOR POOL	UNG	2778570	6389480
62610	0	TAKE GROUND WATER FOR IRRIGATION	UNC	2809220	6368060
62675	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2800860	6370590
62682	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2806030	6367910
62683	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2770320	6396120
62728	0	TAKE GEO WATER FOR DOMESTIC USE	UNG	2788020	6387360
62741	0	TAKE FROM A BORE FOR IRRIGATION & FROST	UNC	2803600	6369620
62742	0	TAKE FROM BORE FOR IRRIGATION & FROST	UNC	2775490	6388990
62751	0	TAKE FROM A BORE FOR IRRIGATION & FROST	UNC	2772470	6397140
62762	0	EARTHWORKS TO RECONTOUR LAND,TAKE,DIS	UNC	2781630	6383410
62763	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2822530	6369000
62766	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2823740	6367630
62767	0	TAKE GEO WATER FOR POOLS & DOMESTIC USE	UNG	2784750	6382360
62778	0	TAKE WATER FROM BORE & EXCAVATE DAM	UNC	2809820	6363050
62782	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2804520	6372000
62789	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2810860	6369900
62812	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2823580	6367590
62846	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2817470	6368250
62864	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2814050	6369700
62887	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2781630	6383400
62897	0	TAKE WATER FROM BORE FOR FROST PROTECTIO	UNC	2770500	6406220
62928	0	TAKE WATER FROM BORE FOR IRRIGATION/FROS	UNC	2769690	6406010
62929	0	TAKE WATER FROM BORE FOR IRRIGATION/FROS	UNC	2770220	6406030
62930	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2770540	6405920
62931	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2770830	6406090
62957	0	TAKE WATER FROM BORE FOR PUBLIC SUPPLY	UNC	2814170	6369450
62967	0	TAKE WATER FROM BORE FOR FROST PROTECTIO	UNC	2801530	6375360
63006	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2768260	6407850
63007	0	TAKE WATER FROM BORE TO FILL POOL	UNG	2779560	6388750
63039	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNG	2780840	6387250
63049	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2772990	6394590
63065	0	TAKE WATER FROM BORE FOR FROST PROTECTIO	UNC	2780140	6387170
63077	0	TAKE WATER FROM BORE FOR IRRIGATION/FROS	UNC	2808950	6374950
63096	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2767940	6398090
63114	0	TAKE WATER FROM BORE FOR IRRIGATION/FROS	UNC	2809570	6373200
63124	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2823260	6367540
63135	0	TAKE FROM BORE FOR IRRIGATION & FROST	UNC	2814660	6365700
63202	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2815110	6367950
63210	0	TAKE SURFACE WATER FOR IRRIGATION/FROST	UNC	2810960	6374280
63227	0	TAKE & DIS GEO WATER FOR POOL	UNG	2794770	6386750
63233	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2815260	6368210
63238	0	TAKE GROUND WATER FOR IRRIG & FROST	UNC	2768040	6401890
63249	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2811480	6374990
63250	0	L/S EARTHWORKS TO RECONTOUR LAND, TAKE	UNC	2783000	6380000
63251	0	L/S EARTHWORKS FOR SUBDIVISION, TAKE	UNC	2801240	6382810
63253	0	TAKE FROM BORE FOR IRRIGATION	UNC	2797700	6384600
63255	0	L/S EARTHWORKS TO CONSTRUCT CAR PARK	UNC	2793200	6388000
63256	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2812930	6373720
63257	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2814570	6369320
63286	0	TAKE FROM BORE FOR IRRIGATION/FROST	UNC	2809510	6368220
63291	0	L/S EARTHWORKS, TAKE & DISCHARGE	UNC	2796610	6385430
63314	0	TAKE FROM A BORE FOR IRRIGATION & FROST	UNC	2769940	6397620
63326	0	TAKE FROM A BORE FOR IRRIGATION & FROST	UNC	2810590	6374540
63331	0	TAKE FROM A BORE FOR IRRIGATION & FROST	UNC	2808890	6373040
63361	0	TAKE FOR HORTICULTURAL IRRIGATION/FROST	UNC	2810820	6371320
63408	0	Take from a bore for irrigation & frost	UNC	2777100	6389470
63452	0	TAKE FROM BORE FOR FROST PROTECTION	UNC	2770040	6401280
63483	0	L/S EARTHWORKS FOR SUBDIVISION,TAKE,DIS	UNC	2767820	6401510

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
63517	0	TAKE & DIS GEOTHERMAL FLUID FOR DOMESTIC	UNG	2785400	6387700
63528	0	L/S EARTHWORKS, TAKE & DISCHARGE	UNC	2770620	6416500
63617	0	TAKE & DIS GEO FLUID FOR DOMESTIC USE	UNG	2788320	6388090
63623	0	L/S EARTHWORKS & DIS FOR SUBDIVISION	UNC	2802100	6382780
63674	0	L/S EARTHWORKS, PERMANENT S/W DISCHARGE	UNC	2767790	6401280
63711	0	L/S EARTHWORKS & DISCHARGE	UNC	2803900	6382200
63714	0	Take geo from bore & dis geo to Harbour	UNG	2780070	6388760
63746	0	TAKE GROUND WATER FOR IRR & FROST	UNC	2793060	6385710
63751	0	TAKE GEO FLUID AND DIS GEO WASTEWATER	UNG	2794320	6388220
63766	0	TAKE WATER FOR DOMESTIC & ORCHARD IRR	UNC	2799720	6371600
63777	0	TAKE FROM BORE FOR DEWATERING	UNC	2790860	6391290
63843	0	PERMANENT STORMWATER DISCHARGE	UNC	2788200	6387800
63969	0	DIS STORMWATER & GROUNDWATER TO DRAIN	UNC	2809520	6375580
64152	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2809990	6372170
64212	0	TAKE WATER FOR IRRIGATION & FROST PROTEC	UNC	2809120	6374030
64250	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2809070	6374250
64279	0	TAKE & DIS GEO HEAT FOR SWIMMING POOL	UNG	2788010	6388040
64365	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2806220	6370190
64400	0	L/S Earthworks, dewatering and temp dis	UNC	2785500	6384720
64476	0	TAKE & DIS GEO WATER FOR LIGHT COM USE	UNG	2789520	6381010
64527	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2783640	6382420
64528	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2778490	6385080
64544	0	TAKE GEO WATER FROM BORE FOR IRRIGATION	UNG	2772690	6397810
64547	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2800440	6376160
64549	0	TAKE WATER FROM A BORE FOR IRRIGATION	UNC	2770830	6406990
64582	0	TAKE FROM A BORE FOR IRRIGATION/FROST	UNC	2811870	6372120
64584	0	TAKE SURFACE WATER FOR IRRIGATION/FROST	UNC	2808590	6363570
64638	0	TAKE WATER FROM A BORE FOR ORCHARD & DOM	UNC	2799930	6374560
64803	0	TAKE & DIS GEO HEAT FOR DOMESTIC USE	UNG	2787590	6388300
64820	0	STORMWATER DISCHARGE & WATER TAKE	UNC	2796230	6384950
64831	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2771140	6406950
64839	0	TAKE WATER FROM BORES FOR IRRIG & FROST	UNC	2809950	6367370
64854	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2804750	6365590
64869	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2804500	6373700
64881	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2768120	6397080
64919	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2788180	6387330
64929	0	TAKE WATER FROM 2 BORES FOR IRRIG & FROS	UNC	2812580	6367000
64941	0	TAKE WATER FROM BORE FOR IRRIGATION	UNC	2810030	6363020
64968	0	TAKE WATER FROM BORE FOR ORCHARD IRRIG	UNC	2771350	6405290
64970	0	TAKE WATER FROM BORE FOR ORCHARD IRRIG	UNC	2769100	6406700
64977	0	TAKE WATER FROM A BORE FOR ORCHARD IRRIG	UNC	2771000	6405000
64978	0	TAKE WATER FROM A BORE FOR IRRIG & FROST	UNC	2769160	6406840
64983	0	TAKE & DIS GEO HEAT FOR DOMESTIC USE	UNG	2771620	6397450
64985	0	Take water from bore for Holiday Park	UNC	2808760	6373360
64989	0	L/S EARTHWORKS, DIS, TAKE & INSTALL BORE	UNC	2796700	6386000
64992	0	INSTALL A BORE	UNC	2796700	6386000
65004	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2769900	6405200
65007	0	TAKE WATER FOR IRRIGATION & FROST PROTEC	UNC	2812130	6374500
65008	0	TAKE & DIS GEO HEAT FOR SWIMMING POOL	UNG	2798710	6383420
65009	0	TAKE WATER FROM BORE FOR IRRIG & FROST P	UNC	2769600	6405200
65014	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2810630	6371590
65016	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2784670	6376350
65030	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2770300	6404400
65034	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2787780	6377730
65036	0	TAKE WATER FROM BORE FOR ORCHARD IRRIGAT	UNG	2771110	6412290
65041	0	TAKE WATER FROM A BORE FOR IRRIG & FROST	UNC	2806350	6367740
65043	0	L/S EARTHWORKS & TEMP DIS TO EXCAVATE SI	UNC	2790580	6391660
65051	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2771800	6406200
65056	0	TAKE WATER FROM BORE FOR IRRIG & FROST P	UNC	2801750	6376000
65099	0	TAKE FROM BORE & COAST; DIS TO PILOT BAY	UNG	2790260	6391430
65117	0	EARTHWORKS & DIS TO WATER & TO LAND	UNC	2791270	6388090
65131	0	TAKE GEO WATER FOR DOMESTIC USE	UNG	2785200	6382600
65137	0	Take & discharge geothermal water	UNG	2780400	6387480
65161	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2781810	6387270
65169	0	INSTALL A BORE	UNG	2780800	6386910
65170	0	L/S EARTHWORKS, TAKE & DIS FOR SUBD	UNC	2778900	6390700
65185	0	INSTALL A HOT WATER BORE	UNG	2796070	6378970
65195	0	L/S EARTHWORKS & TEMP WATER TAKE	UNC	2800730	6382610
65201	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2770600	6405400
65203	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2775000	6388830
65204	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2782430	6378980
65205	0	TAKE WATER FROM BORE FOR IRRIG & FROST P	UNC	2811930	6367350
65237	0	L/S EARTHWORKS FOR SUBDIVISION	UNC	2810770	6370280
65248	0	TAKE WATER FROM A BORE FOR IRRIG & FROST	UNC	2809800	6369800
65258	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2771380	6404970
65259	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2770680	6405870
65275	0	INSTALL A BORE	UNC	2859000	6337000
65279	0	TAKE & DIS GEO WATER FOR DOMESTIC USE	UNG	2789520	6376490
65280	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2768200	6403500
65284	0	TAKE WATER FROM A BORE FOR HORT IRRIG	UNC	2771700	6406100
65288	0	TAKE WATER FROM A BORE FOR HORT IRRIG	UNC	2780100	6386600
65292	0	TAKE WATER FROM BORE FOR NURSERY IRRIG	UNC	2769080	6406450
65294	0	TAKE WATER FROM BORE FOR ORCHARD IRRIG	UNC	2772700	6406300
65309	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2781700	6387000
65310	0	TAKE WATER FROM BORE FOR HORT IRRIGATION	UNC	2769400	6405400

Consent number	Ext	Purpose	Code3	NZMG X	NZMG Y
65313	0	TAKE WATER FROM BORE FOR IRRIG & FROST	UNC	2769500	6405600
65318	0	TAKE & DIS GEO FLUID FOR DOMESTIC USE	UNG	2774050	6411200
65345	0	INSTALL A BORE	UNC	2813700	6363510
65346	0	TAKE WATER FROM BORE FOR IRRIG & FROST P	UNC	2816090	6369080
65371	0	Take groundwater for irrigation & frost	UNC	2809460	6369990
65400	0	Take ground water for irrig & frost	UNC	2769900	6406100
65401	0	take from 5 bores for golf course irrig	UNC	2794000	6388000
65404	0	Install and test a bore	UNC	2801750	6369350
65408	0	Install and test a bore	UNC	2810480	6369900
65409	0	Take ground water to irrig cricket pitch	UNC	2791500	6389500
65415	0	Take groundwater for frost protn & irrig	UNC	2812590	6373200
65440	0	Take groundwater	UNC	2806300	6371880
65441	0	Take groundwater	UNC	2770600	6406900
65442	0	Install and test bore	UNG	2787940	6379380
65449	0	Take ground water for irrigation	UNC	2771400	6407300
65490	0	Carry out earthworks	UNC	2801370	6375660
65492	0	Take groundwater for irrigation and fros	UNC	2811480	6365870
65498	0	Take groundwater	UNC	2810510	6371020
65503	0	Take groundwater for irrigation and fros	UNC	2811320	6364590
65521	0	Geothermal take and discharge - Tga	UNG	2786340	6388720
65529	0	Take groundwater for irrigation & frost	UNC	2780690	6373320
65534	0	Works to construct pump station	UNC	2786800	6380400
65557	0	Install and test a bore	UNC	2799460	6383890
65570	0	Take groundwater for irrigation & frost	UNC	2821700	6370100
65574	0	Test bore (take & discharge)	UNG	2814050	6369000
65582	0	Take groundwater for irrigation & frost	UNC	2806880	6371030
65591	0	Geothemal take and discharge	UNG	2796060	6378960
65610	0	Install a bore - Paengaroa	UNC	2811860	6366920

APPENDIX 19 GROUNDWATER ALLOCATION BY SURFACE CATCHMENT, JANUARY 2009

Categories of allocation used in this table are:

- 'general' used for the EBOP allocation data field 'MAX DAILY QUANTITY' which appears to represent:
  - allocation that is not either for frost protection or for irrigation;
  - multiple types of use (e.g. domestic and irrigation) when the use types are not split.
- 'frost protection' which is the EBOP allocation dat field 'MAX DAILY QUANTITY (FROST)';
- 'irrigation' which is the EBOP allocation dat field 'MAX DAILY QUANTITY (IRRIGATION).

Some consents under the 'general' category are assigned to 'take' and 'discharge'. The following table assumes allocation at the rate of 'take'. Some consents appear to have incorrect units (e.g. L/s when the unit should be m^3/day). All allocation is assumed as m^3/day.

Six consents have no location information and the location is estimated from the street address. These consents are numbers: 61516, 60999, 61773, 63250, 63255 and 64869.

Note that 26 of the consents in the Western Bay of Plenty area do not have allocation data in the EBOP allocation database and:

- 11 of these consents are for construction;
- 6 of these consents are for bore installation;
- 8 of these are for groundwater take;
- 1 of these is for stormwater discharge.

Surface catchment number	Surface catchment name	General (m^3/day)	Frost protection (m^3/day)	Irrigation (m^3/day)	Total (m^3/day)
1	Aongatete	0	0	1285	1285
2	Apata	527	0	706	1233
3	Kaitemako	185.4	0	0	185.4
4	Katikati Streams	1000	0	707	1707
5	Kopurererua	3652.5	2514	2075	8241.5
6	Lower Kaituna	45170.5	45262	52599.4	143031.9
7	Maketu				0
8	Mangapapa/Opuiaki				0
9	Mangorewa	1584	3000	3000	7584
10	Matakana Island	209	0	769	978
11	Maungatawa Area	13012.7	212	4958	18182.7
12	Omanawa	681	0	2645.6	3326.6
13	Ongare/Tanners Point	4560.5	2463	2584	9607.5
14	Otumoetai Area	2684.6	0	150	2834.6
15	Oturu	1297	1256	1826	4379
16	Tahawai	485	0	1068	1553
17	Tauranga City Area	2366.7	0	0	2366.7
18	Te Mania	1180	0	618	1798
19	Te Puna	1402.9	0	2013.4	3416.3
20	Te Puna Area	0	0	118	118
21	Te Rereatukahia	1566	0	306	1872
22	Tuapiro	0	1074	1269	2343
23	Uretara	540	0	400	940
24	Waiau	9782.4	0	1175	10957.4
25	Waihi Beach	2700	0	865	3565
26	Waimapu	3812.55	408	3385.6	7606.15
27	Wainui	636	734	820	2190
28	Waione	967.97	1180	3353.9	5501.87
29	Waipapa	16213.6	1365	3916.5	21495.1
30	Wairoa-Ngamawahine	46.7	0	0	46.7
31	Wairoa-Ohourere	12960	0	0	12960
32	Wairoa-Wairoa	3288.5	115	1550	4953.5
33	Waitao Area	330	0	806	1136
34	Waitekohe	808.6	0	275	1083.6
35	Welcome Bay Area	1907	227	460	2594
36	Whatakao	66	0	690	756
	Total	**135624.12**	**59810**	**96394.4**	**291828.52**

APPENDIX 20 GROUNDWATER ALLOCATION BY GEOLOGICAL UNIT, JANUARY 2009 ALLOCATION

The depth of wells is identified by:

- searching the Environment Bay of Plenty lithological database for wells associated with consents;
- consents with multiple wells are assigned the well number listed with the consent ;
- a total of 352 wells are identified that have well depths and this is less than the number of consents because:
  - many consents do not have well numbers;
  - many wells do not have recorded depths.

Approximately 50% of total groundwater allocation is in wells with recorded well depths (Table A20.1).

Allocation by geological unit is assessed by the procedure:

- estimate elevation of the ground surface at the well by interpolating, in Earth Vision software, the digital terrain model tgadtml.2grd;
- estimate the elevation of the base of the well;
- interpolate formation name, from ground location and elevation of the base of the well, using Earth Vision software with file tgamodell.seq.

Allocation is summed by geological formation and surface catchment (Table A20.2).

Table A20.1 Total allocation in surface catchments and allocation in wells with recorded depths.

Surface catchment number	Surface catchment name	Total (m^3/day)	Allocation with well log depth (m^3/day)	Allocation with well log divided by total allocation (%)
1	Aongatete	1285	898	70
2	Apata	1233	1013	82
3	Kaitemako	185.4	95.4	51
4	Katikati Streams	1707	1707	100
5	Kopurererua	8241.5	1703.5	21
6	Lower Kaituna	143031.9	59282	41
7	Maketu	0	0	na
8	Mangapapa/Opuiaki	0	0	na
9	Mangorewa	7584	0	0
10	Matakana Island	978	978	100
11	Maungatawa Area	18182.7	8301.7	46
12	Omanawa	3326.6	2535.6	76
13	Ongare/Tanners Point	9607.5	5888	61
14	Otumoetai Area	2834.6	2296.5	81
15	Oturu	4379	2949	67
16	Tahawai	1553	868	56
17	Tauranga City Area	2366.7	1742.7	74
18	Te Mania	1798	507	28
19	Te Puna	3416.3	2596.9	76
20	Te Puna Area	118	118	100
21	Te Rereatukahia	1872	1872	100
22	Tuapiro	2343	1395	60

Surface catchment number	Surface catchment name	Total (m^3/day)	Allocation with well log depth (m^3/day)	Allocation with well log divided by total allocation (%)
23	Uretara	940	640	68
24	Waiau	10957.4	6640.4	61
25	Waihi Beach	3565	2845	80
26	Waimapu	7606.15	5894.6	77
27	Wainui	2190	1256	57
28	Waione	5501.87	3298	60
29	Waipapa	21495.1	19419.1	90
30	Wairoa-Ngamawahine	46.7	0	0
31	Wairoa-Ohourere	12960	0	0
32	Wairoa-Wairoa	4953.5	3395.2	69
33	Waitao Area	1136	1096	96
34	Waitekohe	1083.6	628.6	58
35	Welcome Bay Area	2594	2334	90
36	Whatakao	756	556	74
	Total	**291828.52**	**144750.2**	**50**

Table A20.2 Allocation by geological formation and surface catchment.

Surface catchment number	Surface catchment name	Tauranga Group	Waimakariri Ignimbrite	Waiteariki Ignimbrite	Aongatete Ignimbrite	Minden and Otawa	Coromandel	Sum catchment
1	Aongatete	0	0	390	508	0	0	898
2	Apata	75	0	568	370	0	0	1013
3	Kaitemako	0	0	0	95.4	0	0	95.4
4	Katikati Streams	707	0	582	418	0	0	1707
5	Kopurererua	0	0	1653.5	50	0	0	1703.5
6	Lower Kaituna	26896	0	3791	28595	0	0	59282
7	Maketu	0	0	0	0	0	0	0
8	Mangapapa/Opuiaki	0	0	0	0	0	0	0
9	Mangorewa	0	0	0	0	0	0	0
10	Matakana Island	978	0	0	0	0	0	978
11	Maungatawa Area	3307	0	3159.7	831	1004	0	8301.7
12	Omanawa	0	0	2235.6	300	0	0	2535.6
13	Ongare/Tanners Point	5348	0	0	540	0	0	5888
14	Otumoetai Area	918.5	0	1318.3	59.7	0	0	2296.5
15	Oturu	0	0	967	1982	0	0	2949
16	Tahawai	0	0	0	868	0	0	868
17	Tauranga City Area	0	0	0	1742.7	0	0	1742.7
18	Te Mania	0	0	0	507	0	0	507
19	Te Puna	0	0	1605	991.9	0	0	2596.9
20	Te Puna Area	0	0	0	118	0	0	118
21	Te Rereatukahia	150	0	0	862	0	860	1872
22	Tuapiro	0	0	0	845	0	550	1395

Surface catchment number	Surface catchment name	Tauranga Group	Waimakariri Ignimbrite	Waiteariki Ignimbrite	Aongatete Ignimbrite	Minden and Otawa	Coromandel	Sum catchment
23	Uretara	240	0	400	0	0	0	640
24	Waiau	930	0	0	530.4	0	5180	6640.4
25	Waihi Beach	0	0	0	585	0	2260	2845
26	Waimapu	0	156	3972.6	1766	0	0	5894.6
27	Wainui	182	0	636	438	0	0	1256
28	Waione	586	0	1534	1178	0	0	3298
29	Waipapa	172.5	0	17898.6	1348	0	0	19419.1
30	Wairoa-Ngamawahine	0	0	46.7	0	0	0	46.7
31	Wairoa-Ohourere	0	0	0	0	0	0	0
32	Wairoa-Wairoa	300	273	2413.5	362	0	0	3348.5
33	Waitao Area	0	0	120	976	0	0	1096
34	Waitekohe	55	0	340	220	0	13.6	628.6
35	Welcome Bay Area	0	0	885	1358	91	0	2334
36	Whatakao	0	0	0	556	0	0	556
	Total	40845	429	44516.5	49001.1	1095	8863.6	144750.2

APPENDIX 21 ESTIMATES OF ERRORS IN DEEP GROUNDWATER RECHARGE CALCULATIONS

Catchment number	Catchment name	Rainfall (L/s)	Rainfall recharge (L/s)	Base flow discharge (L/s)	Rainfall recharge minus baseflow discharge (L/s)	Estimated deep groundwater recharge (L/s)	Error rainfall recharge (L/s) (+/- 20% on rainfall recharge)	Error stream flow (L/s) (+/- 20% on base flow)	Total error rainfall - baseflow (L/s)
1	Aongatete	2776	1269	583	686	686	254	117	371
2	Apata	664	288	28	260	260	58	6	64
3	Kaitemako	636	297	70	227	227	59	14	73
4	Katikati Streams	442	132	0	132	132	26	0	26
5	Kopurererua	4353	2175	1713	462	462	435	343	778
6	Lower Kaituna (hills)	17100	8559	20928	-12369	0	1712	4186	5898
6a	Lower Kaituna (Plain)	5700	1708	0	1708	854	342	0	342
7	Maketu	79	24	0	24	24	5	0	5
8	Mangapapa/Opuiaki	11811	5905	0	5905	0	1181	0	1181
9	Mangorewa	12919	6448	0	6448	0	1290	0	1290
10	Matakana Island	2358	707	0	707	707	141	0	141
11	Maungatawa area	1936	686	184	502	502	137	37	174
12	Omanawa	5696	2848	0	2848	0	570	0	570
13	Ongare/Tanners Point	634	190	15	175	175	38	3	41
14	Otumoetai area	592	211	207	4	4	42	41	83
15	Oturu	424	146	30	116	116	29	6	35
16	Tahawai	722	268	69	199	199	54	14	68
17	Tauranga City area	229	84	0	84	84	17	0	17
18	Te Mania	837	311	210	101	101	62	42	104
19	Te Puna	1698	509	641	-132	0	102	128	230
20	Te Puna area	139	771	0	771	771	154	0	154
21	Te Rereatukahia	1223	523	220	303	303	105	44	149
22	Tuapiro	3200	1514	1012	502	502	303	202	505
23	Uretara	2183	896	406	490	490	179	81	260
24	Waiau	1788	800	321	479	479	160	64	224
25	Waihi Beach	1309	523	25	498	498	105	5	110
26	Waimapu	6805	3393	1444	1949	1949	679	289	968
27	Wainui	2474	1159	1753	-594	0	232	351	583
28	Waione	441	132	3	129	129	26	1	27
29	Waipapa	2764	1292	516	776	776	258	103	361
30	Wairoa_Ngamawahine	7700	3850	0	3850	0	770	0	770
31	Wairoa_Ohourere	1929	965	166	799	799	193	33	226
32	Wairoa_Wairoa	3914	1712	11825	-10113	408	342	2365	2707
33	Waitao area	2094	1026	202	824	824	205	40	245
34	Waitekohe	1285	536	132	404	404	107	26	133
35	Welcome Bay area	658	309	49	260	260	62	10	72
36	Whatakao	1801	798	266	532	532	160	53	213
	Sum (L/s)	77594	36249	22090	14159	13657	7250	4418	11668
	Sum (m^3/s)	77.6	36.2	22.1	14.2	13.7	7	4	11