greater WELLINGTON
REGIONAL COUNCIL

Review of the Greater Wellington hydrological monitoring network

Contents

1. Introduction

This report is a review of the Greater Wellington Regional Council (Greater Wellington) hydrological monitoring network. The objective of the review is to find out whether any changes are necessary to ensure that the network provides appropriate information to help us sustainably manage water resources of the Wellington region, and provide warning of flood hazards.

This review provides recommendations for changes to the network, and prioritises the recommendations as low (5-7 year timeframe), medium (2-5 year timeframe) or high (2 year timeframe). The report does not include anticipated costs. Parallel reports will be produced on costs and programming to implement the recommendations.

Greater Wellington operates the hydrological monitoring network as part of an overall environmental monitoring programme. The hydrological monitoring network provides information about water quantity in the Wellington region, i.e. rainfall, river levels and flows, lake levels, soil moisture and groundwater levels. This review is of the network of permanent stations where these variables are measured, specifically:

- Automatic and storage rainfall monitoring sites;
- Climate and soil moisture monitoring sites;
- Automatic river level/flow monitoring stations;
- Automatic lake level monitoring stations;
- Automatic tide monitoring stations; and
- Automatic and manually dipped groundwater level monitoring sites.

The network is operated by the Environmental Monitoring and Investigations Department, with offices and hydrological data servers in two offices (Wellington and Masterton). Greater Wellington's network is supplemented by hydrological monitoring sites operated by MetService, NIWA and National Rural Fire Authority (NRFA). These sites will be considered in the review where appropriate.

2. What do we want from the network?

2.1 Rationale and aims of the hydrological monitoring network

Greater Wellington operates the hydrological monitoring network to meet its statutory requirements under the Resource Management Act 1991 (RMA) and the Civil Defence and Emergency Management Act (CDEMA) 2002. The relevant parts of these legislations provide the rationale for the network.

The purpose of the RMA (Part II, section 5) is to promote the sustainable management of natural and physical resources. Regional councils are required to monitor the state of the environment of their region to the extent that is appropriate to enable them to effectively carry out their functions under the RMA (Part IV, section 35). Relevant functions are the establishment and implementation of policies to achieve integrated management of natural and physical resources, the control of the taking, use, damming and diversion of

water, and the control of the quantity, level and flow of water in any water body. Section 35 also requires regional councils to:

- Monitor the efficiency and effectiveness of policies, rules, or other methods in their policy statements or plans;
- Monitor the exercise of any functions, powers, or duties delegated or transferred by that regional council; and
- Monitor the exercise of the resource consents that have effect in their region (Part IV, section 35, reworded).

The CDEMA requires CDEM Groups to identify, assess, and manage hazards and risks, consult and communicate about hazards and risks and identify and implement cost-effective risk reduction. The Wellington region CDEM Group Plan, developed under the CDEMA 2003, specifies that Greater Wellington has the responsibility to operate a floodwarning system. The hydrological monitoring network is vital for carrying out this function.

The **principle aim** of the hydrological monitoring network is proposed to be:

> **To collect hydrological data which helps us effectively carry out our Resource Management Act 1991 functions and duties, and which enables us to operate an effective flood warning system for the Wellington region**.

A secondary aim of the network is to provide data to support other Greater Wellington activities, such as bulk water supply and flood protection, and to provide data for commercial use (such as to assist territorial authorities in carrying out their functions).

2.2 Desirable attributes of a hydrological monitoring network

To achieve the aims listed above, it is vital the hydrological network provides data which is:

- Suitable for developing policies, and assessing consent applications and compliance;
- Adequate to accurately define the water resources of the region;
- Appropriate for promoting the sustainable use of resources;
- Suitable to be used as input for hydrological models and design purposes; and
- Able to show trends (both spatial and temporal).

Desirable attributes of a hydrological monitoring network are therefore:

(i) Good spatial coverage

The network should adequately cover the region to enable accurate interpolation over areas where records are not collected.

(ii) Strategic design

Monitoring sites should be located at appropriate locations to ensure their intended purpose is met. Other aspects of strategic monitoring include: monitoring of resources which are particularly significant or sensitive; anticipating future data requirements; linking the network with other monitoring programmes (e.g. water and air quality); and/or locating single stations to meet several monitoring objectives.

(iii) Continuity

Reliable statistical analysis (e.g. to detect trends) requires long data records collected at an appropriate sampling interval and good data continuity (minimisation of record gaps).

(iv) High quality

Data collected from the hydrological monitoring network should be of the highest possible standard, to allow it to be used confidently for any purpose in the future.

(v) Availability and timeliness

Data collected from the network should be readily available, and collected in real-time wherever possible.

(vi) Efficiency and cost-effectiveness

Data should be collected in an efficient manner and ensure cost-effective use of ratepayer money.

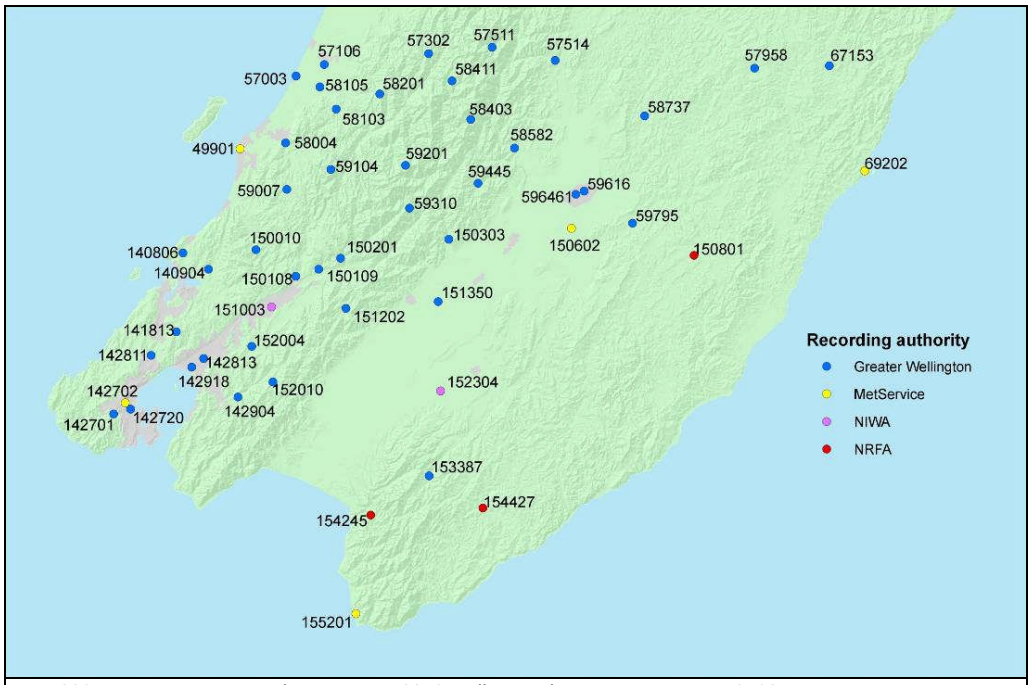
The hydrological network is generally reviewed based on these six attributes.

3. Rainfall station review

3.1 The network

Collection of rainfall data is a vital part of our hydrological monitoring. Rainfall data is the first step in our floodwarning and flood modelling system, and is important for detection of long-term hydrological trends, resource definition, and reporting to ensure sustainable water use.

Greater Wellington operates a network of 42 automatic rainfall stations, which is supplemented by data from stations operated by external agencies (Figure 1). In addition to the automatic stations, Greater Wellington operates several storage rain gauges in the Tararua Range, and at many locations throughout the region privately-owned storage rain gauges are read on a daily basis and the data stored in the National Climate Database.



49901 Paraparaumu aerodrome	59310 Bull Mound	150109 Te Marua
57003 Sims Road	59445 Valley Hill	150201 Kaitoke Headworks
57106 Otaki Depot	59616 Wairarapa College	150303 Phelps
57302 Oriwa	59795 Te Weraiti	150602 East Taratahi
57511 Bannister	67153 Tanawa Hut	150801 Ngaumu
57514 Mt Bruce	69202 Castlepoint	151003 Wallaceville
57958 Castlehill	140806 Whenua Tapu	151202 Centre Ridge
58004 Water Treatment Plant	140904 Snodgrass	151350 Alloa
58103 Transmission Lines	141813 Waynes Mistake	152004 Tasman Vaccine Limited
58105 Centrepoint	142701 Karori Reservoir	152010 Orongo Swamp
58201 Taungata	142702 Kelburn	152304 Martinborough
58403 Angle Knob	142720 Regional Council Centre	153387 Iraia
58411 Carkeek	142811 Seton Nossiter Park	154245 Haurangi
58582 Waingawa	142813 Shandon Golf Course	154427 Stony Creek
58737 Waihi	142904 Wainuiomata Reservoir	155201 Ngawihi
59007 Warwicks	142918 Birch Lane	596461 Masterton Office
59104 Kapakapanui	150010 Blue Gum Spur	
59201 McIntosh	150108 Cemetery	

Figure 1: Automatic rainfall stations in the Wellington region

3.2 Network evaluation

3.2.1 Coverage

The existing network generally provides good spatial coverage, particularly of the western part of the Wellington Region and the Tararua Range. However, there are some areas of relatively poor automatic rainfall station coverage, such as the eastern Wairarapa hills. Additional rain gauge coverage is needed to improve rainfall mapping (and therefore resource definition) in the following areas:

- Makara
- Paekakariki
- South Wainuiomata coast
- Western Lake Wairarapa
- South Wairarapa plains
- Eastern Wairarapa – Pahaoa catchment, Riversdale, Longbush valley.

3.2.2 Network design – is it strategic?

The rainfall monitoring network initially developed from a basis of floodwarning, and data collection for water supply planning. More recently, the network has been expanded to consider other uses of rainfall data, such as post-storm rainfall distribution analysis, groundwater recharge modelling, and drought monitoring.

The review team considered the current network design in view of monitoring significant or sensitive resources (e.g. flood prone areas, wetlands), future data requirements (e.g. where urbanisation or land use intensification is occurring), and linkages with other programmes (e.g. knowledge required for rainfall runoff or groundwater recharge modelling; Rivers State of Environment (RSOE) water quality programme).

In general existing rainfall stations serve their intended purpose. One exception is *Tasman Vaccine Limited*, which may not record rainfall representative of the Mangaroa catchment. A new floodwarning gauge for the Mangaroa catchment should be installed near the catchment divide with the Wainuiomata catchment, and the appropriateness of *Tasman Vaccine Limited* for groundwater recharge monitoring and low flow modelling should be investigated. If the station is not deemed appropriate for those uses then it should be removed following a correlation period.

The review found additional rainfall stations are required at the locations listed for the following purposes:

- Flood warning and flood modelling (Waipoua catchment, upper Kopuaranga/Whangaehu catchment, lower Whangaehu catchment, lower Kopuaranga catchment, mid-Whareama catchment, Longbush, Pahaoa catchment, western Haurangi Range)

- Monitoring of sensitive environments (Paekakariki QE Park, Pencarrow Lakes)

- Groundwater recharge modelling (West Carterton at Belvedere, Carterton east, mid-Ruamahanga valley, lower Ruamahanga valley)

- Drought or farm reporting (Makara, western Lake Wairarapa, upper Kopuaranga/Whangaehu, lower Kopuaranga, mid-Whareama, Carterton east, mid-Ruamahanga, Longbush, Pahaoa, lower Ruamahanga, Riversdale).

The new rainfall stations proposed are generally in locations that ensure more than one monitoring objective is met.

Additional rainfall stations for flood warning or flood model input are vital for improving accuracy of the flood models and our flood warning system, particularly if the frequency of easterly storm events is increasing.

In the past, Greater Wellington's rainfall monitoring of the Wairarapa plains has been limited. If we are to promote efficient use of water over the summer months, and provide more useful information during droughts, rainfall monitoring of the plains and eastern farming country needs to be improved. This is particularly important in areas where land use, and therefore water use, has intensified.

3.2.3 Continuity

Rainfall data is collected at an appropriate logging interval (generally 5 minutes) at all automatic rainfall stations. Some stations have less than 10 years of record and so are not yet reliable for statistical analysis; monitoring should continue at these sites to allow longer records to be built up.

Greater Wellington obtains rainfall data from the National Rural Fire Authority rainfall stations at *Stoney Creek* and *Ngaumu*, but we do not currently archive the data. The data from the stations should be archived to the hydrological database to ensure that a record for the sites can be established.

3.2.4 Data quality

Greater Wellington rainfall stations are established and maintained according to hydrometric standards, to ensure high data quality. Changes to the existing network to improve data quality could include upgrading the rain-o-matic gauges operated at some locations to more accurate OTA gauges.

There is some concern that the quality of rainfall data collected at *Waynes Mistake* may be adversely affected by pine trees surrounding the gauge, which have grown substantially in recent years. It is inevitable that the rainfall station will need to be relocated or removed. An investigation into the necessity for a rainfall station in this area should be carried out, and if it is decided that a station is needed then an alternative nearby location should be found.

3.2.5 Availability and timeliness

Nearly all automatic rainfall stations in the Wellington region are telemetered. Those which are not (*Blue Gum Spur, Iraia, Bannister, Phelps*) are generally problematic sites in terms of communications. Investigations are already underway to determine how these sites can be telemetered.

Bull Mound is a rainfall station of interest to floodwarning in both the Tauherenikau and Hutt Rivers, but is currently telemetered only to the Masterton office. The system should be reconfigured so that staff in the Wellington office have the ability to interrogate the station.

3.2.6 Efficiency and cost-effectiveness

In general the rainfall station network runs efficiently and in a cost-effective manner. To ensure future efficiency, new rainfall stations should be located at existing hydrological monitoring stations (e.g. groundwater or river level stations) wherever possible.

To improve the efficiency of hydrological monitoring in the Waiohine catchment, the existing *Phelps* rainfall station should be moved to the river level site *Waiohine at Gorge*. This will also allow the existing telemetry at the water level site to be used. Some work has already been undertaken to activate this recommendation.

The rainfall station at *Blue Gum Spur* has a history of technical and access problems. The previous network review (Harkness, 1999) recommended investigations into its possible closure, although the recommendation may not have been carried out. Discussions with Water Supply staff indicate that due to future water supply investigations they would not like to see the station closed. Thus although the site may not currently be cost-effective to run, we should continue operating the site or investigate an alternative location for a rainfall station in the upper Whakatikei catchment.

Landcorp operate a rainfall stations at the Wairio and Awaroa blocks on the southern Wairarapa plains east of Lake Wairarapa. The location of these rainfall stations is useful for both network coverage and farm reporting objectives, as mentioned in Sections 3.2.1 and 3.2.2. It would be more cost-effective and efficient for Greater Wellington to obtain real-time access to the data than to install a new rainfall station in the area, and this should be investigated.

The proposed new rainfall stations could be located at existing hydrological monitoring sites to ensure network efficiency. Also, wherever possible the automatic rainfall stations should be located at places where daily rainfall records have been kept in the past (e.g. Waiorongomai, Pururnui, Te Wharau) to allow long-term rainfall trend analyses to be carried out.

Currently a network of stand-alone storage rainfall gauges is operated in the Tararua Range, to aid in mapping rainfall variation over the range. The network includes two gauges on the Wairarapa side of the range, and 10 gauges

in the Western Tararua Range. The data from the Western Tararua storage gauges are rarely used, and staff believe that the gauges are not cost-effective to operate. These gauges should be closed after January 2007, when 10 years of data will have been collected (a reliable length of record should the data ever be used). To more accurately define rainfall variation in the upper Ruamahanga and Tauherenikau catchments two additional storage gauges should be installed in this area.

3.3 Summary of recommendations

Recommendation	Priority
Existing network:	
Maintain the existing automatic rainfall station network	High
Continue work to telemeter the remaining non-telemetered rainfall stations (*Iraia*, *Bannister*, *Phelps*).	High
Move *Phelps* to *Waiohine at Gorge*	High
Investigate the importance of maintaining a rainfall station at or near *Waynes Mistake*. If it is found that a station is required, investigate alternative nearby locations.	High
Archive rainfall data from *Stoney Creek* and *Ngaumu*	High
Investigate alternative locations for a rainfall station in the upper Whakatikei catchment to replace *Blue Gum Spur*. If a location cannot be found, investigate telemetry options for *Blue Gum Spur*.	Medium
Upgrade *Bull Mound* so that the Wellington office has interrogation ability	Medium
Upgrade *Waiorongomai* (Western Lake Wairarapa) to an automatic, telemetered station	Medium
Investigate how rainfall records from Wairio Block and/or Awaroa (Landcorp) can be obtained and install any necessary telemetry equipment	Medium
Upgrade all rain-o-matic gauges to OTA gauges, except where the rainfall data is not considered important	Low
Investigate the relocation of *Tasman Vaccine Limited* to a site more representative of the Mangaroa catchment	Low
Close all storage rainfall stations in the western Tararua Range after January 2007	Low
Install new automatic, telemetered rainfall stations at the following locations (Figure 2):	
Paekakariki township / Queen Elizabeth Park	High
Upper Waipoua (possibly at Kiriwhakapapa)	High
West of Carterton (possibly at *Mangatarere at Belvedere* new river flow site)	High
Whangaehu subcatchment of Huangarua (Longbush valley at Eringa)	High
Upper Kopuaranga or Kopuaranga/Whangaehu catchment divide	High
Mid Ruamahanga valley (possibly at Papawai)	High
Makara	Medium

Lower Ruamahanga valley	Medium
Eastern Wairarapa (Pahaoa catchment in Hikawera area)	Medium
Carterton East (possibly at *Baring* groundwater site)	Medium
Riversdale township	Low
Pencarrow Lakes (in conjunction with lake level monitoring – Section 6)	Low
Western Haurangi Range	Low
Investigate the necessity for rainfall stations in the following locations:	
Mid-Whareama catchment at Rewanui (investigate if *Ngaumu* is adequate to cover this area)	Medium
Eastern Wairarapa at Te Wharau (investigate if *Ngaumu* is adequate to cover this area)	Medium
Te Ore Ore area in lower Whangaehu catchment (investigate if *Wairarapa College* is considered adequate to cover this area)	Low
Lower Kopuaranga catchment, for floodwarning and low flow modelling purposes	Low
Install new storage gauges at the following approximate locations:	
Mid-altitude Tauherenikau catchment	Low
Mid-altitude Ruamahanga catchment	Low

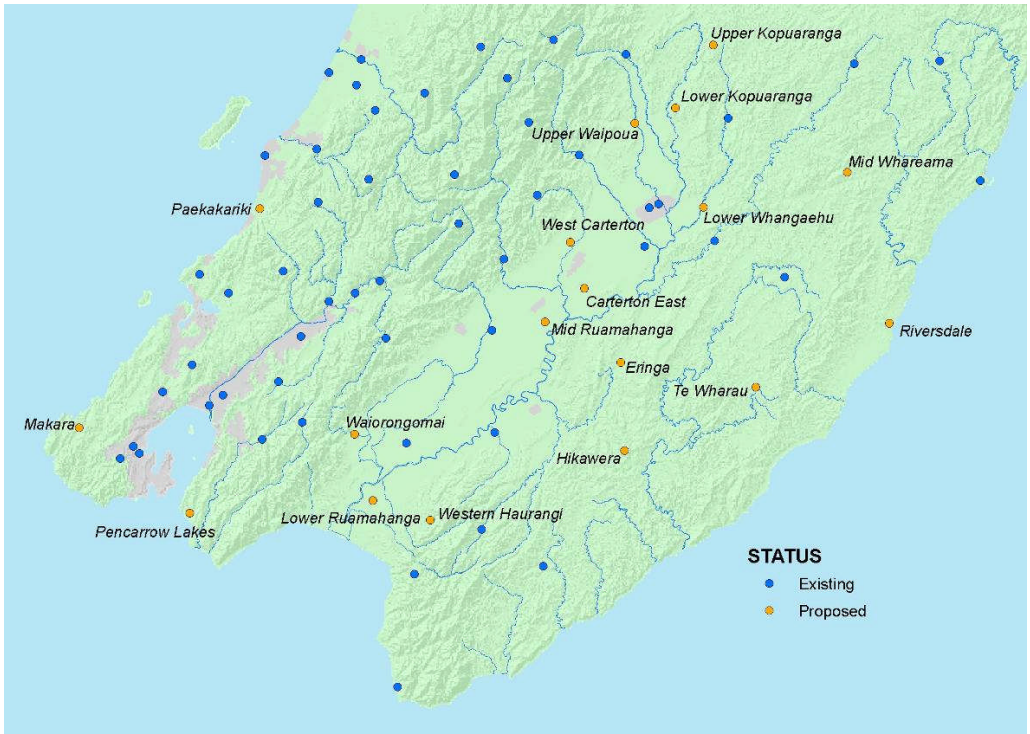


Figure 2: Approximate locations of proposed new rainfall stations

4. Climate and soil monitoring station review

4.1 The network

Greater Wellington operates several climate stations (Figure 3) that are generally associated with air quality or rainfall monitoring stations. The climate parameters measured are usually temperature, wind speed, wind direction, relative humidity, and solar radiation. At some of these locations soil moisture is also monitored. Additional climate and soil moisture stations are operated by MetService and NIWA, and the archived data is available to Greater Wellington through the National Climate Database.

Climate data is important for assisting in the analysis of hydrological and air quality data. For example, temperature and solar radiation data is used to estimate evaporation rates, and knowledge of the links between climate and air quality helps in determining likely conditions for breaches in air quality standards. Climate and soil moisture data is also important for drought reporting and for use in the promotion of efficient irrigation practises.

4.2 Network evaluation

Although the regional spatial coverage of Greater Wellington's climate monitoring station is relatively poor, the data is supplemented by numerous NIWA and MetService climate stations. The main area of poor climate data coverage is the eastern Wairarapa hills. Some climate data may be useful for this area for drought reporting (for farming information). Lake Wairarapa climate (wind speed and direction) information may also be useful for recreational reporting and health and safety.

In terms of air quality monitoring, Greater Wellington operates climate stations in all air sheds except Porirua, Kapiti Coast, and Karori. In general, data from externally-operated climate stations cannot be used for air pollution studies, because the sampling interval is too long (1 hour). An investigation is required into the need for permanent, 15-minute sampling interval climate stations in these air sheds.

Currently, Greater Wellington does not report soil moisture status on a routine basis during the irrigation season. However, to promote irrigation efficiency, particularly as water resources are coming under increasing pressure, it is anticipated that soil moisture and temperature data will be very useful in the near future. Soil moisture data may also be used in the Wairarapa groundwater model and the recalibration of the Ruamahanga flood model.

Greater Wellington invests in the planting of poles through the region, but predominantly in the eastern hills of the Wairarapa. Soil moisture data is important for assessing when pole planting should occur and to understand why survival rates decrease in dry years.

Because Greater Wellington does not obtain soil moisture data from NIWA in real-time, an expanded network of telemetered soil moisture monitoring

stations is needed. In particular, sites at which soil moisture and temperature monitoring equipment could be installed at are:

- Wairarapa plains – west and east of Carterton, southern Wairarapa plains (for farm / drought status reporting and recharge modelling);
- Eastern Wairarapa hills (for drought status reporting and flood modelling); and
- Northern Kapiti Coast (for drought status reporting and recharge modelling).

Soil probes are relatively cheap but provide useful information for farm reporting and potentially for rainfall runoff modelling, and therefore should be installed at as many rural sites as possible. To ensure continued efficiency and cost-effectiveness, soil monitoring equipment should be installed at existing groundwater, climate or rainfall monitoring stations.

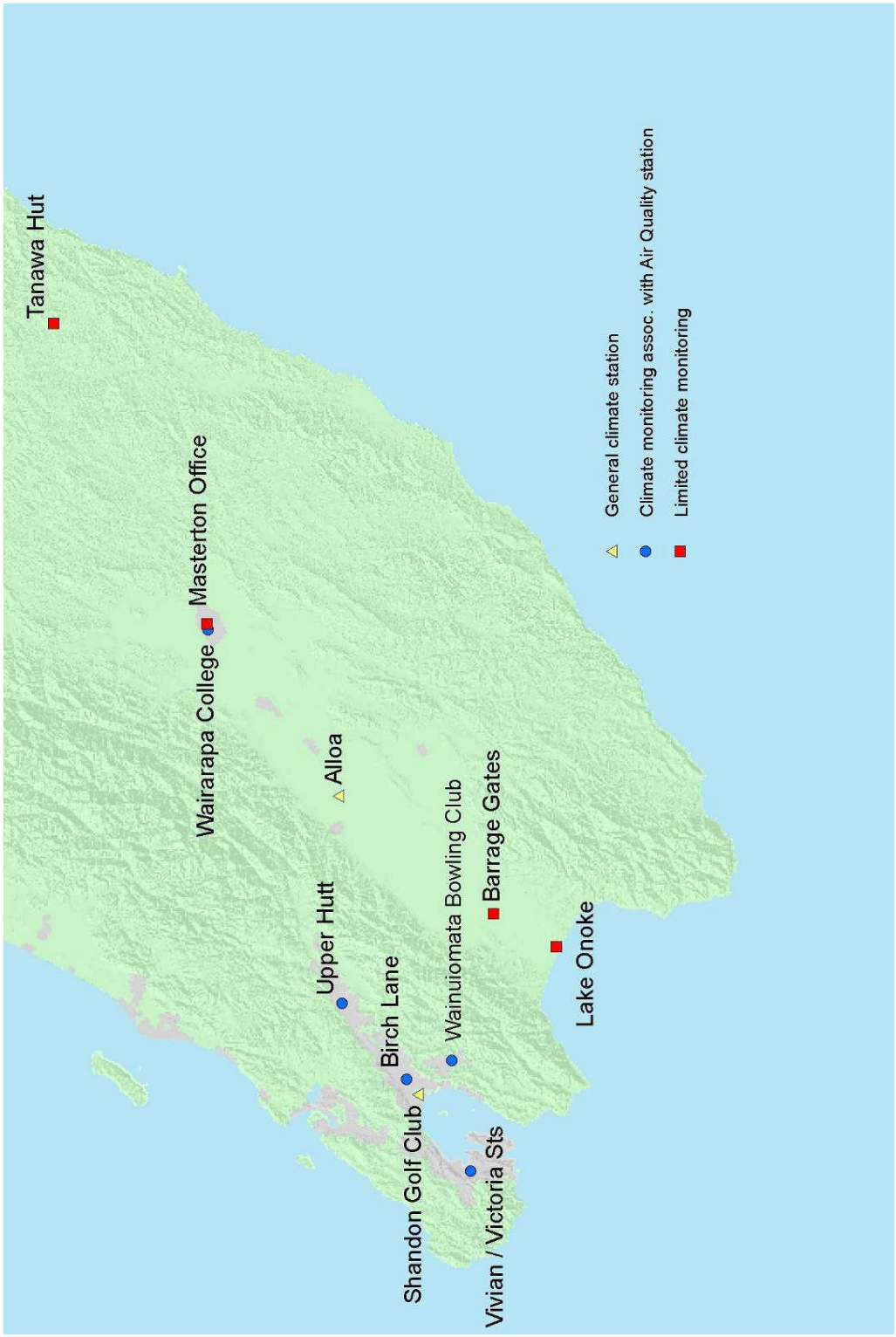


Figure 3: Greater Wellington climate monitoring stations

4.3 Summary of recommendations

Recommendation	Priority
Climate stations:	
Maintain the existing climate station network	High
Install climate monitoring stations in the following airsheds: Porirua, Kapiti Coast, Karori (associated with air quality monitoring stations, if it is deemed necessary)	High (Kapiti Coast) Medium (Porirua) Low (Karori)
Continue to install climate monitoring equipment at new air quality monitoring stations	Ongoing
Continue to liaise with NIWA and MetService to obtain climate data where necessary	High
Investigate the usefulness of future climate monitoring equipment at: *Lake Wairarapa at Barrage Gates* Eastern Wairarapa hills	Medium
Soil moisture / temperature monitoring:	
Continue to install soil moisture and temperature monitoring equipment at the existing rainfall and groundwater stations, with the sites below as highest priority.	Ongoing
Install soil moisture and temperature monitoring equipment at existing rainfall or groundwater level monitoring stations at the following locations: West Carterton (at *Mangatarere at Belvedere*) East Carterton (possibly at *Baring*) South Wairarapa plains (e.g. at Pirinoa or *Wairio*) Eastern Wairarapa hills (two locations in addition to *Tanawa Hut*) Kapiti Coast - Te Horo (possibly at *Sims Road*)	High
Establish protocols with NIWA to obtain soil moisture and temperature data where necessary	Medium

5. River station review

5.1 The network

Greater Wellington operates a network of 33 continuous river level monitoring stations, which is supplemented by data from several stations operated by NIWA (Figure 4). Nearly all of the stations are rated, i.e. flow data is collected as well as river level.

5.2 Network evaluation

5.2.1 Coverage

Spatial coverage of the region is not as important for river level monitoring as it is for rainfall monitoring, and ensuring that streams or rivers are monitored to meet our resource management and floodwarning functions (as discussed in Section 5.2.2) is probably more important. Sampling locations for the Greater Wellington Freshwater Quality Monitoring Programme was determined using the River Environment Classification (REC) system developed by NIWA (after Warr, 2002). The REC system could also be used to ensure that we are monitoring river flows in rivers representative of the Wellington region. Monitoring across the range of river types is important so that we can improve our knowledge of how climate and geology interact to effect flow regimes, and the implications for aquatic habitat and water quality.

The six climate / source of flow / geology REC classes within which 74% of river reaches in the Wellington region fall are:

- **Cool-wet, low elevation, hard sedimentary**: Reaches in this class are found in the south-west of the region, e.g. Wainuiomata River and the Karori, Kaiwharawhara, and Makara Streams. Some south eastern Wairarapa reaches also fall into this category, such as the Opouawe River.

- **Cool-wet, low elevation, soft sedimentary**: Reaches in this class are found on rivers associated with the northern and eastern Wairarapa hills. Examples are Kopuaranga, (Northern) Whangaehu, and Pahaoa Rivers.

- **Cool-dry, low elevation, soft sedimentary**: Reaches in this class are found in rivers associated with the eastern Wairarapa plains and hills. Examples are the Tauweru River and (southern) Whangaehu River.

- **Cool-extremely wet, high elevation, hard sedimentary**: Reaches in this class are fed from the wettest parts of the Tararua range. Examples are the Upper Ruamahanga, Waingawa and Waiohine Rivers.

- **Cool-wet, high elevation, hard sedimentary**: Reaches in this class are fed from the slightly lower rainfall parts of the Tararua Range. Examples are the Hutt, Otaki and Waikanae Rivers.

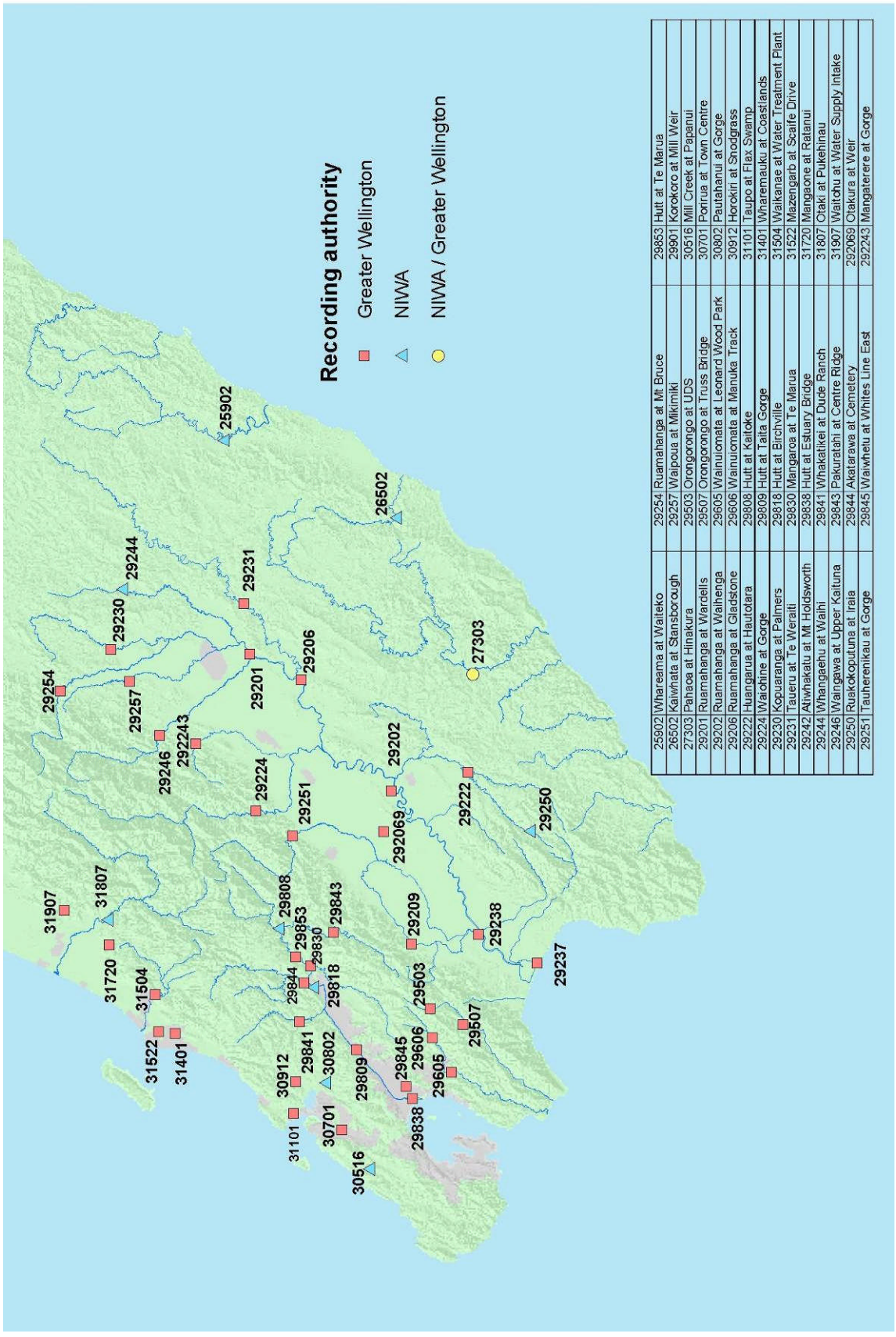


Figure 4: River level monitoring stations in the Wellington region

- **Warm dry, low elevation, alluvium**: Reaches in this class are found in rivers on the Wairarapa plains and parts of the Kapiti Coast. Examples are Stonestead Creek, Parkvale Stream, and Mangapouri Stream.

By assigning REC classifications to the river reaches with river level monitoring stations it was found that the categories 'Cool-extremely wet, high elevation, hard sedimentary' and 'Cool-wet, high elevation, hard sedimentary' are best represented. To ensure all major river reach types are monitored additional sites could be installed in the categories 'Cool-wet, low elevation, hard sedimentary' (e.g. Makara Stream and Opouawa River) and 'Warm dry, low elevation, alluvium' (e.g. Parkvale Stream).

5.2.2 Network design – is it strategic?

Like the rainfall station network, the river level station network evolved from a basis of floodwarning and water supply planning. Stations were slowly added for consent monitoring purposes as abstractions for water supply and irrigation increased.

The review team considered the current network design in view of monitoring of significant or sensitive resources (e.g. flood risk areas, springs), future data requirements (e.g. where demand for water for abstraction is increasing, or where urbanisation/subdivision is), linkages with other programmes (e.g. knowledge required for freshwater quality data interpretation), and consent management (e.g. knowledge required for minimum flow compliance or water restrictions).

In general, stations in the existing network were found to be at the best location to serve their intended purpose. The exceptions are the following stations:

- *Pakuratahi River at Truss Bridge*: This site would be more useful if it was moved to the catchment outlet. This would give knowledge of total flows in the catchment for low and high flow modelling of the entire Hutt catchment. (See Section 5.2.6)

- *Whakatikei River at Dude Ranch*. This site would be more useful if it was moved to the catchment outlet. This would give knowledge of total flows in the catchment for low and high flow modelling of the entire Hutt catchment. (See Section 5.2.6)

- *Tauweru at Te Weraiti*. The current site does not allow accurate monitoring of low flows for consent management purposes.

Additional rated river level stations would improve the network for the following functions:

- Floodwarning and flood forecasting (lower Kopuaranga River, Whareama River near Tinui township, Waiwhetu Stream in upper reaches);

- Consents management i.e. for ensuring water restrictions are implemented to comply with consent conditions and minimum flows (lower Waipoua

River near Masterton town centre, permanent site on Parkvale Stream at Renalls, Papawai Stream, lower Tauweru River);

- Engineering design information provision (Makara Stream, a representative eastern Aorangi-fed river with potential gravel issues such as Awhea or Opouawe River);

- Hydraulic modelling (unrated – only water level required) (Ruamahanga River downstream of Waiohine River, Whangaehu River tributary of Huangarua River, Waitohu Stream in lower reaches);

- Resource definition – improving knowledge of surface water / groundwater interactions (Papawai Stream, a Masterton spring-fed stream, Poterau Stream, Mangatarere Stream at Belvedere Road);

- Improving linkages with the Rivers State of Environment Water Quality Monitoring Programme (Makara Stream, Tauweru River at Castlehill, Awhea River).

Increased subdivision in eastern Wairarapa, and the potential increase in the frequency of easterly storm events, means that it is vital that we increase our river flow monitoring in eastern rivers for both floodwarning and engineering design.

Changes to the network are also important to ensure sustainable water allocation and minimum flow compliance, particularly on the Wairarapa plains where many small streams are considered to be under pressure from abstraction. At present, flows in many streams or rivers are manually gauged (rather than continuously monitored) so that restrictions can be implemented. Installing continuous stations at these locations (particularly Waipoua River, Parkvale Stream, Papawai Stream, and lower Tauweru River) will ensure that restrictions are implemented early to avoid adverse effects on instream values.

Streamflow depletion from groundwater abstraction is increasingly becoming an issue, particularly in the Wairarapa. We need to improve our knowledge of groundwater and surface water interactions so that we can better predict potential stream flow depletion rates. Improved knowledge of interactions is also vital for accurate groundwater modelling. Continued monitoring of flow in the Mangatarere Stream at Belvedere Road over the low flow season for the next five years will improve our knowledge of flow losses and gains within this catchment. New flow monitoring stations are proposed in some of the small spring-fed Wairarapa streams (Papawai Stream, Poterau Stream, and a Masterton spring-fed stream) and in the Mawaihakona Stream (see Section 8).

The springfed stream Waimeha has been monitored at a temporary recorder station since September 2004. The aim of the site was to collect data to assist in modelling the Waikanae groundwater system. The necessity for this recorder site needs to be investigated; if it is found that a permanent site is required on the Waimeha Stream then a more appropriate location should be found and the site relocated.

The water quality monitoring under the Rivers State of Environment Monitoring Programme was recently reviewed (Warr, 2002), and changes to the programme were made. Water quality data collected from the sampling sites generally needs to be flow-adjusted. In some cases, river flow stations are located nearby, or correlations can be made with other catchments. Three new river level stations (Makara Stream, Tauweru River at Castlehill, and Awhea River) are proposed which will improve linkages with this programme. Further investigations should be carried out on the need for enhanced flow monitoring, or correlation development, to aid in interpretation of water quality data.

5.2.3 Continuity

Flow data is collected at an appropriate interval (15 minutes) and record continuity is generally good.

Parkvale Stream at Weir is usually installed on a temporary basis over summer months, and data loss may occur due to flood damage. Upgrading this site to become a permanent station will improve data continuity and quality for this catchment.

5.2.4 Data quality

River flow data collected by Greater Wellington is of a high standard, and ratings are audited on an annual basis.

Some Wairarapa river level stations are only rated for high flows, as the stations are for floodwarning purposes and may not be suitable for low flow measurement. Relocation of *Tauweru at Te Weraiti* to a site more appropriate for low flow measurement will improve the quality of low flow data for this catchment. Low flow data from *Huangarua at Hautotara, Waipoua at Mikimiki*, and *Tauweru at Te Weraiti*, should not be displayed on the Greater Wellington website, as it is not considered to be reliable data.

To improve the quality of high flow data at some sites additional high flow gaugings are required. The Environmental Monitoring and Investigations Department regularly reviews the priority list for high flow gaugings, which is included in the Flood Warning Procedures Manual.

5.2.5 Availability and timeliness

Most of Greater Wellington's river flow stations are telemetered and therefore data is available in real-time. In the Western Wellington region, the exceptions are *Pakuratahi at Truss Bridge*, and *Whakatikei at Dude Ranch* (see discussion of these stations in Sections 5.2.2 and 5.2.6).

A network of water level recorders (not shown in Figure 4) is maintained in the Ruamahanga floodways. These recorders are currently not telemetered. Installing telemetry equipment at Jenkins Dip and Oporua Floodway will mean that the data is more readily available during a flood event.

5.2.6 Efficiency and cost-effectiveness

River flow stations that were previously deemed non-cost effective or inefficient to run have generally now been closed, or are funded by other departments or organisations.

Whakatikei at Dude Ranch and *Pakuratahi at Truss Bridge* are located in the middle of their respective catchments. The stations were originally installed to gather data for water supply planning. At their current locations the stations are not useful for Environment Management Division's work (i.e. flood forecasting or low flow quantification in the entire Hutt catchment), and may not be cost effective to run. However, Water Supply staff have expressed an interest in retaining the stations for the present. If funding is sought from the Water Supply, Parks and Forests Division it may be cost-effective for Environmental Monitoring and Investigations Department to install additional sites at the outlets of these catchments.

If a suitable site for a full-range flow station in the lower Tauweru River can be found then it will not be cost effective to retain *Tauweru at Te Weraiti*. However, the station should not be removed until a new site has been found and fully-rated to ensure accurate floodwarning for the lower catchment.

5.2.7 Other flow-data related issues

Data from the flow recorder stations is used in flood forecasting models, which aid in the floodwarning system. The flood model for the Ruamahanga River was reviewed in 2006 and recommendations from this review have been incorporated into this report.

The flood models for the western region are seldom used. The Hutt catchment flood model was once useful for predicting flood peaks, but needs recalibration due to the removal or unavailability of the NIWA sites *Phillips* and *Hutt at Kaitoke*. A targetted investigation into the need and cost of recalibrating the Hutt flood model is required.

5.3 Summary of recommendations

Recommendation	Priority
Existing network:	
Maintain the existing river flow station network	High
Obtain high flow gaugings for priority sites	High
Continue to monitor low flows at *Mangatarere Stream at Belvedere Road* for another five years (this requires the site to be rebuilt)	High
Telemeter the floodway recorders at Jenkins Dip and Oporua Floodway; upgrade dataloggers at the other floodway recorder sites	Medium
Assess the costs and benefits of recalibrating the Hutt flood model	Medium
Investigate the need for river flow stations at the outlets of the Pakuratahi and Whakatikei catchments (may depend on the results of recalibrating the Hutt flood model)	Medium
Investigate the need for a permanent flow station on the Waimeha Stream	Medium
Investigate/install new automatic, telemetered river flow stations at the following locations:	
Waipoua River near Masterton town centre, OR, fully-rate *Waipoua at Mikimiki*	High
Parkvale Stream (permanent site at Renalls weir)	High
Lower Kopuaranga River (and if an appropriate site is found, investigate the removal of *Kopuaranga at Palmers*)	Medium
Papawai Stream	Medium
Upper Tauweru River (Castlehill)	Medium
Lower Tauweru River (this may allow the removal of *Tauweru at Te Weraiti*, if a suitable fully-rateable flow site is found)	Medium
Mawaihakona Stream (*underway*)	Medium
Whareama River near Tinui	Medium
Upper Waiwhetu Stream	Medium
Awhea River	Low
Poterau Stream	Low
Masterton springfed stream (Makoura/Kuripuni/Fleet Street)	Low
Makara Stream	Low
Install temporary water level recording equipment at the following locations:	
Ruamahanga River immediately downstream of Waiohine River confluence	Medium
Whangaehu River near Huangarua confluence	Medium
Lower Waitohu Stream	Low

6. Lake and wetland level station review

6.1 The network

Monitoring water levels in lakes and wetlands is needed to improve our knowledge of how human activities affect these resources, the relationship between water levels and water quality in lakes and wetlands, and interactions between groundwater and surface water. This knowledge is important to ensure that we can protect wetlands and lakes from adverse effects associated with human activities.

The existing lake level monitoring station network is fairly limited. The only lakes that have continuous level stations are Lake Onoke (*Lake Onoke at Lake Ferry*) and Lake Wairarapa (*Lake Wairarapa at Burlings*, *Lake Wairarapa at Barrage Gates*).

Currently the only wetlands in the Wellington region that have continuous water level monitoring stations are on the Kapiti Coast: Te Harakeke (in Waikanae) and Te Hapua Road wetland (in Te Horo). Monitoring water levels in the Nga Manu wetland (also in Waikanae) will commence shortly by Kapiti Coast District Council, as part of their water supply wellfield consent monitoring.

6.2 Network evaluation

The existing water level stations serve their intended purpose, and should remain in place. The *Lake Wairarapa at Barrage Gates* and *Lake Onoke at Lake Ferry* stations exist as part of the floodwarning system for controlling levels in Lake Wairarapa, and are important for this purpose. The *Lake Wairarapa at Burlings* station is important for assessing compliance with target lake levels in the Regional Freshwater Plan. The *Te Harakeke at Te Hapua* wetland level monitoring stations are important for monitoring these sensitive and regionally significant wetland resources. These stations all provide high quality data and are cost-effective to maintain.

Additional water level monitoring stations are needed to improve the coverage of the lake and wetland monitoring network, to ensure that we are collecting adequate data to protect the lakes and wetlands of the Wellington region. Expansion of the network is also needed to fulfil our commitments under the Wetland Action Plan (Goals 1 – 2) and will contribute to our commitment to a collaborative research project with Landcare Research.

New continuous water level monitoring stations should be installed in the following wetlands / lakes:

- A representative northern Otaki wetland (e.g. Forest Lakes, Lake Waiorongomai);
- Pencarrow Lakes (Lake Kohangatera and Lake Kohangapiripiri);
- Mangaroa Swamp;
- Waingawa Swamp;
- Lowes Bush;

- Carters Reserve;
- Eastern Lake Wairarapa wetland (e.g. Boggy Pond);
- Lake Pounui;
- Hayes Lagoon.

A continuous water level station could also be installed in Fensham Reserve, although because water levels are already being manually read this location is a lower priority for a continuous station.

Water levels in Taupo Stream (exiting Taupo Swamp) are already continuously monitored. However, to gain better information about the controls on water levels in this wetland, an investigation should be carried out into the usefulness of an expanded water level monitoring network across this wetland.

Although this review does not specifically address continuous water quality monitoring, at some of proposed water level monitoring stations water quality instrumentation would be useful. The highest priorities for continuous water quality monitoring are Te Harakeke and Pencarrow Lakes.

6.3 Summary of recommendations

Recommendation	Priority
Existing network:	
Maintain the existing lake and wetland level station network	High
Install continuous water quality monitoring instrumentation at Te Harakeke	High
Investigate the need for an expanded water level monitoring network across Taupo Swamp	Medium
Install new water level monitoring stations at the following locations:	
Nga Manu (in collaboration with Kapiti Coast District Council)[1]	High
Pencarrow Lakes (2 stations required, with continuous water quality monitoring instrumentation)	High
Mangaroa Swamp	High
Carters Reserve	High
Boggy Pond	High
Lake Pounui	High
North Otaki wetland system (Forest Lakes or Lake Waiorongomai)	Medium
Waingawa Swamp	Medium
Lowes Bush	Medium
Hayes Lagoon	Medium
Fensham Reserve	Low

[1] This has now been completed.

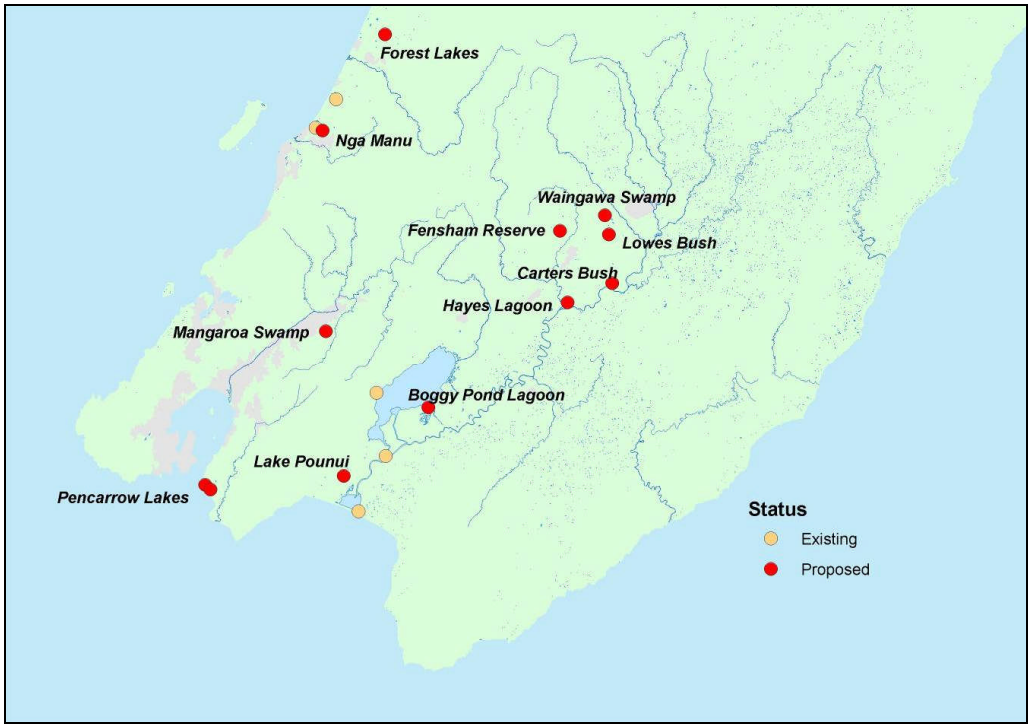


Figure 5: Proposed new lake and wetland level monitoring sites

7. Tide stations

7.1 The network

Greater Wellington operates one tide station (*Queens Wharf*), although a second station at the mouth of the Hutt River also shows a tide cycle (*Hutt at Estuary Bridge*). This data is supplemented by NIWA tide stations on Kapiti Island and at Riversdale.

Tide monitoring is required for the following purposes:

- To enable the removal of tidal influence from groundwater level data;
- To enable the Harbours Department to access real-time tide data for operations and surveys;
- To contribute data to the international tide database;
- To assess the tidal influence on flood levels in the Hutt and Kapiti Coast catchments.

7.2 Network evaluation

Data from *Queens Wharf* is highly used (for example, by Greater Wellington Harbours Department, and Land Information New Zealand) as a representative Wellington harbour tide site. Data from *Hutt at Estuary Bridge* is also very useful, particularly for assessing flood levels in the Waiwhetu Stream and in the lower part of the Hutt River. Both sites are therefore considered cost-effective and necessary to maintain for the public good.

No further tide stations are considered necessary in the Wellington region at this time.

7.3 Recommendation

To continue to operate the current tide station network.

8. Groundwater level station review

8.1 The network

Greater Wellington monitors groundwater levels on a continuous basis at 58 automatic monitoring sites in the region, 54 of which are currently telemetered (Figure 6). Groundwater levels are manually measured, at four to six-weekly intervals, at an additional 68 sites.

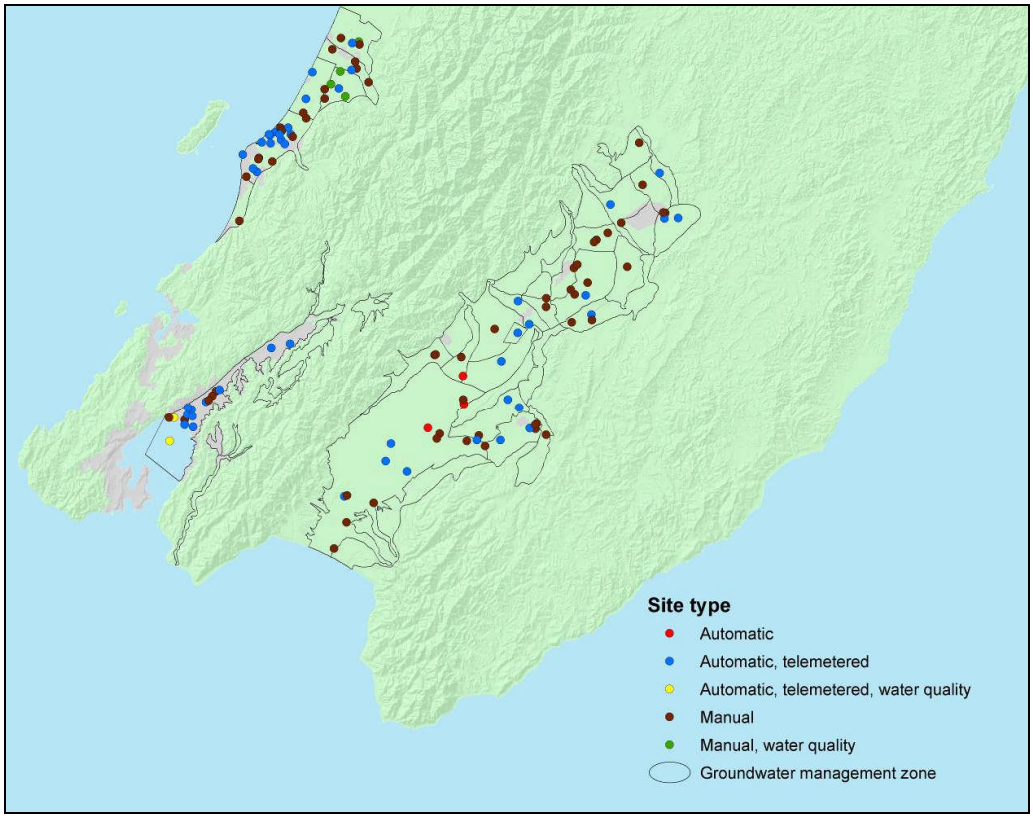


Figure 6: Groundwater level monitoring stations in the Wellington region

A work programme is currently underway to improve our understanding of the Wairarapa groundwater system, through the development of a robust conceptual hydrogeological model. Once the model is completed it is likely that recommendations of changes to the groundwater level (and recharge) monitoring network will be made. Thus at this time the main recommendation is to retain the *status quo* groundwater monitoring network, until the investigations are complete. However, bearing this in mind, a brief network evaluation is included below and some recommendations are made.

8.2 Network evaluation

In general, groundwater level monitoring was historically focussed on highly-used aquifers. In recent years there has been a push toward monitoring resources that are at risk (e.g. of saline intrusion) or particularly sensitive (e.g. springs). The completion of the Wairarapa conceptual groundwater model will provide us with a better understanding of groundwater resources that may be at risk in that area.

Some work has been initiated to develop a saline intrusion monitoring programme for the Hutt groundwater zone, in conjunction with Water Supply, Parks and Forests Division. It is recommended that two or three sentinel wells are installed in this area.

Groundwater use from the deeper Kapiti aquifers has increased since the granting of consents for Kapiti Coast District Council (KCDC) to install a wellfield. KCDC have now installed production bores and have funded monitoring equipment. Environmental Monitoring and Investigations has agreed to install and maintain this equipment, and telemeter the data to the hydrological database in the Wellington office. To date, nine sites have been installed with one remaining to be installed. It is important to collect robust groundwater level and quality data in this area, to fully determine the impact of abstraction and monitor for potential saline intrusion.

There is potential for future abstraction from the Upper Hutt groundwater zone, and Water Supply, Parks and Forests Division is currently carrying out investigations. Environmental Monitoring and Investigations have installed some temporary monitoring equipment to assist with these investigations. A stream flow monitoring site should be installed in the spring-fed Mawaihakona Stream in order to better understand groundwater-surface water interactions in this area. Monitoring sites are also recommended in other springs, particularly in the Wairarapa (see Section 5).

There is considerable overlap with other hydrological monitoring programmes, as mentioned in other sections of this report. It is important, from the perspective of groundwater recharge modelling, that rain gauges and soil monitoring equipment are installed at all new automatic groundwater monitoring stations. The rainfall and soil moisture data collected will also help achieve other objectives, such as soil moisture status for farm reporting and rainfall data for State of Environment reporting. Conducting several types of monitoring at a single station ensures cost-effectiveness.

Most automatic groundwater level monitoring sites have now been telemetered, with the exception of four sites. The remaining non-telemetered sites – all located in the Wairarapa – are ‘investigation’ sites and are not part of the State of Environment monitoring network. Therefore it is not considered necessary that they are telemetered at this stage.

Some manually-operated groundwater level sites may no longer be required, and are therefore not cost-effective to run. In particular, manual water level monitoring is no longer required in the Hutt groundwater zone, because automatic monitoring is adequate to determine groundwater trends in this area. The number of manual groundwater monitoring sites in the Wairarapa may need to be changed following the completion of the Wairarapa conceptual groundwater model.

Most of Greater Wellington’s groundwater level monitoring is conducted in privately-owned bores, with the permission of the landowners, and is therefore subject to access issues. In priority areas it may be necessary for Greater

Wellington to install dedicated monitoring bores, and this should be investigated further.

8.3 Summary of recommendations

Recommendation	Priority
Maintain the existing automatic groundwater level monitoring stations	High
Install the one remaining KCDC wellfield monitoring site	High
Install rainfall and soil moisture monitoring equipment at all new groundwater monitoring stations	Medium
Install 2-3 new sentinel wells in the Hutt groundwater zone	Medium
Install spring flow monitoring sites at locations recommended in Section 5	Low - Medium
Investigate the installation of dedicated groundwater level monitoring bores in priority groundwater zones	Low
Discontinue manual groundwater level monitoring in the Hutt groundwater zone	n/a
Implement any network changes recommended following completion of the Wairarapa conceptual groundwater model investigation	n/a

9. References

Harkness, M., 1999: Surface water hydrological network review. Greater Wellington Publication No. WRC/RINV-T-99/38.

Warr, S., 2002: Rivers state of the environment monitoring review. Greater Wellington Publication No WRC\PRW-G-02/64.