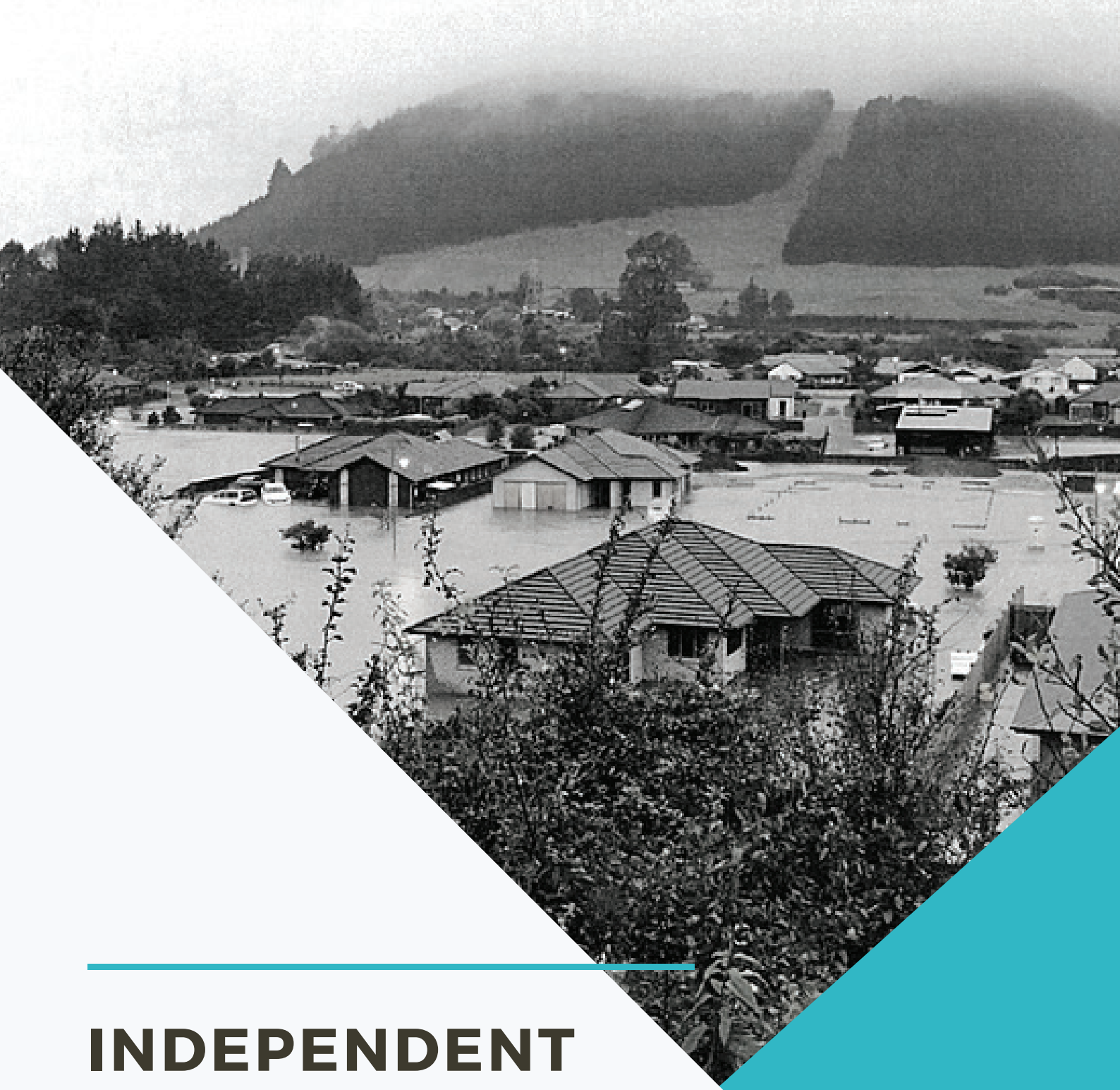
THIS REPORT
(Indpendent Review Ngongotahā Flood Event 29 April 2018: Report date: December 2018) IS STRICTLY EMBARGOED
(NO PUBLICATION OR USE) UNTIL 8.30AM TUESDAY 11 DECEMBER 2018



INDEPENDENT REVIEW NGONGOTAHĀ FLOOD EVENT 29 APRIL 2018

REPORT DATE;
DECEMBER 2018

Disclaimer

This report has been prepared solely for the purposes stated in the report and should not be relied upon for any other purpose. The statements and opinions expressed in this report have been made in good faith, and on the basis that all information provided to us and relied upon as true and accurate in all material respects, and not misleading by reason of omission or otherwise.

We reserve the right, but will be under no obligation, to review or amend our report, if any additional information, which was in existence on the date of this report, was not brought to our attention, or subsequently comes to light.

Table of Contents

Table of Figures

Table of Tables

Mihi (Foreword)

Tēnā rā tātou i ngā mihi ki o tātou mate tūturu nui e hinga ake nei. Tēnei rātou kua riro ki te kāpunipunitanga o ngā wairua, ki tua o te pae o maumahara, ā, e waiho ake ana i a tātou ki konei haku ai, taute ai ki a rātou. Ko te whakatau noa ake, ko rātou ki a rātou, ko tātou ki a tātou i roto i te wā nei. No reira, tēnā rā anō tātou.

E rere ana ngā wai o tuawhenua ki te kōngutu awa o Ngongotahā, ka puta ngā wai tuku kiri ki te Rotorua-nui-a-Kahumatamomoe. He wai Māori, he wai ora, he roimata tonu, e heke nei i a Ranginui e tu nei, ka tau ki runga o Papatūānuku e takoto nei. Ka piki, ka heke, ka kōpikopiko te awa. Arā anō ngā kai hei whāngai i te tinana i te ngākau o te tangata.

Koia nei te mihi o tēnei rōpu arotake i whakaritea mai ki te āta titiro ki te āhuatanga o te waipuke i tau ki te rohe o Ngongotahā i ngā rā kua hipa. I tirohia ngā take, anei ngā hua hei mea wānanga mā koutou te marea. Tēnā koutou katoa.

Greetings, upon our acknowledgments to our deceased. They have departed to the gathering place of the spirits, beyond the veil of memory, and they have left us here lamenting and grieving for them. To settle this, we leave them to each other, and we acknowledge ourselves at this time.

On this basis, greetings.

The waters from inland flow to the mouth of the Ngongotahā Stream where they enter Lake Rotorua. Fresh water provides us sustenance. The tears of the Sky Parent fall to our Earth Mother who lies below us. Water will rise and fall, rivers will weave and turn. It is water that will feed our bodies and spirits.

This is an acknowledgment by this Panel, which was established to consider the recent floods that affected the Ngongotahā area. The event has been considered and we present our findings to the community. We greet you all.

1 Introduction

1.1 Flood Event

On Sunday 29 April 2018 the Rotorua district was subjected to a severe weather event. The rainfall depth over a six-hour period in the areas around the Ngongotahā catchment reached 145 mm, with 62.5 mm of rain falling in one hour. Rotorua streams, wastewater and stormwater systems were overwhelmed with the large volume of water that fell in that short period of time, with floodwaters flowing across roads and affecting numerous residential dwellings as well as commercial and industrial properties.

The Ngongotahā Stream reached its highest recorded level and overflowed its banks in several places. While flooding occurred throughout the Rotorua district, the Ngongotahā catchment experience was extreme and resulted in floodwaters inundating many homes and several businesses. Some 38 houses were declared insanitary and required extensive repair work, some businesses were closed for days while they undertook repairs, and Rotorua Lakes Council (RLC) faced roading and other infrastructure repairs.

Emergency services were activated on the morning of 29 April 2018 and the RLC Mayor, Steve Chadwick, declared a State of Emergency at 17.25 hours on that day, which remained in place until 6 May 2018. Indications were that this was a 100-year flood event in the Ngongotahā catchment and possibly more extreme than in some other parts of Rotorua.

1.2 Independent Review

As a response to the flood and the impact it had on Ngongotahā and the wider district, RLC, in conjunction with the Bay of Plenty Regional Council (BOPRC), commissioned an independent Panel to investigate the events of 29 April 2018 and to make recommendations intended to reduce the impact of severe flood events in the future.

The Independent Review Panel consisted of Judith Stanway (Chair), Te Ururoa Flavell, Kyle Christensen and Rob van Voorthuysen. (Appendix 1 has further details of the Panel) Ranui Maxwell provided administrative support for the Panel. The Panel obtained independent legal advice on the contents of the draft of this Report, responses to that draft from both councils, and the wording of this final Report.

1.2.1 Review Scope

The Terms of Reference (See Appendix 2) were developed by RLC in conjunction with BOPRC and approved by resolutions[1] of the respective councils. They state that the purpose of the review is to *"understand the circumstances and contributing factors which led to the flooding of the Ngongotahā subdivisions and to make recommendations to RLC and BOPRC on measures which may prevent or minimise the risk and effects of future flood events. It is also to provide clarity as to the various roles and responsibilities of RLC, BOPRC and landowners in relation to stormwater and waterbody management for future residential development"*

The outcome sought is *"the identification of potential improvements which may prevent or minimise future flooding events in the Ngongotahā catchment. The applicability of any recommendations for other catchments in the Rotorua district will also be identified and incorporated into risk reduction planning".* The Panel was not required to comment on civil defence emergency management during the flood event or recovery events after the flood.

While this report focuses on the impact on, and recommendations for, the Ngongotahā catchment, there has also been a strong interest from residents in other areas of Rotorua who were affected by

[1]This was adopted by RLC council of 31 May 2018 and BOPRC on 1 June 2018.

the events on 29 April, or who have concerns regarding the impact of severe weather events in the future. The Panel believes that many of the recommendations from this report have relevance to the wider Rotorua District.

1.2.2 Review Process

The Panel set out to first understand the circumstances leading up to and during the flood on 29 April 2018. This included understanding the combined knowledge of RLC and BOPRC staff members and residents of the catchment, as well as reviewing relevant documentation and reports.

RLC and BOPRC staff initially made presentations to all Panel members. Documentation and technical reports were requested and provided to the Panel for further review and analysis. Additional interviews were carried out by various Panel members to gain a full understanding of the event and council management practices. In some cases, past staff and independent technical experts were interviewed. In addition to this a Panel member undertook a walkover of Ngongotahā stream from State Highway 5 (SH5) to Lake Rotorua with BOPRC staff to understand the current condition of the stream channel and to inspect post flood repair works.

All Panel members were involved in community consultation, largely held at the Ngongotahā Bowling Club facilities, although Judith Stanway and Te Ururoa Flavell held additional sessions while the technically qualified members of the Panel were carrying out their research and analysis. Written submissions were also invited from the wider community and to cater for those who were unable to attend the scheduled meetings.

The information obtained was collated and analysed to understand the perceptions and specific effects of the flood event to assist the Panel in its analysis. The analysis was undertaken using a framework of legislative requirements and best practice standards to better understand the circumstances and contributing factors of the April 2018 flood event and to identify areas for improvement regarding RLC's and BOPRC's flood risk management functions. The Panel have also made use of the New Zealand Standard *NZS9401:2008 – Managing Flood Risk A Process Standard* in the assessment.

The Panel has met several times during the process and each Panel member was responsible for drafting sections of this report. The Panel has jointly agreed on the conclusions and recommendations.

The draft report was supplied to: Rotorua Lakes Council, Bay of Plenty Regional Council, Pioneer Property Trust, and Forbay Limited (previously MTEC Limited). This was to enable them to make comments on the conclusions and recommendations of the Panel in order to ensure that due process was followed. Subsequently meetings were held with BOPRC and RLC to discuss matters they had raised. The Panel then finalised its report and delivered it to BOPRC and RLC. No formal comments were received from Pioneer Property Trust or Forbay Limited

The Panel would like to acknowledge the cooperation and goodwill from all those who contributed to the preparation of this report. BOPRC and RLC staff invested their time in ensuring the Panel received relevant information. The Ngongotahā community contributed significantly with their insights.

1.2.3 Outline of the Report

Section 2: Flood Event in Ngongotahā Community
This section provides background to the flood event on 29 April 2018 and the Ngongotahā community which bore the brunt of the impact.

Section 3: Impact on the Community
This section summarises the insight gained from interactions with those affected by the flood event. This section reflects the community's experience only and the views expressed are not necessarily shared by BOPRC and RLC.

Section 4: Flood Risk Management in the Ngongotahā Catchment
This section provides a description of the management of the flood hazard in the Ngongotahā catchment within the context of legislative and best practice requirements.

> Section 4.2 describes the roles and responsibilities of BOPRC and RLC in managing flood hazards.
>
> Section 4.3 explains flood management design standards
>
> Sections 4.4 - 4.7 cover the primary tools for managing flood risk i.e. Operational Maintenance (Section 4.4); Structural Works (Section 4.5); Planning Controls (Section 4.6) and Emergency Management (Section 4.7).

Section 5: Pioneer Property Trust Subdivision
This section outlines the design and performance during the April 2018 flood, of key flood management infrastructure within the Pioneer Property Trust Subdivision. It discusses the subdivision consent process in 2006 and current RLC processes and policies for consenting subdivisions.

Section 6: Future Flood Risk Management Options
This section discusses specific measures that RLC, BOPRC, stakeholders and the community can consider to better manage the risk and effects of future flood events. It covers the primary tools for managing flood risk as outlined in Section 4.

Section 7: Conclusions
This section summarises the Panel's conclusions, but it is recommended that the reader reads the whole report to allow consideration of the conclusions in context.

Section 8: Recommendations
This section summarises the Panel's recommendations to minimise the risk and effects of future flood events. These recommendations are also included in the body of the report under the relevant headings.

2 Flood Event in Ngongotahā Catchment

2.1 Ngongotahā Township

Ngongotahā (Maori: "Ngongotahā") is a town on the western shores of Lake Rotorua. It is located 10 kilometres northwest of Rotorua city, and is often regarded as an outer suburb of the larger centre. Its population was 4107 in the 2013 census. Its name is derived from a legend of Ihenga, the famous Māori explorer. It is said Ihenga met the Patu-paiarehe on Mount Ngongotahā and was offered a drink from a calabash (ngongo = to drink, tahā = calabash). Ngongotahā is often referred to by locals as the "Sunny side of the Mountain" and “the Village”. The main road through the village, known as Ngongotahā Road or State Highway 36, runs via Kaharoa and Pyes Pa to Tauranga.

Figure 1: Ngongotahā township location

2.1.1 Ngongotahā Community

During community consultation, the Panel engaged with a cross section of people who without exception spoke highly of a thriving close-knit community. People enjoy the “small town” feel of the township and its closeness to all activities the larger city has to offer while enjoying its semi-rural environment.

There are several families who have lived in the community for a very long period such as the Brake family, the Mohi whanau and the Rika whanau. Some family names are synonymous with the township. Over more recent years; the community has expanded into areas on the periphery such as the Pioneer Property Trust subdivision (PPTS) incorporating Pioneer Road, Mohi Crescent and Oakland Place.

There are several marae that associate with the Ngongotahā community:
- Parawai
- Waikuta
- Waiteti
- Awahou

These marae are the tūrangawaewae for the tribes of:
- Ngāti Tura
- Ngāti Te Ngākau
- Ngāti Ngararanui

- Ngāti Tamahika
- Ngai Te Ahi
- Ngāti Tuteaiti
- Ngāti Rangiwewehi

2.1.2 The Ngongotahā Stream

The Ngongotahā Stream has a 7,680 hectare catchment arising from the fringe of the Mamaku plateau near the township of Mamaku and flowing through the Umurua and the Otamaroa tributary streams, to Lake Rotorua. The catchment is largely in the BOPRC region, with a small section of the upper reaches located in the Waikato Region. The Ngongotahā Stream, which flows through the centre of the village, is recognised as being an important part of the community. Notably, people travel from throughout the country and from overseas for trout fishing on the stream. Other nearby streams (Awahou, Waiteti and Hamurana) also offers good fishing.

There are four main geographical areas around the Ngongotahā Stream:

1. Paradise Valley;
    - Paradise Valley is commonly known as the land that borders Paradise Valley Road, including Relph Road, Te Miri Road, Manu Road and Endean Road[2]
2. The area from the Bridge at State Highway 5 to the Ngongotahā Bridge, State Highway 36 at the township including both sides of the stream to the south of Western Rd;
    - Brookdale Drive
    - Streamdale Place
3. Western Road and the Pioneer Property Trust subdivision;
    - Pioneer Road
    - Mohi Crescent
    - Oakland Place
4. Below the Ngongotahā Bridge at the township to the river mouth.

The impact of the flood in each of these areas is discussed later in this report.

[2] Definition of Catchment: Paradise Valley Community Catchment Plan, May, 2018, Paradise Valley Catchment Group, Geographical Scope, page 4.

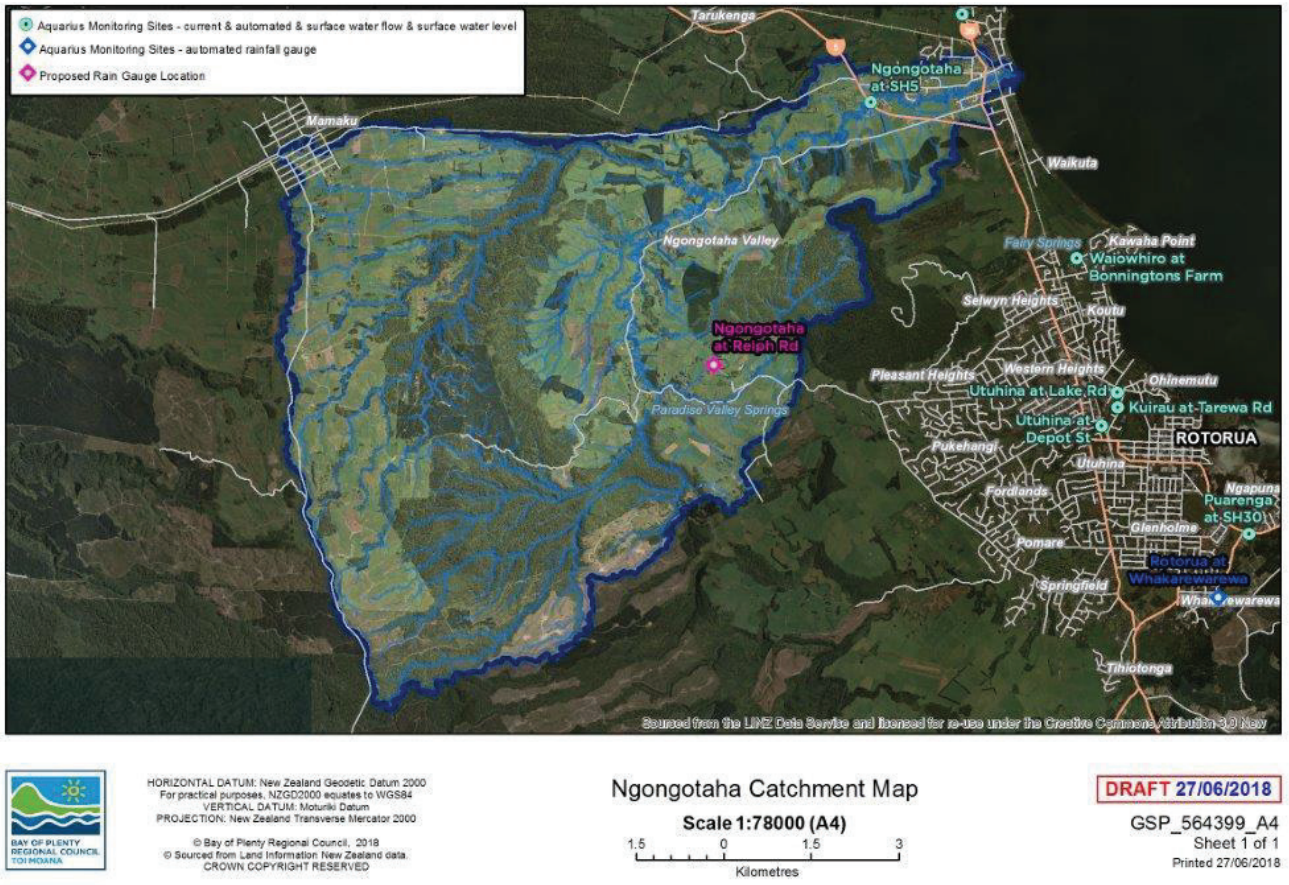


Figure 2: Ngongotahā Catchment.

2.2 The Flood Event

On 29 April 2018 a slow-moving, low-pressure weather system became stalled in the Tasman Sea to the northwest of New Zealand due to a stationary high-pressure system to the east. This atmospheric set-up resulted in deep tropical moisture being brought down to the upper North Island bringing the highest ever recorded rainfall in one hour to Rotorua since records began in 1963 (NIWA, 2018). A summary of the rainfall that occurred during this event and the resulting flood flows in Ngongotahā Stream is provided in the following sections.

2.2.1 Rainfall around the Ngongotahā Catchment 29 April 2018

At the time of the April 2018 flood event there were no officially monitored (i.e. NIWA or BOPRC) rain gauges in operation in the Ngongotahā catchment. Since the April 2018 event BOPRC have installed a rain gauge in the Ngongotahā catchment at Relph Road (See Figure 3). With no rain gauges within the catchment the Panel has used the closest rain gauges from adjacent catchments to understand rainfall depths and intensities during the event.

Figure 3: Location of Current Rainfall Gauges in Rotorua and the Ngongotahā Stream Flow Gauge (Numbers in bubbles indicate rainfall depth for year to date at 6 August) (Source - BOPRC website)

The closest rainfall gauge to the Ngongotahā catchment is in the Waiteti catchment immediately north of Ngongotahā. The gauge in this catchment is located on Upper Oturoa Road and hourly rainfall from 29 April from the BOPRC website is presented in Figure 4.

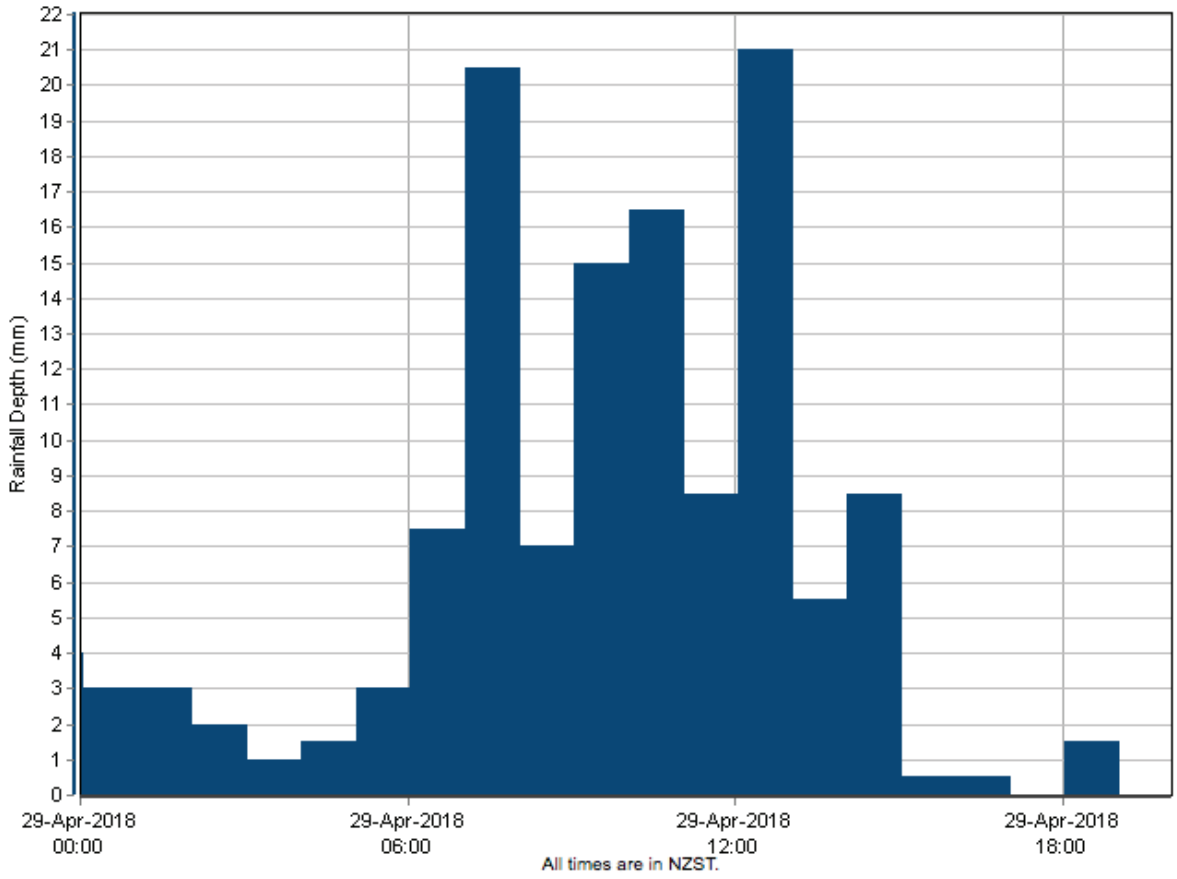


Figure 4: Hourly Rainfall Measured from Rotorua at Upper Oturoa Road (Source - BOPRC website)

As shown in Figure 4 there was heavy rain from around 0600 in the morning on 29 April through until mid-afternoon, with two heavier bursts in excess of 20 mm/hr from 0700 and again at 1200. Although this is clearly indicative of a very wet day these rainfall depths are not substantial in terms of their expected frequency. The maximum rainfall depth of 21 mm in one hour is less than a 2-year return period [3]event, and the total rainfall depth over the 12 hours of the storm was 116 mm being approximately a 5-year return period event.

Examination of the closest rainfall information to the south of Ngongotahā, being the gauge at Whakarewarewa, reveals a far greater depth of rainfall compared to the Upper Oturoa Road gauge. In the three hours from 0800 to 1100 a total rainfall depth of 117.5 mm was measured (at hourly resolution) at the Whakarewarewa rain gauge with over half of the total depth (62.5 mm) falling in just one hour before midday (See Figure 5)

This one hour depth of rainfall was some three times the depth measured at Oturoa Road and the return period of the three-hour rainfall depth at Whakarewarewa is estimated, using HIRDS V3, to be in excess of a 100-year return period. A summary of the rainfall depths and approximate return periods measured at the Upper Oturoa Road and Whakarewarewa gauging stations is provided in Table 1.

[3] These return periods have been estimated using the Niwa High Intensity Rainfall Design System (HIRDS) Version 3 with the unaudited hourly rainfall data from the BOPRC website and should be considered approximate only.

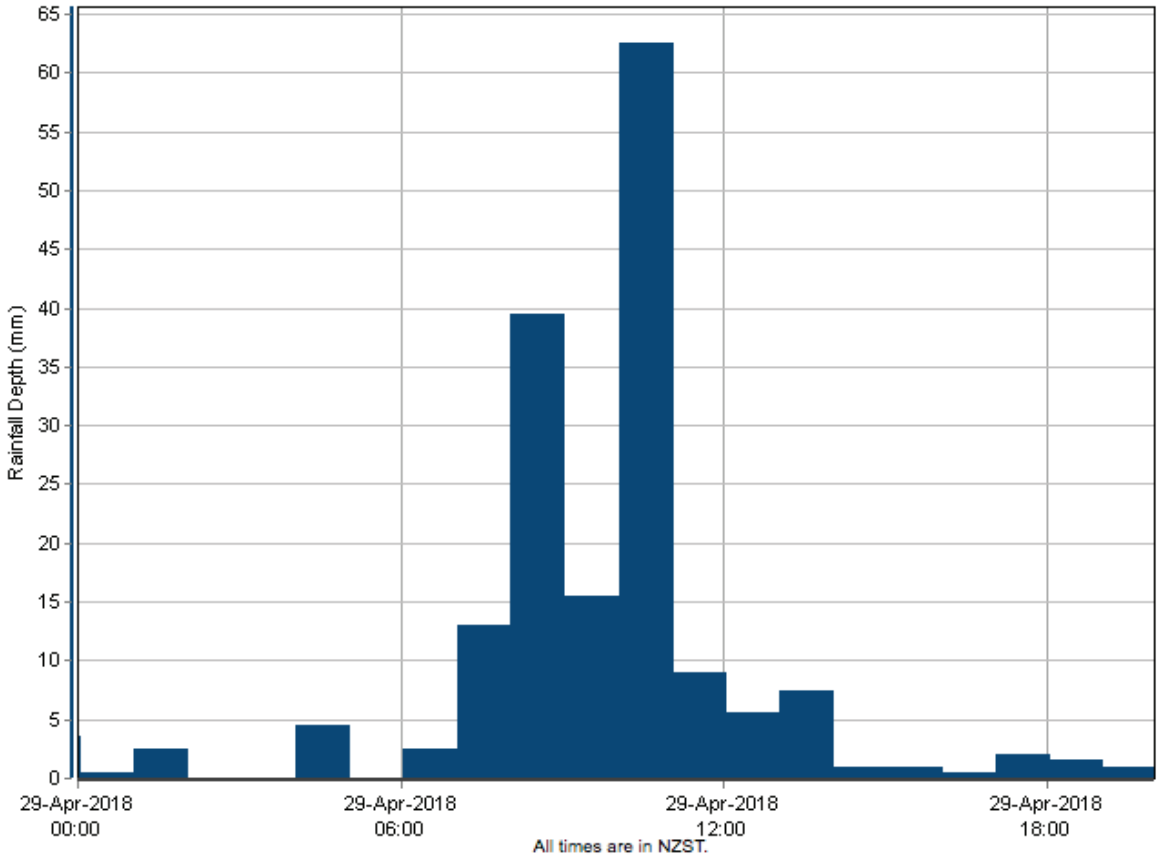


Figure 5: Hourly Rainfall Measured from Rotorua at Whakarewarewa (Source - BOPRC website)

Table 1: Summary of Rainfall Depths and Return Periods April 29 2018

Rainfall Duration	Rainfall Depth Upper Oturoa Road	Rainfall Return Period [4] Upper Oturoa Road	Rainfall Depth Whakarewarewa	Rainfall Return Period Whakarewarewa
1 hour	21 mm	< 2-year	62.5 mm	65-year
2 hour	31.5 mm	< 2-year	78 mm	45-year
3 hour	46 mm	2-year	188 mm	> 100-year
6 hour	88.5 mm	5-year	145 mm	90-year
12 hour	116 mm	5-year	150 mm	30-year

From the above analysis of rainfall during the event there was considerable variability in rainfall depths and intensities across the areas to the immediate south and north of the Ngongotahā catchment. The area to the south being far more significantly affected, especially considering the three to six hour rainfall duration that would most significantly affect[5] larger catchments such as the Ngongotahā Stream.

The analysis of rainfall depths and return periods is certainly related to the expected flood size, but it is the combination of several factors that produce the overall flood size including –

a) spatial and temporal distribution of rainfall;
b) variability in underlying soil drainage;
c) soil conditions at the beginning of the rainfall event (antecedent conditions);
d) variation in topography and vegetation;
e) various other factors.

[4] Approximate return period based on Niwa High Intensity Rainfall Design System (HIRDS) Version 3
[5] In larger catchments it takes longer for the upper catchment areas to contribute to peak flows in the lower catchment, so a longer duration of rainfall is required to generate the biggest peak flood flows.

It is for these reasons that rainfall can generally only be used to provide an indication of the expected resulting flood size and an analysis of measured flood levels (or preferably flood flows from stream gauging's) is required to provide a more definitive estimate of flood size and frequency. The following section provides analysis of the measurements of flood levels taken at the SH5 Bridge on Ngongotahā Stream during the 29 April 2018 event.

2.2.2 Measure Water Levels in Ngongotahā Stream 29 April 2018

With the above measured rainfall, especially to the south of Ngongotahā, it would be expected that a notable flood flow would occur in Ngongotahā Stream. During the event continuous (15-minute intervals) water levels were automatically recorded at the Ngongotahā Stream river flow gauge at SH5.

There are two water level recorders at this site, a primary and back-up gauge. It is the primary gauge that is presented on the "Live Monitoring" section of the BOPRC website[6] and this gauge malfunctioned during the event with no information recorded or transmitted to the website during the peak of the event. Fortunately, the back-up water level recorder functioned effectively during the event and the data it collected was able to be subsequently retrieved. The measured water levels from the back-up gauge at SH5 during the 29 April 2018 event are shown in Figure 6.

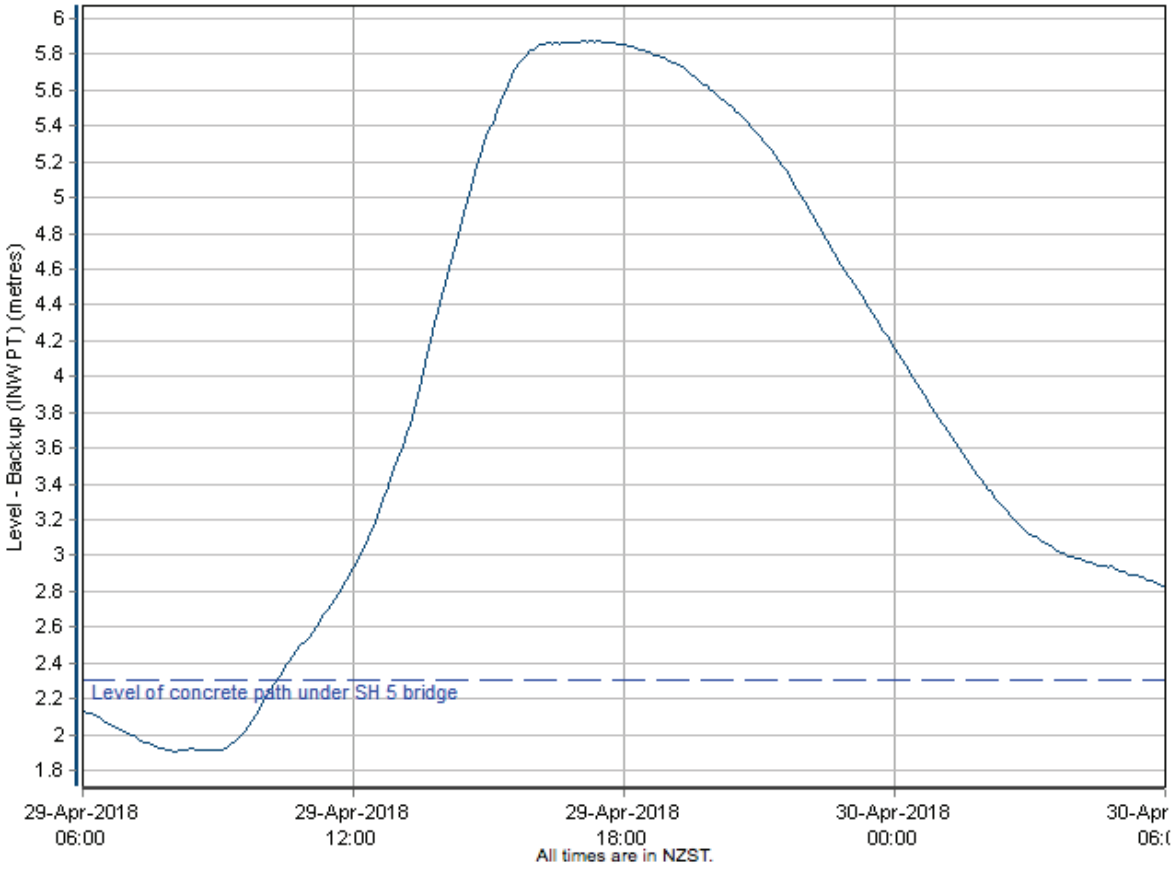


Figure 6: Flood levels measured at SH5 Ngongotahā Stream during 29 April 2018 event (Source – BOPRC website)

The measurements are of the water levels and not the flow at this location. The maximum water level measured during the event was 5.874 m (291.1 mRL Moturiki Datum). To determine what flow

[6] (https://www.boprc.govt.nz/our-region-and-environment/live-monitoring/)

(discharge) a level of 5.874 m represents requires the use of a rating curve which provides an estimate of flow across the range of levels expected at the site.

2.2.3 Stage vs Discharge Rating Curves at SH5

The accuracy of a rating curve greatly depends on the number of physical measurements of flow (gaugings[7]) that have been undertaken at the site, especially during large floods, and the stability of the site in terms of its geometry and other factors that can affect flow conveyance such as vegetation, sediment waves and tail water effects. As well as the above factors the methods used for extrapolating the rating curve beyond the measured flow gaugings is also very important for ensuring accurate estimates of peak flows.

The BOPRC hydrology staff in the data services team were already committed to performing flow gauging in the Waimapu catchment near Tauranga during the day of April 29 and they arrived back into Rotorua in the dark after the peak of the event at 1730[8]. For health and safety reasons gaugings cannot be undertaken in the dark, largely due to the lack of visibility of large debris coming down with the flow that can be extremely dangerous for snagging equipment and pulling operators into the water. It was unfortunate that no gaugings were undertaken during the April 2018 event and that the highest flow gauging dates back to 1996 and is at a level around 1 m lower than the peak level measured the April 2018 event. The BOPRC hydrology team did undertake extensive gaugings (16 measurements) on the smaller flood event that happened on 5 June 2018.

With the somewhat limited high stage gauging information, the method for extrapolating the rating curve becomes particularly important for estimating the size of larger events. At this site BOPRC have used the log-log method for extrapolating the rating curve beyond the measured gaugings. This is an accepted extrapolation method, as described in Section 2.3.3.7 Extensions (Curve Extrapolation) of the 2016 National Environmental Monitoring Standards (NEMS) for Rating Curves. Within this section of the Standard it is also recommended that, whenever possible, two or more methods are used to improve the confidence in the extrapolated portion of the rating curve.

The Panel has made use of a second approved method for checking the accuracy of the rating curve at this location. The second method makes use of the outputs from the 2007 BOPRC 1-dimensional MIKE-11 hydraulic model of the Ngongotahā Stream. The outputs of the model provide estimated water levels for a selection of flood flows at SH5. Figure 7 shows two rating curves, the current BOPRC rating based on the log-log extrapolation of gaugings, the Review Panel derived rating based on the 2007 BOPRC hydraulic model outputs, along with the high stage gaugings which are mostly from the 5 June 2018 event and the measured peak water level of 5.874 m from the 29 April 2018 event.

[7] Flow gaugings involve physically measuring the cross sectional area (A) at a site and the velocity across the channel (V) to determine the flow (Q) by multiplying the area (A) by the velocity (V).
[8] BOPRC, personal communication 4 July 2018

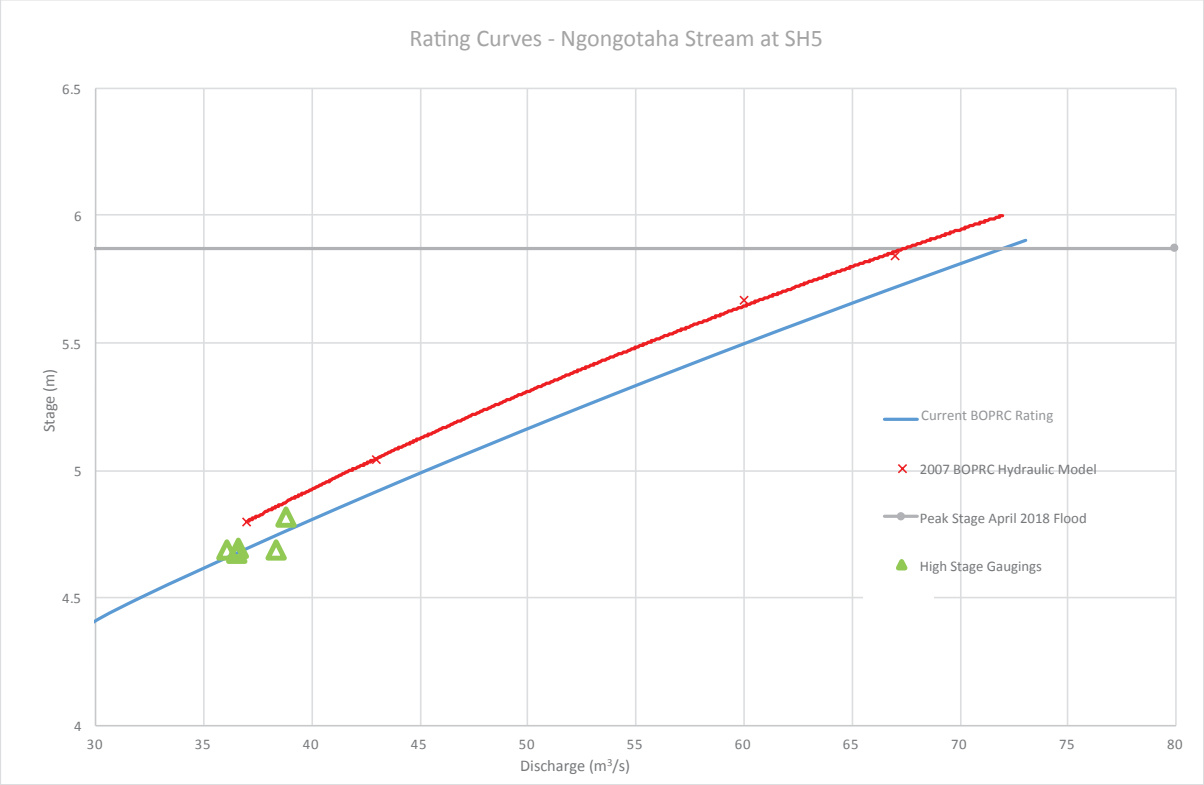


Figure 7: Rating Curves, High Stage Gaugings and Measured Peak Water Level Ngongotahā Stream at SH5

Based on the BOPRC log-log extrapolated rating curve the peak flood flow during the event was 72 m^3/s, this is compared to the rating curve derived from the hydraulic model which suggests a slightly lower peak flood flow of 68 m^3/s. Overall it is considered there is a good degree of confidence in the estimated flood flows at the site and the peak flood flow during the event was approximately 70 m^3/s +/- 8% (5 m^3/s).

2.2.4 Flood Frequency Analysis at SH5

With a reasonable degree of confidence in the estimated peak flood flow at SH5 during the 29 April event consideration can now be given to estimating the frequency at which this size of flood could be expected to occur. The frequency is often referenced in terms of a return period in years which provides the probability of the event occurring. A 100-year return period event has a 1% probability of being exceeded in any given year, which translates to -

a) a 10% chance that it will occur in the next 10 years;
b) a 40% chance of occurring in the next 50 years;
c) and a 63% chance of occurring in the next 100 years.

Prior to the 29 April 2018 flood event the published flood frequency for Ngongotahā Stream at SH5 was as presented in Table 2 below. It is noted that this was based on frequency analysis of the 1976 to 2000 flood series which produced a 100-year flood of 61 m^3/s which was scaled up to 67 m^3/s to account for the predominantly positive IPO phase[9] that existed over the duration of the flood record. A positive IPO is recognised as being quiescent in terms of flood extent and frequency in the Bay of Plenty region (BOPRC, 2018). In an original Bay of Plenty Catchment Commission Report from 1975 the 100-year flood was estimated to be 125 m^3/s, but it is not clear what data or analysis was used to support that estimate. In 1975 there would have likely been direct experience of a 20-year period of frequent large floods attributable to the negative IPO phase that existed from 1945 to 1976 including the very significant historic flood of 1966.

[9] The IPO is the Interdecadal Pacific Oscillation which reflects a predominance of La Nina or El Nino weather patterns and has significant effects on the flood extent and frequency of different regions across New Zealand.

Table 2: 2018 Flood Frequency for Ngongotahā Stream at SH5

Flood Flow	Return Period
30 m^3/s	5-year
37 m^3/s	10-year
43 m^3/s	20-year
60 m^3/s	50-year
67 m^3/s	100-year

It was the flood frequency presented in Table 2 that was used for the 2005 to 2007 flood modelling undertaken by BOPRC for the Ngongotahā Stream Catchment. Recent work by Prattle Delamore Partners for RLC reviewed the flood frequency to include the period from 2000 which had not been previously included in the flood frequency analysis. This analysis produced an estimate of the 100-year flood flow of 62 m^3/s.

This was reviewed by BOPRC who provided comment on the likelihood of the Ngongotahā Stream being characterised by an extreme value Type 2 (EV2) frequency distribution as with other rivers in the region as well as the possibility of the best fit of frequency distributions changing following large events as occurred in the Manawatu following the 2004 flood[10]. On the basis of the above it was agreed to keep the 100-year design flood flow at 67 m^3/s. It is worth noting at this point that upon receiving advice from BOPRC, Pattle Delamore Partners added 20% to the 100-year flood flow of 67 m^3/s to account for climate change to provide a design 100-year flood flow of 80 m^3/s.

The most recent assessment of flood frequency undertaken by BOPRC, which includes the April 2018 flood based on their rated peak flow estimation of 72 m^3/s, produces a current estimate of the 100-year flood of 69 m^3/s. Figure 8 provides a summary of the interim frequency analysis undertaken by BOPRC on the full length of record (1976 – 2018) including the April 2018 flood. If this assessment was re-done using the lower end of the range of flood flow estimates (68 m^3/s) based on the hydraulic model derived rating curve then the current 100-year flood estimate would be closer to the existing, adjusted estimate of 67 m^3/s. The most recent interim assessment is considered reasonable and justifies the past adjustments made to the base flood frequency analysis to account for IPO phases, EV2 frequency distribution and possible changes to frequency distributions.

[10] BOPRC, personal communication 9 January 2018)

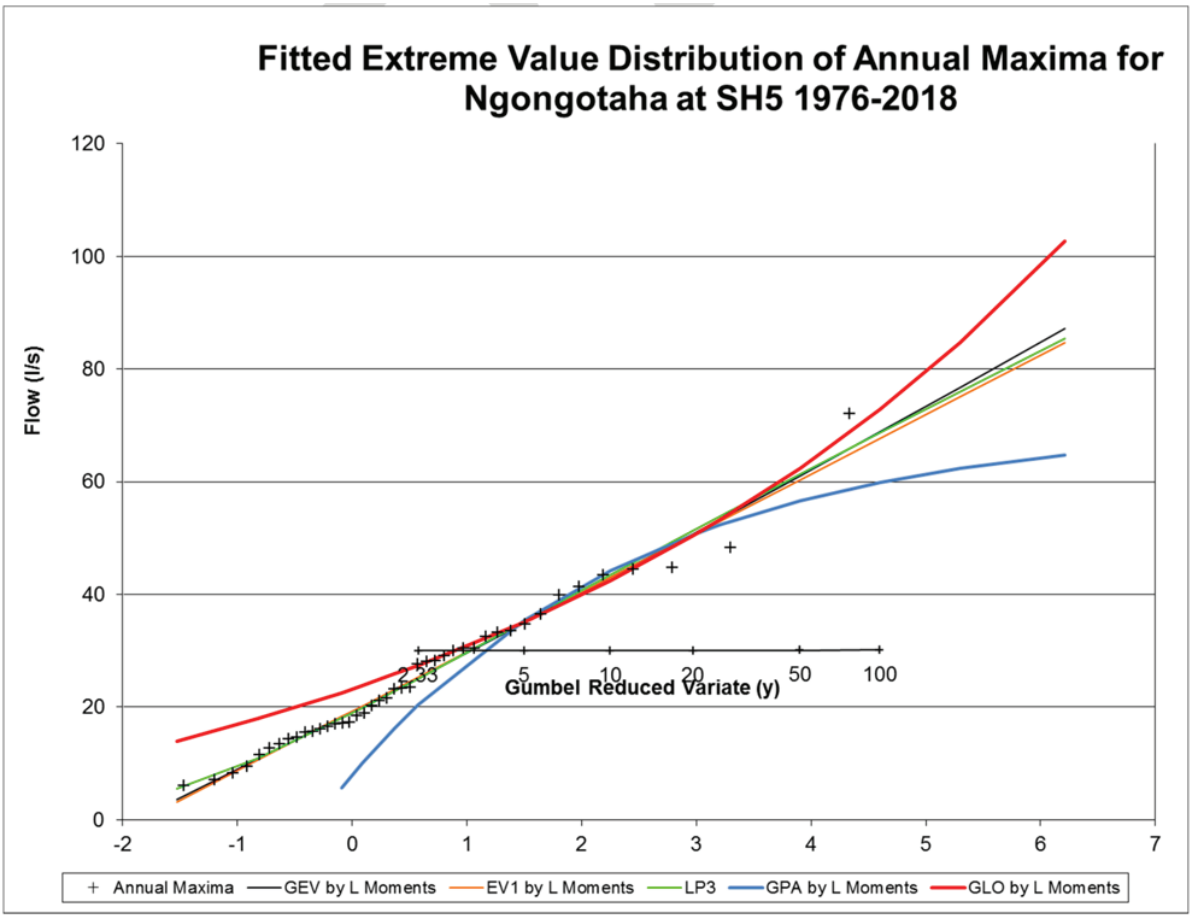


Figure 8: Interim Flood Frequency Analysis for Ngongotahā Stream at SH5 (Source BOPRC, 2018b)

2.2.5 Flood Event Conclusions

It is therefore concluded that the April 2018 event was approximately a 100-year return period event with the possibility that it was slightly greater (+ 8%) if the higher estimate of flow is assumed to be more accurate. However, in the future with the inclusion of a 20% allowance for climate change the return period would be reduced to approximately a 50-year return period event.

This was a significant flood event and flooding and erosion damage would be expected in areas where the flood management systems had a level of service of less than the 100-year return period event.

In areas with a 100-year return period level of service, prudent infrastructure design would have provided a system that could be expected to perform adequately in an event slightly larger than the design level of service.

3 Impact on the Community

This section summarises the insights gained from interaction with those affected by the 29 April flood event and the wider Ngongotahā community. The Panel emphasises that this section reflects the community's view point and BOPRC and RLC have not had an opportunity to respond to specific comments from community members.

The force and speed of the flooding took residents and businesses by surprise. Residents told the Panel of how the flood waters rose over their sections and then into their houses in a matter of minutes. Many had little or no time to save their belongings, and cars and furniture were caught in the flood waters. Some residents talked about having to swim or hold on to fences to avoid being swept away. Others had concerns for their families and animals that were trapped on the other side of the floodwaters. No severe injuries or loss of life occurred which was a testament to the resourcefulness of the residents and those who assisted. Stormwater drains and sewerage systems in the area were unable to cope and there were reports of manholes bursting open and spreading sewerage onto people's sections. Some 114 houses in Ngongotahā were inspected after the floods with 38 being recorded as insanitary and uninhabitable.

3.1 Community Engagement

The Panel was interested in talking to a wide cross section of the community who lived in vicinity of the Ngongotahā Stream and, in particular, those who were impacted by the flood. Where possible, individuals and businesses were identified and invited to meet with Panel members.[11] Other individuals and groups who requested meetings with the Panel were also accommodated. [12]

Three informal sessions were held in the Ngongotahā Bowling Club facilities, with the intention of encouraging free and frank discussion. The objective was to ensure that all voices were heard as well as to gather useful information to assist with the review.

Discussions were held with affected businesses, iwi, residents and community groups. Interested parties were also invited to provide submissions to the Panel, by email or by post, on a prescribed form. Eleven submissions were received and some of the submitters chose to attend the open sessions as well. The Panel was impressed by the resilience of the community, how keen they were to participate, and how constructive their comments were. Many had lived in the area for upwards of 40 years. Families had heart wrenching stories of the impact of the flood on their lives and it was clear the effects would continue to be felt for many more months. They were keen to tell their stories, but their focus was on getting on with their lives and ensuring a flood like this did not happen again.

The response of the Ngongotahā community groups was also impressive. The Panel heard how neighbours, the Volunteer Fire Brigade, and other groups had played their part on 29 April and were still continuing to do so. For example, we were told of the efforts of the local branch of the Volunteer Fire Service who have on previous occasions provided support to people and the recent flood was no exception.

[11] Closed consultation meetings were held on the 28th June with five people in attendence and July 2 with six people in attendence. An Open consultation day was held on 4 August where eleven people attended

[12] Invitations were sent to Ngāti Tura, Ngāti Te Ngākau, Ngāti Rangiwewehi, Ngāti Ngāraranui, Te Tatau o Te Arawa, Te Arawa Lakes Trust, Te Pūmautanga o Te Arawa and Te Kōmiti nui o Ngāti Whakaue

3.1.1 Consultation with Tangata Whenua

Invitations were issued to the Iwi who have connections and interests in and around Ngongotahā to meet with the Panel. Ngāti Tura and Ngāti Te Ngākau representatives outlined their historical connections to this land and advised the Panel that their interactions with both councils had been limited to dealing with issues when they arose in their area and their involvement with the Pioneer Property Trust subdivision consenting process. They suggested that communication and monitoring could be better. The Panel was advised that the iwi had objected to the subdivision on historical grounds, but nothing happened in that regard. The damage to and loss of land behind the Parawai marae during the April 2018 flood was a concern for them, but post flood repairs, involving the placement of rock rip-rap on the stream banks and vegetation clearing on the stream berms, had been completed for which they were grateful. They were keen to have an ongoing dialogue with both councils in the future about issues affecting their rohe (area).

3.1.2 Affected Areas

Paradise Valley Road

This is a rural area consisting of farms and lifestyle blocks of land. Paradise Valley Springs Wildlife Park (Wildlife Park) resides on this road as does the Ngongotahā Trout Hatchery. The Wildlife Park is described as "*Rotorua's must-see wildlife park where visitors of all ages can interact closely with a range of New Zealand's wild animals, native birds, farm animals and trout, as well as view and get up close to a large pride of African Lions".*

The Panel was advised that the Wildlife Park had to be closed for almost two weeks to clear damage caused by the flood. The flood passed through a number of properties, as well as the Wildlife Park, on its path to the SH5 Bridge. The key matter raised by most of those spoken to, was astonishment at how fast the water rose, arrived and then dissipated. Some residents of the Paradise Valley area suggested that the suddenness of the flood may well have been the result of natural dams caused by fallen trees and debris in the stream tributaries prior to the downpour bursting, but the Panel received no tangible evidence of that being the case.

To illustrate the concerns conveyed to the Panel below we paraphrase comments recorded from a discussion with a landowner in Paradise Valley Road, who resides close to a location where the stream overflowed its banks -

"On the 29 April he observed solid rain all day. At 1200 he went outside to shut gates and secure objects on the property. At 1230 he saw the water rising over his property. By 1330 there was a serious overflow occurring over the stream bank and water was flowing over his driveway. He went to get bee keeping equipment from his property and from the time he crossed his section the force of the water was so strong he had to hold on to the fence. He noted that there were log jams in the stream affecting the flow of the water. Once the rain had stopped the water drained from his property within two hours. His house was inundated with water 1 m deep. He noted that there is lack of maintenance of the stream which he suggests contributed to the issues with the water flow on the 29 April. There was a lot of silt and debris left behind."

A group of landowners within Paradise Valley have formed the Paradise Valley Community Catchment Group which meets regularly. Panel members met with and received submissions from, this group. They set out their observations and declared a willingness to work with other parties to address the issues of flooding in their area. They recognised the part they play as landowners to look after issues on their land, but also understood the opportunities for working with the councils in clearing blockages from streams.

Landowners and others involved on 29 April 2018 in the Paradise valley area, such as the Ngongotahā Volunteer Fire Brigade, observed that the peak of the flood seemed to reach them two or three hours before it reached Western Road.

Figure 9: Paradise Valley Road Property Photo taken on 29 April 2018 by resident

State Highway 5 to Ngongotahā Road on Southern Side of Western Rd

Affected tourist facilities included Velocity Valley and the Agrodome, both located close to the Ngongotahā Stream. The Agrodome had tourist groups on site at the time of the flood, many of whom were evacuated with the help of specialist amphibian vehicles owned by Duck Tours. A swing bridge was lost and the Agrodome has subsequently hired an engineer to assess their main bridge which had been hit by debris. Interestingly, both the Agrodome and Velocity Valley had been flooded several times before, however, the Agrodome carpark flooded on 29 April which had not happened before. Velocity Valley advised they had been flooded seven times between February and August 2017. The Agrodome had a marker near the SH5 Bridge to warn them when water levels made it unsafe to continue their farm tours. A farm tour had been cancelled at least twice in the last 12 months. The businesses commented on the loss of revenue and the difficulties with insurance as a result of so many flood events.

A number of residents were also flooded in this general area. Some houses had flooding from a breach at the western end of Western Road from water that travelled down that road, while others were flooded from the rise in water levels and subsequent flows in the Ngongotahā Stream. This area has a mixture of older houses along Western Road as well as the newer houses in Brookdale Drive and Streamdale Place.

Houses on Northern Side of Western Road Including Pioneer Property Trust Subdivision

A number of the houses on the northern side of Western Road have been there for over 60 years. From around 2004 engineering design and consenting work commenced on what is variously termed the Pioneer Property Trust subdivision (PPTS) or the Oakland Estate Development, a subdivision where all the houses were new builds. Controversy over this subdivision dates back to 2008 where reports in the local newspaper document an ongoing battle between land owners, the developers and RLC over damage to houses from subsidence of the land. The development of this subdivision is discussed in full in Section 5 of this report.

People observed flooding and very high water levels above the Ngongotahā Bridge at Elliot Park and on both sides of the river at the Ngongotahā Town Bridge.

Figure 10: Photo of Western Road Property taken 29 April 2018 by resident

Ngongotahā Road Bridge to the Lake

The Panel was advised that some damage had been suffered on property directly below the Ngongotahā Bridge, but this did not affect dwellings in this area and residents spoke more of stream bank erosion. This occurred in particular behind Parawai marae and adjacent to other properties further downstream. The Panel was advised that a stopbank in close proximity to the Rika whanau land was close to overtopping before the water receded.

The Panel was advised that there were sewerage overflows both at the PPTS as well as on the Rika whanau property. The Panel understands that some Volunteer Fire Brigade personnel were treated at the hospital due to infections from contamination.

3.2 Historical Stream Maintenance

3.2.1 Urban Areas

In this section we discuss the views expressed by residents regarding their understanding of which council is responsible for stream maintenance and their experiences in dealing with council staff. We acknowledge that these are unverified views, but we include them here to provide context for our subsequent discussion of actual roles and responsibilities in Section 4 of this report. The main conclusion is that there is community uncertainty regarding those roles and scepticism about their implementation.

Submitters all had a view on the maintenance of the stream and its environs. Their opinions on what maintenance should be undertaken differed, depending on where they resided. Views included removing all the debris, maintaining foliage on the banks, removing all plantings, planting more, removing silt, building stop banks, and reducing the meanderings in the stream, amongst other things. From these many and varied views, it seems that that there was not a clear stream maintenance plan in place, or if there was one, it has certainly not been communicated sufficiently to the residents.

In this regard, BOPRC advised the Panel that they have responsibility for maintenance of the Ngongotahā Stream. They have had a policy of managing the stream proactively below the Ngongotahā Road Bridge to a 100-year flood design standard and undertaking reactive maintenance to clear blockages up to SH5. Above SH5 they have largely left it for nature to take its course.

However, they have at times worked with landowners upstream of SH5 to jointly fund minor stream maintenance works requested by individual property owners.

While residents were consistent in their view that the lack of a stream maintenance plan contributed to the flooding, they were less clear when asked who was responsible for stream maintenance. Most recognised that RLC was probably the first point of contact, but they did not understand what happened thereafter. Many had called RLC several times about issues, such as a tree fallen into the stream, but reportedly received no satisfaction from their call. Most submitters professed to have no knowledge of the process; this is discussed fully in Section 4.

Residents also understood the importance of the stream for trout spawning and as a draw card for fishermen.

3.2.2 Non-Urban areas

The BOPRC's Regional Natural Resources Plan 2017, Method BW M18 (Method 218) signals that the Council will undertake stream maintenance in conjunction with landowners in certain circumstances, including where there is significant bank erosion, substantial blockages or excessive plant growth. Relevantly then, we note that the landowners and business owners in non-urban areas of the catchment were generally aware that they may have to contribute to work on the stream but were vague about the process by which that occurred and how that worked.

Many had stories to tell of where they had contacted BOPRC or RLC about an issue in the stream, Council staff had come out and discussed a solution, but then nothing came of it. This included where the landowner was willing to contribute some funds, equipment and time. Others said that if they managed to talk to more senior staff members, they got a better response. Others talked about the frustration of *"ping ponging"* between BOPRC and RLC several times to try to get some support when they saw a need for some work to be done on the stream. Others talked of having been discouraged by bureaucracy. One landowner told the story of offering to hire a digger to remove a tree fallen in the stream. He related that he was advised by BOPRC that he could not do it as he would need resource consent. Later, heavy rain led to the road being washed out around the tree. Some residents lost access to their properties until NZTA re-established the road.

The cost of maintaining the stream was now a concern for some farmers. They considered there was a public good from maintaining their section of the stream and the costs should be shared more equitably.

3.3 Community Engagement Summary

While it is recognised that the information provided to us is anecdotal, the above is considered a useful summary of submissions and interactions that the Panel has had with the affected community. Through this community engagement some common themes emerged -

- Most submitters professed to have no knowledge that their properties were subject to a risk of flooding. We did note that a sample of Land Information Memorandum reports for the area commented on the overland flow paths that occurred on private properties.

- Everyone commented on the speed and the force of the flood water. They were generally taken by surprise – either they had not expected any problem and there was no warning, or they thought the danger was over. There were anecdotal examples of water rising to a depth of 1.2 m through a house in a matter of minutes.

- The force of the water became dangerous – particularly as residents, who had not experienced flooding before, appeared to initially take it too lightly. The actions of emergency response groups were crucial in evacuating people from the flooded areas, and it seems that it was largely luck that averted potential disaster. One resident talked about a freezer and washing

machine being overturned. Residences provided a video of a substantial caravan being washed down the road.

- The panel heard about the storm water drains not coping, or back flow from these drains contributing significantly to the flood water.

- The water drained away very quickly in most cases.

- While the community responded quickly to the flooding, many considered that the communication from RLC and BOPRC was too little, too late.

- People we spoke to were unclear about the respective roles and responsibilities of both RLC and BOPRC. Many understood that the first point of contact for any stream maintenance issues was RLC but were confused as to who should respond to their concerns both during the event and days after. Submitters talked about being passed between the RLC and BOPRC, with neither taking responsibility.

- Many residents and businesses had proactively engaged with BOPRC to advise of debris or overgrown vegetation in the stream, or on its banks. The general view was that there was minimal response from the BOPRC staff.

- Several people spoke of how beautiful the stream can be when walking its banks, but prior to the flood it had become overgrown with vegetation and trees.

- Residents recognised the importance of the stream as a trout habitat.

- People appreciated that BOPRC had undertaken some stream maintenance after the flooding of 29 April 2018.

3.3.1 Options for Improvement - Community Engagement.

The Panel recognises that communication is always a subject for continuous improvement. It became clear throughout discussions with RLC and BOPRC and with the Ngongotahā residents, that there exists frustration with attempts to engage with the councils and that there is scope for improving communication channels.

The Panel believes that regarding the development of flood management plans there is a need for the BOPRC and RLC to clarify their roles, regulations and processes between themselves in the first instance, provide those guidelines to front line staff who deal with the community by phone or in person and to publicise regularly those responsibilities where it is appropriate, for example applications for building consents in certain areas.

These options have been included in the Roles and Responsibilities Recommendations in Section 4.2.8

4 Flood Risk Management in the Ngongotahā Catchment

This section provides a description of the management of the flood hazard in the Ngongotahā catchment within the context of legislative and best practice requirements. Introductory sections are provided to explain the different elements of flood hazard management (Section 4.1) and the Roles and Responsibilities regarding their implementation (Section 4.2). The important topic of design standards (level of service) is explained. (Section 4.3) The specific discussion of flood risk management within the Ngongotahā catchment is split into sections covering the four primary categories of tools for managing flood risk –

- Operational Maintenance Section 4.4;
- Structural Works Section 4.5;
- Planning Controls Section 4.6; and
- Emergency Management Section 4.7.

The introduction to flood risk management provides further explanation below on what is encompassed within these categories of flood risk management tools.

4.1 Introduction to Flood Risk Management in New Zealand

To provide context for the elements of flood hazard management being described in this section a brief introduction of the recommended process and the specific tools used to manage flood hazard in New Zealand is provided below.

The recommended process for managing flood risk in New Zealand is explained in the New Zealand Standard NZS 9401:2008 Managing Flood Risk – A Process Standard. The overall process is divided into three key phases –

a) Establish the Context;
b) Understand the Risk & Treatment Options;
c) Achieve Sustainable Solutions.

Throughout all phases there is communication, consultation and collaboration occurring in parallel with monitoring, reviewing and adaption. Successful implementation of the overall process should produce the following six sustainable flood risk management outcomes as described in NZS 9401:2008 –

a) Engaging communities and stakeholders;
b) Understanding natural systems and catchment processes;
c) Understanding the interaction of natural and social systems;
d) Decision making at the local level;
e) All possible forms and levels of management;
f) Residual risk.

It is these six outcomes that have been used as part of the overall evaluation of the RLC and BOPRC management of the Ngongotahā Stream flood hazard, in terms of best practice, and to determine the areas for detailed analysis and reporting by the Panel.

Further explanation around the meaning of “all possible forms and levels of management” is provided below to provide some context around the Panel’s evaluation of a much broader range of elements than simply the structural flood defences including stormwater infrastructure.

The four key categories of tools for managing flood risk along with examples of each are summarised in Table 3. These have been summarised from the New South Wales Government’s Floodplain Development Manual (2005) and the Greater Wellington Regional Council’s Guidelines for Floodplain Management Planning (2015).

Effective flood hazard management requires consideration of all four categories of tools for the full range of flood events up to very extreme events beyond the capacity of any primary structural works. It is the development, agreement on, and implementation of a comprehensive suite of tools that provides the overall flood risk management solution.

Table 3: Tools for managing flood risk (Source: New South Wales Government, 2005; Greater Wellington Regional Council, 2015)

1. River Management & Maintenance
• Tree pruning, blockage removal (within main channel); • River bed and beach recontouring (with bulldozers or excavators); • Gravel extraction, sand/silt dredging; • Weed spraying/removal (aquatic and terrestrial); • Hard river bank protection (groynes, rock revetments); • Planted willow buffer zones and other riparian planting for erosion protection and habitat.
2. Structural Works
• Stopbanks; • Flood diversion channels (overland flow paths); • Non-return valves on large culverts (flap gates); • Detention dams; • Floodplain storage compartments; • Pump stations; • Raising or flood proofing buildings.
3. Planning & Land Use Controls
• Flood hazard maps or zones (often included in District Plan); • Restrictions on subdivision or building; • Minimum floor levels; • Designations; • Voluntary or compulsory property purchase.
4. Emergency Management
• Flood risk awareness and education; • Community readiness; • Flood forecasting and warning; • Evacuation triggers and procedures; • Inspection of key structures (e.g. floodgates, stopbanks); • Planned emergency works (e.g. deployment of sandbags, installation of temporary flood barriers, portable flood pumps); • Asset monitoring and reactive emergency works (e.g. additional earth reinforcement of stopbanks for seepage and heave, rock placement for erosion); • Insurance.

Depending on existing land uses and zoning in the District Plan it could be appropriate for flood risk to be managed by non-structural, non-intervention means such as Planning Controls and Emergency Management. This is often the case in rural areas where the land-use is more resilient to inundation from floods. In built-up urban areas there is usually the need for a greater amount of intervention in terms of active management of the channel including extracting sediment, removing weeds and other detrimental vegetation that could block the channel during flood flows. It is also common to have stopbanks on either side of the channel to reduce the frequency for which the surrounding floodplain is inundated.

In situations where there is active channel management and stopbanks the non-structural options of Planning Controls and Emergency Management are critically important for managing the risk from events greater than the design standard of the structural works as well as the risk of the structural works failing in events below their design standard.

Different design standards can be applied for river channel maintenance works and structural works such as stopbanks, with flood risk above these design standards managed with non-structural tools such as Planning Controls (District Plan) and Emergency Management (evacuations, temporary works, resilience). Figure 11 provides an example of different combinations of options across the four categories of tools to manage flood hazard from the smallest (2-year return period) to the largest (PMF – probable maximum flood) flood events.

This is reflected to some degree in the overall management of the Ngongotahā Catchment with a 100-year design standard provided in terms of structural works (stopbanks) downstream of Ngongotahā Road Bridge, an undefined maintenance standard provided up to and beyond SH5, but with no District Plan or planned Emergency Management provisions in place. These points are discussed in further detail in the following sections.

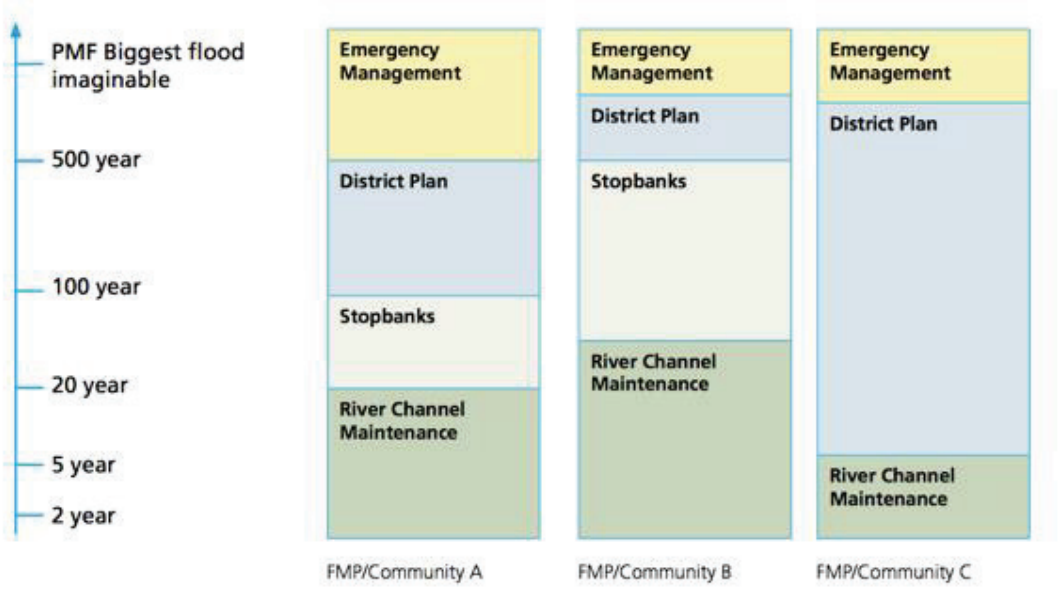


Figure 11: Combinations of flood risk management tools over the continuum of flood events. (Source - GWRC (2015) Guidelines for Floodplain Management Planning)

The development of a comprehensive solution covering all available tools is where the process becomes particularly complex as the selection of the option for each category is dependent on what options have been selected for the other categories throughout the area being managed. For example, it may be perceived as relatively straightforward to manage risk at an isolated location by building a stopbank, but this will result in more flood water being confined within the main channel. This will then likely increase the risk further downstream and is simply transferring the risk from one location to another. In some cases, this may be advantageous, if the risk is transferred from areas with higher consequences associated with flooding (e.g. residential, commercial) to those with lower consequences (e.g. open green space), but within an RMA context it can be difficult to shift the hazard for the benefit of one area to the detriment of another.

It is for the above reason that flood hazard management is not effective if done in an ad-hoc and isolated manner and that a comprehensive floodplain or catchment scale plan is required to ensure that flood management "solutions" aren't simply transferring the flood issues to other areas.

A further point to highlight with regard to structural options is that very careful consideration should be given to any solution that requires stopbanks. The issue with stopbanks is that they can increase the flood risk due to the intensification of development that typically follows their construction and the fact that they will eventually be overtopped when an event exceeds their design capacity. The evidence for this is clearly documented in the seminal publication of the National Water and Soil Conservation Authority by Dr Neil Ericksen (Water & Soil Directorate, Ministry of Works & Development) – Creating Flood Disasters? New Zealand's need for a new approach to urban flood risk management.

The title of this publication "Creating Flood Disasters" is a direct reference to the flood disasters that can be created by building stopbanks. Notwithstanding the above, stopbanks are prevalent throughout New Zealand's, and the worlds' developed floodplains. This being the case it is of critical importance to effectively manage the risks for events that exceed the capacity of the stopbanks through Planning Controls and Emergency Management and to avoid the construction or raising of stopbanks wherever possible but especially for greenfield sites.

A final point to note on the overall philosophy of flood risk management is to recognise the principles described in the guideline, Preparing for Future Flooding: A Guide for Local Government in New Zealand (Ministry for the Environment, 2010). A summary of these guiding principles is provided below -

a) Take a precautionary approach;
b) Use flexible or adaptive management options;
c) Use no or low regrets options;
d) Avoid making decisions that potentially compromise future options;
e) Progressive risk reduction;
f) Integrated sustainable approach.

The Panel has taken these guiding principles into account outlining the RLC and BOPRC use of the various flood risk management tools described above for achieving the sustainable flood risk management outcomes as described in NZS 9401:2008.

4.2 Roles and Responsibilities

Roles and responsibilities for flood hazard management are shared between the BOPRC and the RLC under several statutes. For the purposes of this review we briefly discuss[13] the -

a) Local Government Act 2002 (LGA);
b) Resource Management Act 1991 (RMA);
c) Soil Conservation and Rivers Control Act 1941 (SCRCA);
d) Building Act 2004 (BA);
e) Local Government and Official Information Meetings Act 1987 (LGOIMA).

4.2.1 Local Government Act 2002

Under the LGA[14] the purpose of both the BOPRC and RLC is very broad, being to meet the current and future needs of communities for good-quality local infrastructure, local public services, and performance of regulatory functions in a way that is most cost-effective for households and businesses.

The avoidance or mitigation of natural hazards is a core service that both councils must pay particular regard to.[15] Both councils are obliged to identify flood protection and control works that they are responsible for and how they will manage those assets in the long term. These obligations are discharged through various accountability documents including the Long Term Plan (LTP),[16] Annual Plans, and Asset Management Plans (AMP). Each council's LTP and AMP should specify the level of protection afforded by their flood management assets.

In this case Ngongotahā falls within the BOPRC Upper Kaituna Catchment Control Scheme. We discuss the particulars of that Scheme later in this report.

[13] The Panel does not discuss the Civil Defence Emergency Management Act 2002 as the effectiveness of the local and Group Civil Defence Emergency Management response and the establishment and implementation of the recovery phase of the flood event are excluded from the scope of this review.
[14] Section 10(1)(b)
[15] Section 11A
[16] The LTP must include a separate infrastructure strategy for a period of at least 30 consecutive financial years.

BOPRC has specific powers[17] to make bylaws relating to flood protection and flood control works undertaken by, or on behalf of, itself. The BOPRC has promulgated the Floodway and Drainage Bylaw 2008. That bylaw does not relate to the effects of flooding, instead it protects BOPRC assets from damage or misuse and is not relevant here.

In this case given the broad flood management mandate available to both councils under the LGA, the BOPRC and RLC had previously agreed that:

a) From 2003 until 2013[18] BOPRC delegated responsibility for Upper Kaituna maintenance works,[19] including in the Ngongotahā Stream above Ngongotahā Road, to RLC.[20] That arrangement no longer exists and BOPRC is now responsible for stream maintenance; and
b) RLC is contracted by BOPRC to be the first 'port of call' for queries or complaints from members of the community regarding Ngongotahā Stream maintenance issues. RLC staff receive the query, undertake an inspection and recommend to BOPRC what, if any, remedial action should occur. We understand this arrangement is still in place but may not currently be formalised.[21]

Accordingly, maintenance of the stream now rests with BOPRC whereas the role of responding to queries regarding stream maintenance still rests with RLC. This is a potentially confusing split of responsibilities.

4.2.2 Resource Management Act 1991

For the purposes of giving effect to the RMA, the BOPRC has the functions of controlling the use of land for the purpose of the avoidance or mitigation of natural hazards[22] and controlling the planting of plants on the bed of a river for the purpose of avoiding or mitigating natural hazards.[23] The RLC has the function of controlling any actual or potential effects of the use, development, or protection of land, for the purpose of the avoidance or mitigation of natural hazards.[24]

Both councils are required to keep reasonably available records of natural hazards to the extent that each considers appropriate for the effective discharge of its functions.[25]

The RLC is responsible for approving subdivision proposals.[26] It can refuse to grant consent for a subdivision if it considers there is a significant risk from flooding.[27] The risk assessment should consider both the likelihood of a flood occurring and material damage that would result. Conditions of consent can be imposed requiring the protection of the land from flooding or that floor levels are above a specified height.[28]

The BOPRC and RLC have potentially overlapping land use control responsibilities with regard to flood hazard management. Consequently, the RMA directs that the regional policy statement must state the local authority responsible in the whole or any part of the region for specifying the objectives, policies, and methods for the control of the use of land to avoid or mitigate natural hazards.[29] The Bay of Plenty RPS contains provisions on natural hazards[30] that were made operative on 5 July 2016.[31]

[17] Section 149(1)(c)
[18] Upper Kaituna Liaison/Advisory Group minutes and as advised to the Panel by RLC.
[19] Checking floodways and clearing trees, checking and repairing floodgates and culverts, periodic inspections. As set out in BOPRC Doc No. 171595 titled "Upper Kaituna Catchment Control Scheme Delegated Maintenance Contract".
[20] Works were undertaken by Castle Corp (RLC's contracting subsidiary) – email from BOPRC dated 10 August 2018.
[21] Operational Policy: Kaituna Catchment Control Scheme Upper Kaituna Scheme Asset Maintenance Policy, 2016
[22] Section 30(1)(c)(iv)
[23] Section 30(1)(g)(iv)
[24] Section 31(1)(b)(i)
[25] Section 35(5)(j)
[26] Section 31(2)
[27] Section 106(1)(a)
[28] Section 220(1)(c) and (d)
[29] Section 62(1)(i)

The RPS[32] assigns the following responsibilities:

- Developing objectives, policies and methods other than rules – both BOPRC and RLC;
- Developing rules – RLC.

The RPS[33] also states that the BOPRC is responsible for undertaking area-based flood susceptibility mapping for flooding from natural water courses outside urban areas that have reticulated stormwater networks. The RLC is responsible for that mapping for urban areas that have reticulated stormwater networks.

In Figure 12 the Ngongotahā urban area where the RLC is responsible for flood susceptibility mapping is shown. The green lines show the stormwater network (pipes). The Panel asked both BOPRC and RLC to delineate their interpretation of RPS Policy NH 13C on that figure. RLC agreed that the 'black line' drawn by BOPRC represented "*a reasonable reflection of the split between urban and rural purely based on the policy*".[34]

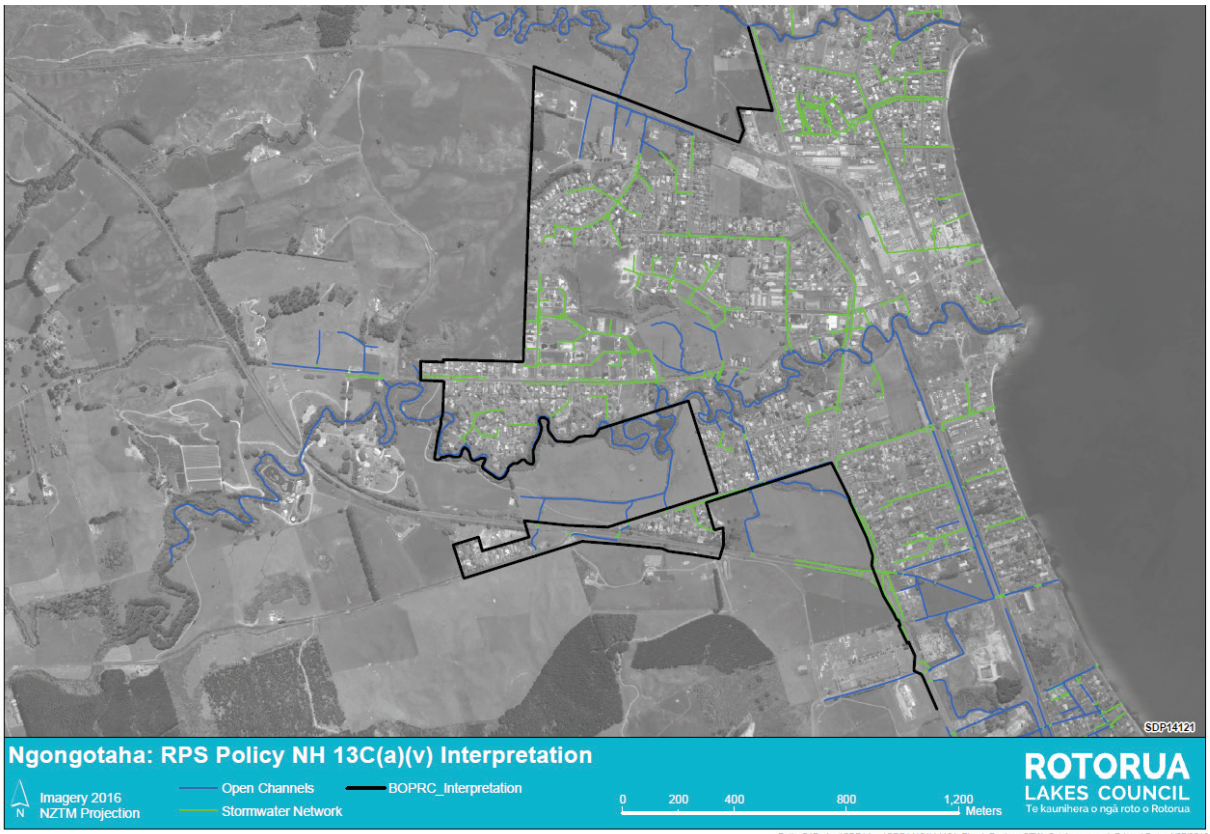


Figure 12: Area of RLC flood hazard responsibility

However, RLC were of the view that BOPRC should undertake flood susceptibility mapping in the Ngongotahā urban area "*as part of the flood maintenance and flood protection work that they undertake under the Upper Kaituna Scheme*."[35] That may be RLC's view, but it does not reflect the actual wording of the operative RPS to which the District Plan must give effect.[36] Consequently, the

[30] Chapter 2.11 Natural hazards
[31] In total the RPS contains one objective, 14 policies and 27 methods of implementation for natural hazards
[32] Policy NH 14C
[33] Policy NH13C
[34] Email from Panel conveying the views of RLC, dated 14 August 2018
[35] Ibid.
[36] Section 75(3)(c) of the RMA requires the RLC's District Plan to give effect to the RPS.

Panel concludes that RLC has responsibility for flood hazard mapping within the Ngongotahā urban area within the black line shown in Figure 12.

4.2.3 Soil Conservation and Rivers Control Act 1941

The SCRCA assigned powers, functions and duties to catchment boards. The local government reorganisation orders promulgated in 1989 assigned the catchment board role to regional councils. Although the SCRCA was heavily amended by the RMA it still sets out the general discretionary functions and powers of catchment boards.[37] These include minimising and preventing damage by floods[38]; constructing, reconstructing, altering, repairing, and maintaining works for controlling or regulating the flow of water towards and into and in and from watercourses; preventing or lessening any likelihood of the overflow or breaking of the banks of any watercourse and preventing or lessening any damage which may be occasioned by any such overflow or breaking of the banks.

Of particular importance and relevance to the later discussion of BOPRC's actions on extending the Upper Kaituna Scheme to the residential area upstream of Ngongotahā Road are sections 126 (1) and 126 (2) (c) & (d) –

> **Section 126 General Powers of Catchment Boards**
>
> (1) It shall be a function of every Catchment Board to minimise and prevent damage within its district by floods and erosion.
>
> (2) Each Board shall have all such powers, rights, and privileges as may reasonably be necessary or expedient to enable it to carry out its functions, and in particular each Board shall have power to construct, reconstruct, alter, repair, and maintain all such works and do and execute all such other acts and deeds including the breaching of any stopbank as may in the opinion of the Board be necessary or expedient for—
>
> > (c) preventing or lessening any likelihood of the overflow or breaking of the banks of any watercourse:
> >
> > (d) preventing or lessening any damage which may be occasioned by any such overflow or breaking of the banks.

The above is of particular relevance to the known overflow point on Ngongotahā Stream opposite Brake Road which was where the majority of flood damage originated from in the April 2018 event.

The SCRCA also gives the regional council a discretionary power[39] to undertake the "maintenance and improvement of watercourses and defences against water".

The functions, powers and duties of the BOPRC under the SCRCA are subject to the RMA.[40] It must gain RMA consents (or reply on permitted activity rules in regional and district plans) to undertake flood control works. The SCRCA functions are discretionary, but in the Ngongotahā catchment they underpin the Upper Kaituna Catchment Control Scheme and the operational activities of BOPRC with regard to that Scheme.

4.2.4 Building Act 2004

The BA assigns a wide range of functions to the RLC. Of relevance here, the BA restricts the granting of building permits on land subject to inundation:

> **71 Building on land subject to natural hazards**
> (1) A building consent authority must refuse to grant a building consent for construction of a building, or major alterations to a building, if—

[37] Section 126
[38] Section 10(c)
[39] Section 133
[40] Section 10A.

(a) the land on which the building work is to be carried out is subject or is likely to be subject to 1 or more natural hazards; or

(b) the building work is likely to accelerate, worsen, or result in a natural hazard on that land or any other property.

(2) Subsection (1) does not apply if the building consent authority is satisfied that adequate provision has been or will be made to—

(a) protect the land, building work, or other property referred to in that subsection from the natural hazard or hazards; or

(b) restore any damage to that land or other property as a result of the building work.

(3) In this section and sections 72 to 74, **natural hazard** means any of the following:

(d) inundation (including flooding, overland flow, storm surge, tidal effects, and ponding)

The Panel note that building consent can still be granted[41] if a building will not accelerate, worsen, or result in a natural hazard on the land where the building is located and the RLC considers that it is reasonable to grant a waiver or modification of the building code in respect of the inundation hazard. If the RLC issues a building consent in those circumstances, it must impose a condition on the building consent and notify the Director-General of Land, resulting in a notation being placed on the certificate of title that a flooding hazard exists.[42]

4.2.5 Local Government and Official Information Meetings Act 1987

Under the LGOIMA[43] the RLC must issue Land Information Memoranda (LIM) upon request. A LIM must include information known to the RLC about any inundation that the property is subject to if that material is not apparent from the district plan. In this case, as we discuss in Section 4.6 of this Report, the Rotorua District Plan has no flood hazard maps for watercourses and so any information held by the Council concerning the potential for flooding should be disclosed on LIMs.

4.2.6 Roles and Responsibilities Conclusions

It is a core planning function under the RMA of BOPRC to avoid or mitigate flooding hazards within the Ngongotahā catchment. It is also a core operational function of under the SCRCA of BOPRC to minimise and prevent damage due to floods within the Ngongotahā catchment. However, although BOPRC has discretionary specific statutory powers to undertake flood protection and river control works under the SCRCA (subject to the need to gain any necessary authorisations under the RMA for physical works), under the LGA either the BOPRC or the RLC could undertake flood protection works in Ngongotahā and have such works included in their LTPs, Annual Plans and AMPs.

In this case, under the Upper Kaituna Catchment Control Scheme, promulgated under the SCRCA, the BOPRC has assumed responsibility for flood protection and stream maintenance works for Ngongotahā Stream.[44] However, somewhat confusingly, BOPRC has delegated responsibility to RLC to respond to some stream maintenance complaints from the public[45] and recommending to BOPRC what if any remedial works should be undertaken.

Under the RMA, and as directed by the RPS, the RLC is responsible for undertaking area-based flood susceptibility mapping for the Ngongotahā Stream within the urban area serviced by a reticulated stormwater network. The extent of that area is shown in Figure 12 and it includes much of the area flooded in the April 2018 event.

Under the RMA, and as directed by the RPS, the RLC is also responsible for promulgating rules (in the Rotorua District Plan) that control of the use of land to avoid or mitigate flooding hazards.

[41] Sections 72 and 73
[42] Sections 73(1) and 74(1).
[43] Section 44A(2)(a)
[44] Flood protection to a 100-year return period standard is provided by BOPRC between the Lake and Ngongotahā Road (SH36) whereas only maintenance works are undertaken by BOPRC between Ngongotahā Road (SH36) and SH5. Above SH5 the Panel understands BOPRC undertakes ad hoc stream maintenance works (such as tree removal) in response to public complaints that it receives via its land management staff.
[45] In the reach of stream below SH5 and out to the Lake.

Under the BA, the RLC should not generally grant building permits for houses and other buildings on land that is subject to a known flooding hazard unless it is satisfied that adequate provision has been made to protect the building from flooding.

Under LGOIMA the RLC must disclose any information concerning the potential for flooding on any LIM that is requested for a property.

4.2.7 Roles and Responsibilities Recommendations

The Panel recommends that:

- BOPRC ensure they are fulfilling their discretionary advisory and operational function to minimise and prevent damage by floods and erosion, especially with regard to areas where new residential development is proposed;

- BOPRC and RLC ensure they are fulfilling their requirements to meet the current and future needs of communities by providing and planning for good quality local flood control and stormwater infrastructure in their Long Term Plans and Annual Plans;

- BOPRC and RLC work collaboratively with each other and the Ngongotahā community and iwi to improve inter-council and public relationships and communication channels.

- BOPRC and RLC revisit existing understandings and informal agreements regarding management roles and responsibilities for maintenance of the full length of the Ngongotahā Stream and document these in a formal and binding Memorandum of Understanding

- The agreed management roles and responsibilities are documented in an easy to understand format which is then distributed to residents and explained to 'front line' council staff;

- Front line council staff to receive additional training on how to take calls from concerned residents and the proper procedure for recording and responding to those calls, based on the agreed Memorandum of Understanding.

4.3 Design Standard for Ngongotahā Stream

The agreed design standard for specific reaches of Ngongotahā Stream is of critical importance when undertaking a post-flood assessment of performance. The design standard or level of service for flood management infrastructure is what the respective councils have agreed to provide to the community. This agreed standard is then the basis from which the rated contributions from the community to fund the construction and maintenance of flood hazard management schemes is determined.

The agreed design standards for Ngongotahā Stream are specified within the BOPRC Kaituna River Scheme and are as follows –

- Lake Rotorua to Ngongotahā Road Bridge - 100-year return period + 500 mm freeboard;
- Ngongotahā Road Bridge to SH5 – Maintenance Only (no specific design standard);
- Upstream of SH5 – Working with landowners on case by case basis (no specific design standard).

The reaches downstream of SH5 are shown in Figure 13.

The Panel notes the significance of the 100-year return period level of service only extending as far as Ngongotahā Road and requested that BOPRC provide some further information regarding this decision. As part of this information BOPRC provided comments regarding the original Kaituna

Scheme plans from circa 1969. BOPRC stated that these plans were largely focussed on the lower part of the Kaituna catchment in the Te Puke/Maketū basin with only one early concept design drawing for Ngongotahā Stream being the section downstream of Ngongotahā Road.

The construction contract for the Ngongotahā works in 1981 included stream improvement works upstream of Ngongotahā Road in the Brookdale Drive/Streamdale Place area which was in the early stages of development at the time (See Figure 14).

BOPRC also commented that it was their opinion that "it would be assumed that the (then) design Engineer was well aware that the Brookdale Drive and some houses in that vicinity were pre-existing; and he must have been satisfied that the design flood level in the adjacent stream must have been lower than the floor levels at that time for the purposes of (then) Rotorua District Council consents and future dwellings". [46]

Examining the details of the subdivision approvals and flood hazard assessment for Brookdale Drive and Streamdale Place is beyond the scope of this review but the Panel concludes that the key decision that established the boundary of the 100-year design standard at Ngongotahā Road was based on scheme plans and works completed 40 – 50 years ago. The Panel assumes that the 100-year design standard was only extended up to Ngongotahā Road as this was the point at which the stopbanks constructed as part of the Upper Kaituna Scheme ended and there was not considered to be significant flood related effects that required stopbanks and a 100-year design standard upstream of this.

[46] BOPRC personal communication, 1 November, 2018

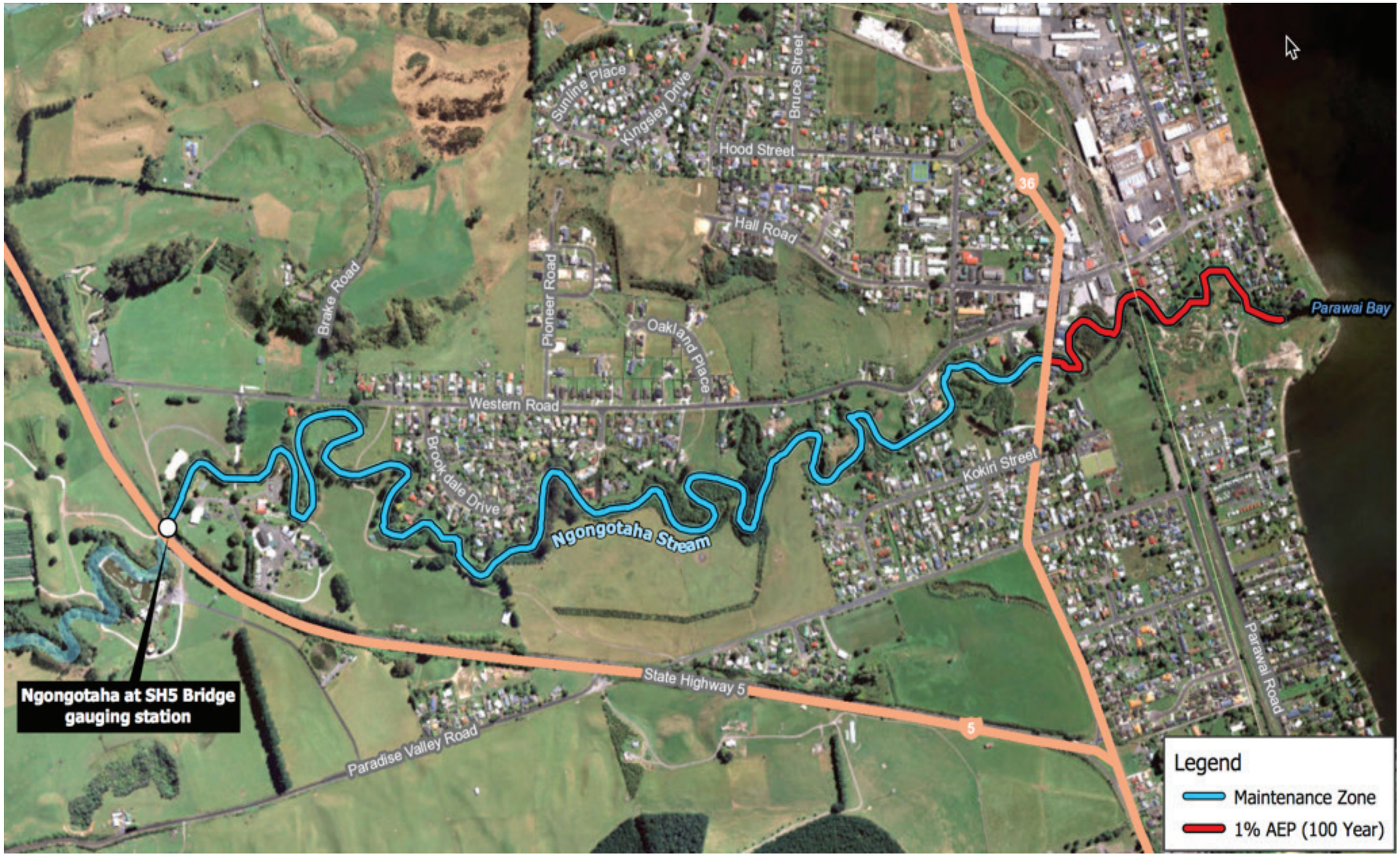


Figure 13: Upper Kaituna Scheme Design Standards (Source – BOPRC)

Figure 14: Kaituna Scheme Construction Contract Plans 1981 (Source – BOPRC)

Regardless of the basis of the original decision to have the 100-year standard only to Ngongotahā Bridge, flood hazard modelling work completed by BOPRC between 2005 and 2007 highlighted that a number of existing dwellings on Western Road [47], Brookdale Drive and Streamdale Place were at risk of inundation in a 100-year flood event (See Figure 15).

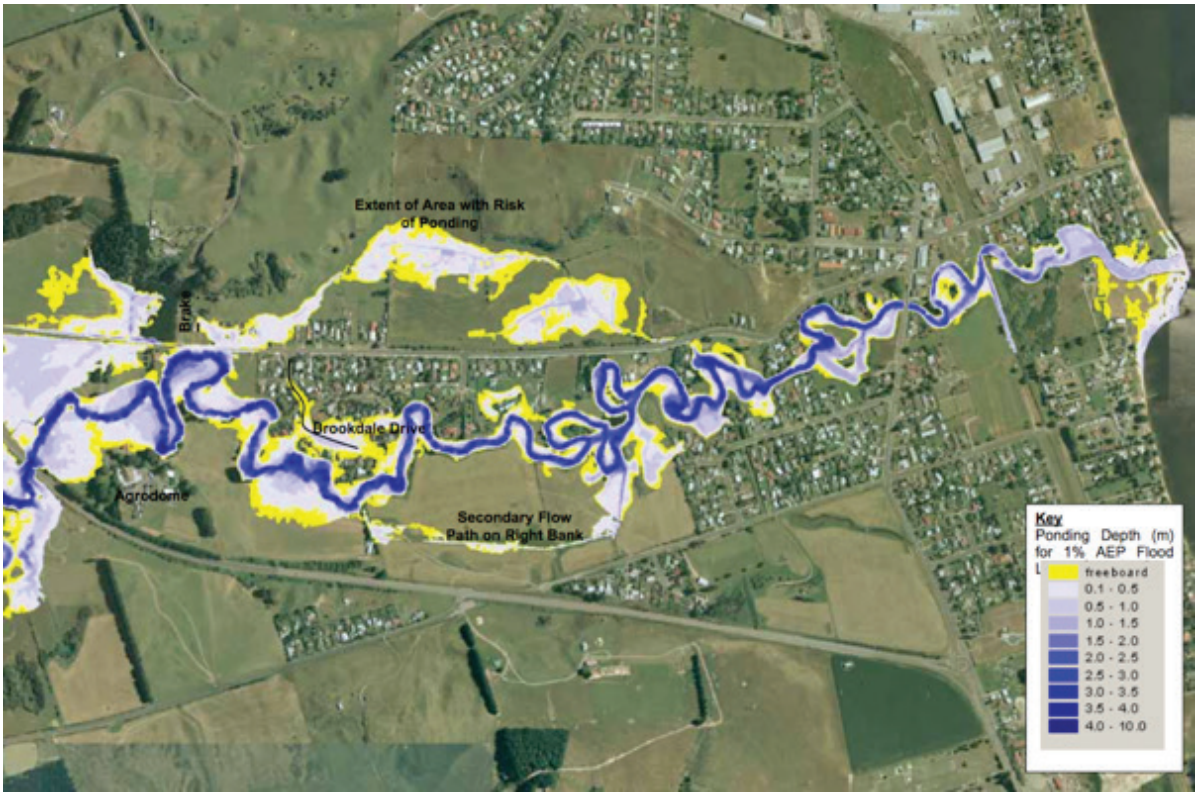


Figure 15: 100-year Flood Extent Map (Source – BOPRC 2007 Modelling Report)

[47] From a circa 1950's subdivision

The production of this information by BOPRC coincided with the resource consent application and early stages of construction of the Pioneer Property Trust subdivision (PPTS) on the north side of Western Road. This subdivision was within a notable overflow path and ponding area emanating from Ngongotahā Stream adjacent to Brake Road. The details of the design and approval process of the PPTS are examined in detail in Section 5 of this report.

It was during this period that RLC contacted[48] BOPRC highlighting the "inadequacies in the level of flood protection provided by the works upstream of the bridge *(Ngongotahā Road)*" and it was RLC's opinion that "the scheme should provide the level of flood protection to the urban community as stated by the scheme *(Upper Kaituna Scheme)*".

There was ongoing discussion between BOPRC with RLC and the Pioneer Property Trust subdivision engineers (MTEC) over the 2005 – 2007 period which is examined in Section 5 of this report. In terms of the outcome relevant to this section of this report, the BOPRC decision at the time was that they were not going to extend the 100-year standard upstream of the Ngongotahā Road boundary.

Further discussion[49] that the Panel has had with BOPRC provided further context to this in that BOPRC will generally not undertake new structural flood protection works to enable new development in areas at risk of flooding. This is somewhat nuanced in this particular situation in that there were existing houses on Western Road, Brookdale Drive and Streamdale Place which were now[50] also identified as at risk of flooding. The focus of discussion between RLC and BOPRC at that time was around a stopbank at Brake Road to reduce the likelihood of floods overtopping the stream bank and flowing through the Western Road properties and into the area of the proposed PPTS. The stopbank could have also reduced the flood risk to the existing properties on Western Road but would at the same time have enabled the PPTS to proceed with lessened requirements for managing the overland flow path. The construction of a stopbank at Brake Road, without mitigation in terms of downstream upgrades in the main Ngongotahā Stream channel, would however have further increased the existing flooding at Brookdale Drive and Streamdale Place.

At this point the Panel wishes to highlight that BOPRC, RLC, or individual property owners could have taken steps to reduce the newly identified flooding risks. BOPRC and RLC have legislative mandates and responsibilities for managing flood hazards, being the SCRA 1941 for BOPRC and the RMA 1991 and Local Government Act 2002 for both BOPRC and RLC.

The Panel notes that the steps taken by BOPRC were to provide the new flood hazard information to RLC which is also still currently available on its website and that RLC and PPTS engineers used the information in the design of flood management infrastructure for the new subdivision. Further discussion regarding the PPTS engineer's desire to undertake stopbanking works at Brake Road is contained in Section 5 of this report.

The issue was in a sense concluded at this point with the upstream extent of the 100-year flood protection standard for Ngongotahā Stream remaining at Ngongotahā Road and the BOPRC advice taken into account in the design requirements for the subdivision.

The issue with regard to the flood protection design standard upstream of Ngongotahā Road was raised again in 2009 by RLC through the Upper Kaituna Scheme Liaison Committee during a meeting held to discuss the Ten year plan/Annual Plan/Asset Management Plan. RLC raised the point "*capacity issues needing addressing in the following streams in the Upper Kaituna: Ngongotahā Stream above Ngongotahā Road*". The BOPRC action was "*to have further discussion with RLC to define areas of responsibility*". It is not clear to the Panel that this action would have

[48] RLC personal communication 23 September, 2005
[49] BOPRC personal communication 18 October, 2018
[50] Beyond the scope of this report to determine whether they met the required flood management standards for consent and permits applicable at the time of subdivision and building.

gone any way towards addressing capacity issues and there was no change at this point in the design level of service upstream of Ngongotahā Road bridge.

The flood protection design standard issue was raised yet again in early 2018 (prior to the April flood) in submissions that RLC made in relation to the proposed BOPRC Long Term Plan (2018-2028). The first submission noted that the Upper Kaituna River Scheme only provides 100-year flood protection up to the Ngongotahā Road Bridge and that there is considerable urban development upstream that has some vulnerability to flooding during major storm events. The submission went on to discuss increasing future flood risk with climate change and acknowledged that there had been development in potentially flood prone areas.

A second RLC submission highlighted the significant growth of willows and other vegetation in some channels and the desire to see a programme to manage the channels more effectively with community assisted efforts led by BOPRC. The submission went on to highlight the cultural significance, amenity values and the importance of these features within the Rotorua environment

The submissions went on further to state that RLC would like to resolve these issues, specifically in the Ngongotahā catchment, in conjunction with BOPRC by firstly determining the extent of the flood risk and if required extending the 100-year flood standard further upstream from the current boundary at Ngongotahā Bridge.

There was no BOPRC reply regarding these submission points, but it was noted by the Panel that the BOPRC 2018-2028 LTP adopted on 28 June 2018 included $500,000 for urgent post-flood stream bank repair works in the Rotorua area, including projects on the Ngongotahā Stream. It is also noted by the Panel the BOPRC and RLC are currently working together on developing options for managing the flood risk on Ngongotahā Stream. This is discussed in further detail in Section 6 of this report.

The Panel queried BOPRC on their consistent reluctance to extend the 100-year flood protected area of the Upper Kaituna River Scheme upstream of Ngongotahā Road. The BOPRC response suggested that it would be complex to retrofit flood protection structures around the overflow points at Western Road (Brake Road intersection) and Brookdale Place, as well as possibly needing to raise or setback existing stopbanks downstream of Ngongotahā Road due to resultant increased flows.

BOPRC also advised that funding any such upgrades would need to be carefully considered on the basis of fairness and equity regarding where the benefits would largely be attributed. This is particularly the case for the properties within the PPTS development which would derive a significant portion of the benefits but for whom it may be unaffordable or unfair to attribute the greater portion of the costs. The fairness element arises because the current owners had purchased their properties on a reasonable expectation that the stormwater and flood management infrastructure had been designed to the required standard and having no expectation that significant costs might be levied against them in the future to contribute to works to retrofit an incorrectly designed system. The question of fairness could equally arise with the wider Ngongotahā, Rotorua or Bay of Plenty ratepayers and their willingness to contribute to a scheme if it only provides benefits to a relatively small number of households. While the Panel has been asked to consider funding alternatives in its recommendations, the design standard has to be agreed before this can be addressed.

The Panel agrees that the technical flood management solutions are complicated and that determining a fair and equitable method of funding will be difficult, but it is considered that these issues can be worked through with on-going communication, consultation and collaboration with the community and key stakeholders. This is discussed further in Section 6 of the report.

It is unfortunate that a flood has had to occur to physically demonstrate the extent and consequences of the flood hazard to the Ngongotahā community and to instigate a response from BOPRC and RLC to reduce flood risk. The Panel has already noted that both councils have responsibilities for managing flood risk and that either council could have proactively taken steps to

reduce known flood risks, especially in the reach upstream of Ngongotahā Road bridge, on the basis of the information provided by BOPRC in 2005-2007. Neither council did so, even though the avoidance and mitigation of natural hazards is a core service to be considered in the roles performed by both councils under Section 11(a) of the Local Government Act 2002, while for BOPRC it is a function under Section 126 (1) of the SCRCA to minimise and prevent damage within its district by floods and erosion.

4.3.1 Design Standard Recommendation

The Panel recommends that –

- The flood management design standard (level of service) for Ngongotahā Stream be considered and determined as part of the options for reducing flood risk to the Ngongotahā community.

4.4 Operational Maintenance, Management and Monitoring

With the previous sections introducing flood risk management and the roles and responsibilities with regard to flood risk management, it is now time to specifically describe and assess the first of the four categories of flood risk management tools used in the Ngongotahā catchment. The first category of tools to be discussed is that of operational maintenance, management and monitoring of river and stream channels and stormwater networks.

As discussed in earlier sections of this report the recent responsibility for maintaining the channel of Ngongotahā Stream from SH5 to the lake has been with BOPRC since 2013. A description of the maintenance and management of this area is described below as well as a discussion of the reach upstream of SH5. The RLC maintenance of the stormwater network and the reserves bordering Ngongotahā Stream is also discussed.

The BOPRC channel management reach from SH5 to the Lake is shown in Figure 16. The lower end of this reach from Ngongotahā Road has a specified design standard of the 100-year flood event plus 500 mm freeboard as part of the Upper Kaituna River Scheme.

The BOPRC 2018 Asset Management Plan for the Kaituna Scheme describes the below activities as being key activities undertaken within the channel -

a) Retaining the strength and integrity of erosion control works;
b) Keeping channels clear of obstruction.

There are no plans or annual maintenance schedules provided specifically for Ngongotahā Stream, but the Panel acknowledges that Ngongotahā Stream forms only a very small part of the overall Kaituna Scheme.

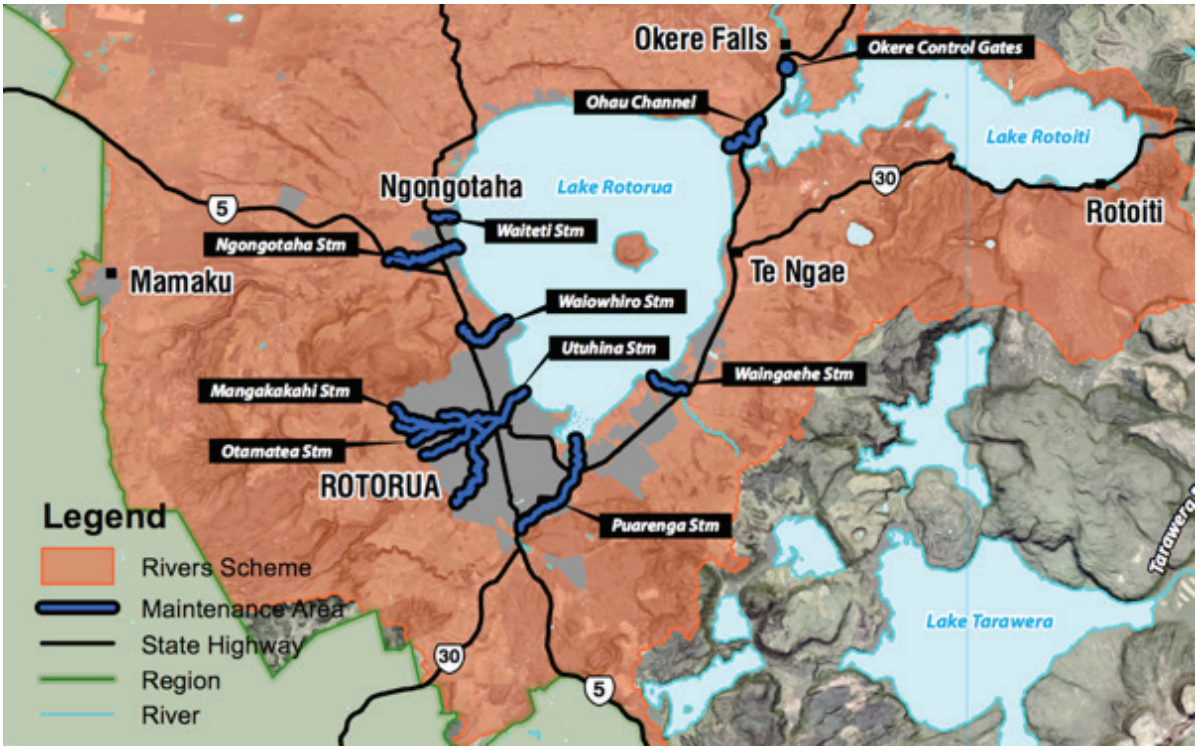


Figure 16: BOPRC Maintenance Areas for Upper Kaituna Scheme

Under the Kaituna Scheme, the reach upstream of Ngongotahā Road to SH5 is "maintenance only" with no specific design or performance standards. Upstream of SH5, BOPRC work with individual landowners, often on a cost sharing arrangement to undertake channel maintenance works.

For the reaches where BOPRC has a specific maintenance responsibility (i.e. downstream of SH5) the Panel has used the following methodology to assess the effectiveness of the channel maintenance. Firstly, an inspection of the recent (April 2017) aerial photography has been undertaken. This provides an indication of where there appears to be significant vegetation across the channel. This method is by no means conclusive as the vegetation could be above flood waters if it is part of the higher canopy, but it is considered useful as a high level indication of potential channel obstructions.

In addition to the assessment of aerial photography, the surveyed flood levels from the April flood event are compared to design levels from the BOPRC 2007 hydraulic model. As reported in Section 2.2, the April 2018 flood event was very close in size to the existing design 100-year event of 67 m^3/s so comparison of the modelled flood levels to those surveyed following the event is considered useful. It is noted that there is only a formal design standard (100-year + 500 mm freeboard) downstream of Ngongotahā Road but a comparison of flood levels to modelled levels in the reach between SH5 and Ngongotahā Road is useful to highlight any significant discrepancies from what was expected in terms of flood levels. Finally, observations from a post-event stream walkover (SH5 to lake) undertaken by the Panel with BOPRC staff members, are considered to form an overall assessment of the channel maintenance.

It is worth highlighting at this point that trees and vegetation on channel banks are generally considered beneficial as they reduce the speed of a stream during floods and the roots also reinforce the channel banks. Both of these properties reduce the likelihood of bank erosion occurring. In addition to reducing bank erosion, overhanging vegetation also provides an important food source to the aquatic environment as well as potentially reducing the extent of aquatic weed growth by reducing the amount of sunlight in the channel.

It has been noted by the Panel that Ngongotahā Stream is an important trout fishery and that maintaining appropriate aquatic habitat diversity, terrestrial food sources and minimising

sedimentation from bank erosion will be important considerations for the overall management of the stream. This is particularly regarding vegetation in and around the channel margins and banks.

Countering the above benefits and value of vegetation is the potential reduction in channel capacity, especially due to large trees growing across and creating obstructions in the main channel itself. This situation can cause blockages and increase flood levels for the surrounding and upstream areas. Also, very large and old/dead trees can create issues if they fall into the stream channel during flood events due to the weakened soil structure when it is saturated by elevated groundwater. It is for these reasons that vegetation management in Ngongotahā Stream must be very carefully considered.

4.4.1 Ngongotahā Stream Channel (Downstream of Ngongotahā Road Bridge)

The Ngongotahā Stream downstream of Ngongotahā Road Bridge is within the BOPRC Upper Kaituna Scheme area and is included in the areas which have a specified level of service in terms of a flood design standard. The design standard, as reported in the BOPRC 2014/15 Rivers and Drainage Asset Management Plan, is the 100-year flood of 67 m^3/s plus 500 mm freeboard. The structural works (stopbanks) that are designed to provide this level of service in terms of hydraulic capacity are discussed in Section 4.5., whereas this section focuses on the channel maintenance and instream works undertaken in this reach to ensure the structural works are able to function effectively during flood events.

Inspection of the 2017 aerial photograph in Figure 17 suggests three locations where there may have been vegetation obstructing the channel. The reach most affected appears to be adjacent to, and immediately downstream, of Parawai Marae.

Figure 17: 2017 Aerial Photograph Ngongotahā Road Bridge to Lake Rotorua (Source - Google Earth)

Inspection of the surveyed flood levels suggests that they were at or below the design level (without freeboard) in the lower reach downstream of Parawai Marae but possibly significantly higher upstream of the Railway Bridge. These elevated levels were also evidenced by the inundation that occurred around the dwelling at 268 Ngongotahā Road. The inundation affected the property but did not enter the dwelling. This site is adjacent to a BOPRC stopbank which is discussed further in Section 4.5.

It is not clear whether the surveyed flood level immediately upstream of the Railway Bridge was an isolated anomaly or whether there was a partial blockage of this structure that caused elevated flood levels upstream. It is also possible that vegetation in the channel immediately downstream was

creating a backwater effect. Inspection of the multiple surveyed flood levels upstream of Ngongotahā Road Bridge suggest that the surveyed level at the Railway Bridge is likely to be higher than what occurred. However, it is inconclusive to as to whether there were actually elevated (above design + freeboard) levels through this reach and to what degree various possible contributing factors led to this.

Figure 18: Flood Level Comparison – Ngongotahā Road to Lake Rotorua

During the stream walkover undertaken by the Panel the area around the bend in Ngongotahā Stream at Parawai Marae was highlighted as an area where the April 2018 event caused significant erosion and there had subsequently been a rock revetment (see Figure 19) constructed to reinstate the bank. It also appeared that vegetation from the opposite bank had been removed as part of the works. It also appeared that other areas where there had previously been vegetation across the channel had now been cleared.

It was noted that the right bank stopbank in the most downstream reach, immediately upstream of the lake, had eroded away during the event. This is a relatively low (<1 m high) stopbank with currently undeveloped land on the landward side of it. The failure of this stopbank is discussed further in Section 4.5.

Figure 19: Rock revetment works and vegetation removal Parawai Marae (Post event)

During the stream walkover a large tree trunk protruding from the river bank was identified in the reach downstream of Parawai Marae (See Figure 20). This tree trunk was mostly submerged during the normal (i.e. not flood) flow conditions apparent during the stream walkover. During flood flows this would be submerged by 3 - 4 m of water and would be unlikely to create significant turbulence that would notably increase flood levels. This type of feature would also generally be considered to provide useful habitat diversity within the stream during normal flows and be considered to be “large woody debris” which is a particular feature that is often designed and constructed as part of stream restoration projects.

Overall it is considered that this reach performed adequately in terms of the 100-year flood standard with the exception of the stopbank that was eroded on the right bank at the downstream end of the reach and the stopbank at the upstream end that was possibly overtopped. The flood damage repairs, including vegetation removal, undertaken following the flood event were largely complete at the time of writing (August 2018) with the exception of the reinstatement of the lower right bank stopbank. Once the lower right bank stopbank is complete and an evaluation and remedial works of the upper right bank stopbank are complete the Panel consider that the overall reach downstream of Ngongotahā Road is back to the 100-year flood design standard required by the Upper Kaituna Scheme.

Figure 20: Large woody debris right bank downstream of Parawai Marae

4.4.2 Ngongotahā Stream Channel (SH5 Bridge to Ngongotahā Road Bridge)

This reach of Ngongotahā Stream is managed by BOPRC under the Upper Kaituna Scheme as a "maintenance only" reach and not to the same 100-year design standard as specified for the reach downstream of Ngongotahā Road. It is understood by the Panel that maintenance of this reach is largely reactive following notification from RLC or the public that trees or vegetation are blocking the channel.

Inspection of the 2017 aerial photographs of this reach (Figure 21 to Figure 24) suggests extensive vegetation encroachment across the stream channel throughout much of this reach and especially so in the upper reach from SH5 through the Agrodome property to Brake Road. As previously noted, this vegetation could be seen as beneficial in terms of slowing down flood waters, minimising bank erosion as well as providing habitat and a food source for aquatic fauna.

However, excessive vegetation, and complete channel blockage would generally be considered adverse in terms of conveyance of flood waters and "keeping channels clear of obstruction" is highlighted as one of the key activities for this reach in the 2018 BOPRC Asset Management Plan.

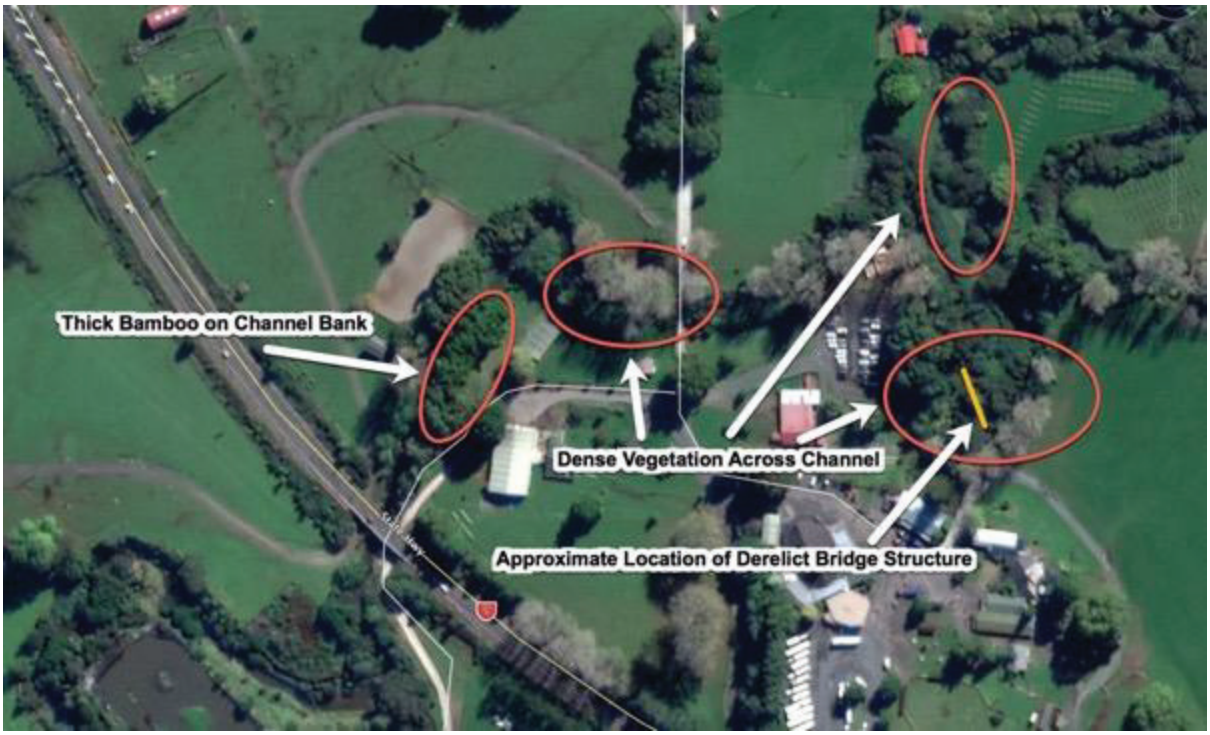


Figure 21: 2017 Aerial Photograph Agrodome Reach (Source Google Earth)

Figure 22: 2017 Aerial Photograph Brake Road – Brookdale Drive Reach (Source Google Earth)

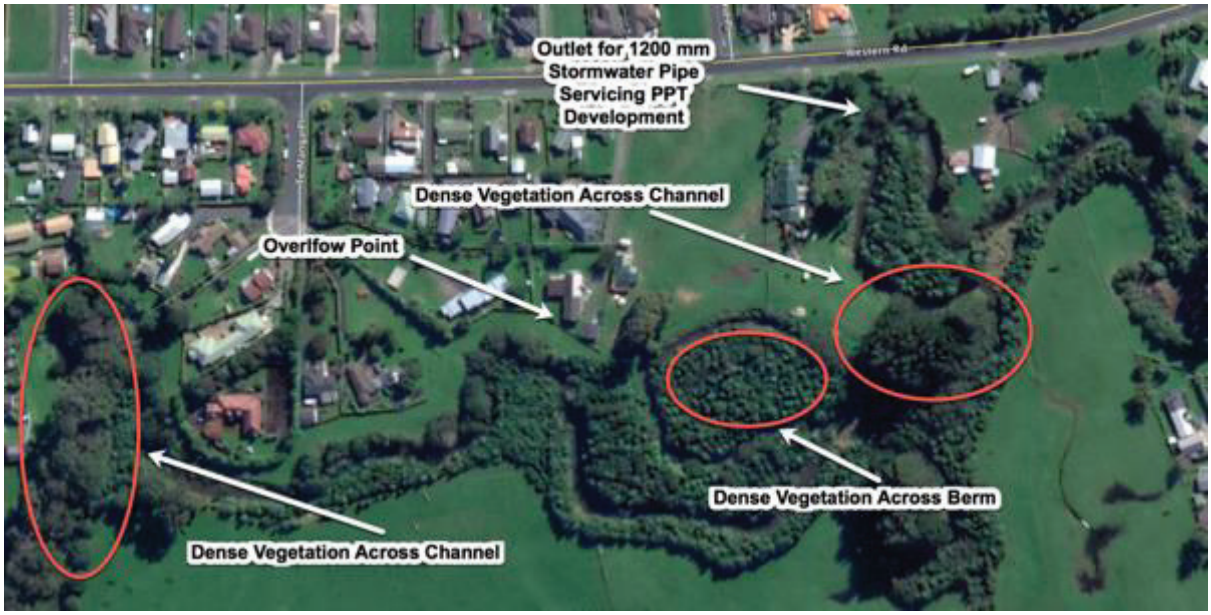


Figure 23:2017 Aerial Photograph Te Manga Place – Western Road Reach (Source Google Earth)

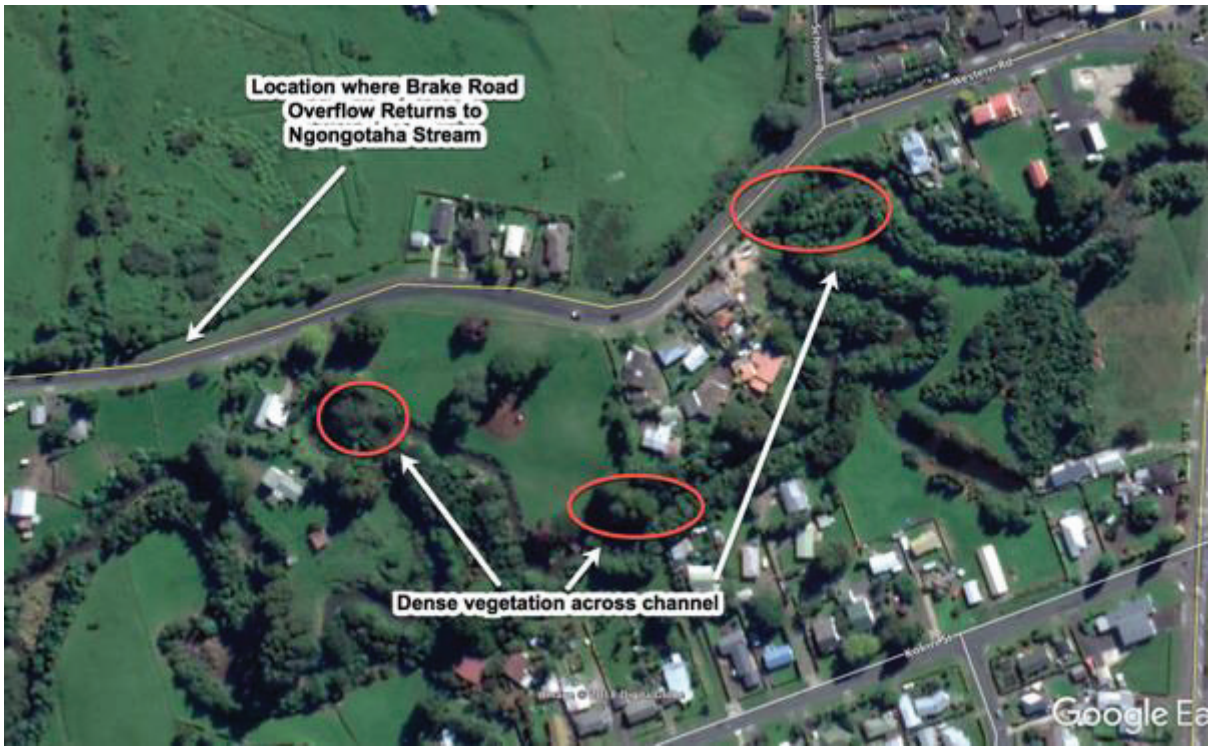


Figure 24: 2017 Aerial Photograph Kokiri Street – Western Road Reach (Source Google Earth)

The Panel acknowledges that there is no specific design standard for the channel maintenance in this reach, but it is of interest to compare the surveyed flood levels of the April 2018 event to the design levels presented in the 2007 BOPRC Hydraulic Modelling Report. Noting that the design levels presented in that report were largely determined by the calibration of the December 2005 flood of 33 m^3/s being around half the size of the April 2018 event. The comparison of the modelled flood levels to surveyed flood levels is shown in Figure 25.

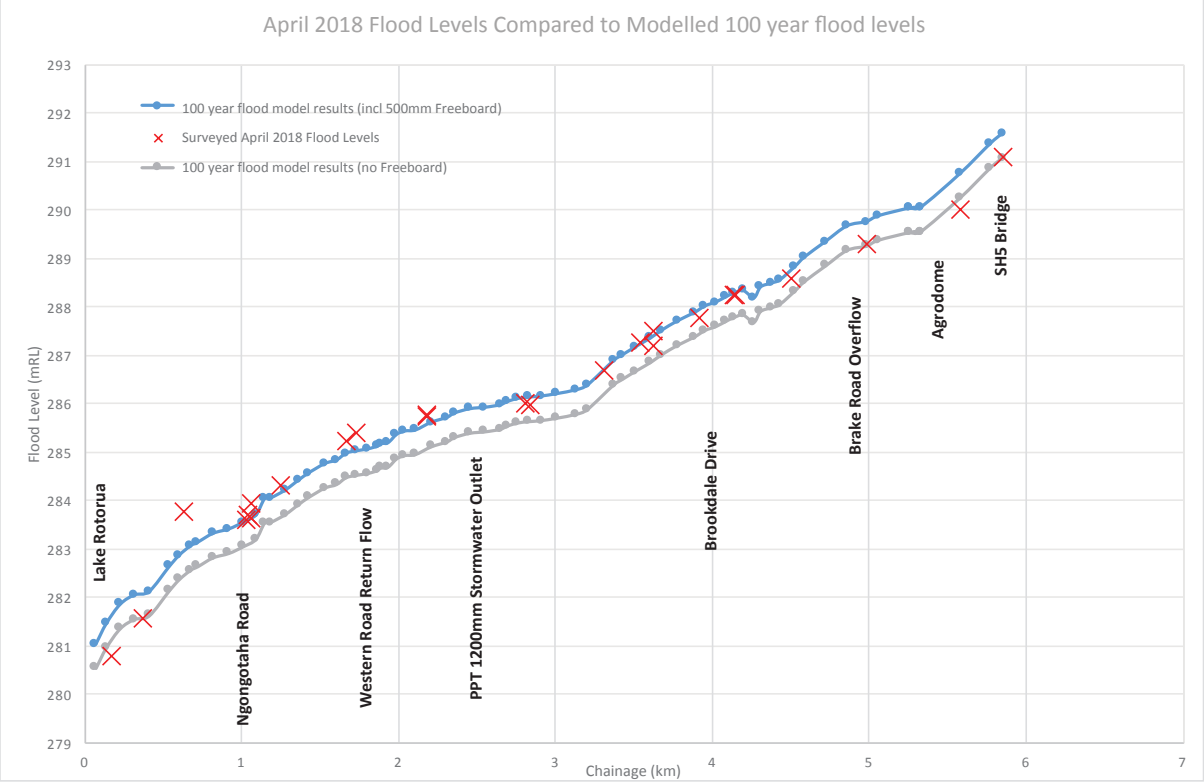


Figure 25: Flood Level Comparison – Ngongotahā Road to Lake

There are three distinct conclusions drawn from inspection of this flood level comparison with modelled flood levels. Firstly, the levels from SH5 through the Agrodome down to where the overflow occurred very closely match the modelled flood levels (without freeboard). Although this reach is considered to be the most thickly vegetated (See Figure 26) of the stream downstream of SH5 the roughness characteristics used in the hydraulic model (n = 0.1 to 0.14) provide an accurate reflection of these channel conditions. There are certainly opportunities for reducing levels through this reach with the removal of significant channel blockages, but this would likely result in increased flood flows in the downstream reach, so a comprehensive solution that resolved downstream capacity issues would need to be addressed first.

Secondly, a very key point is that the surveyed flood level at the Brake Road overflow point was approximately equal to the modelled flood level (without freeboard) at this point. This is important in that the flood level at this point determined the quantity of water that overflowed across Western Road, through the properties on Western Road and through the PPTS subdivision. This is discussed in greater detail in Section 5 of this report, but for the purposes of this section it is concluded that the flood levels in Ngongotahā Stream at the Brake Road overflow point were in-line with those predicted by the 2007 BOPRC Hydraulic Model and the resulting overflow was therefore likely to be in the range predicted by BOPRC (5 – 15 m^3/s). This was the same range of overflow advised as the required design flow by BOPRC to both RLC and the PPTS developer's design consultants (MTEC now Forbay Ltd) for the overland flow path through the subdivision.

Figure 26: Notable Channel Obstructions Ngongotahā Stream (Agrodome Property)

Moving to the reach immediately downstream of Brake Road, adjacent to Brookdale Drive, the surveyed flood levels are within the range (including freeboard) predicted by the BOPRC Hydraulic Model. The modelled roughness of this reach (n = 0.07) is probably on the lower side in terms of representing the vegetation in this reach at the time of the flood event, especially with respect to the extensive stands of bamboo on the flood berm areas adjacent to the main channel. This area of bamboo has subsequently been removed by BOPRC (See Figure 27). It is noted that the bamboo was not in the channel as such but would be considered to be on a flood berm area where flood waters would flow during large events. The area where the bamboo was growing is an RLC local purpose (esplanade) reserve.

It should also be noted that within this reach, where flood levels were in the expected range, the 1200 mm stormwater outlet from the PPTS development discharges into Ngongotahā Stream. The performance of this stormwater system is discussed in detail in Section 5 of this report, but for the purposes of this section it is concluded that the conditions at the outlet of the pipe were in the range provided by BOPRC to both RLC and the PPTS developer's design consultants.

Figure 27: Extensive area of post-flood bamboo clearance adjacent to Brookdale Drive

The third area of interest is the where the overflow from Brake Road returned into the main Ngongotahā Stream channel at Elliot Park. Surveyed flood levels from the April 2018 event were up to 1 m higher than the modelled flood levels (without freeboard) in this reach. It is acknowledged that there is no required design standard in this reach and the modelled levels simply provide a comparison to how the system performed compared to the calibration based on the 2005 flood.

The likely reason for these higher than expected flood levels would be extensive vegetation in and across the channel as well as thick vegetation on the local purpose reserves and private property bordering the stream channel from Elliot Park to Ngongotahā Road Bridge. As already highlighted the maintenance of obstructions in the main channel in this reach are the responsibility of BOPRC, with the reserves generally being the responsibility of RLC, with private owners being responsible for vegetation on their property. It is also noted that a community stream care group has undertaken planting in this area over the past several years. The management for reserves and areas bordering the main stream channel is discussed further in Section 4.4.3 of this report.

It is important to consider whether elevated flood levels in this area had an effect on the rate and efficiency of the Brake Road overflow re-entering the main stream and the subsequent flood levels in Oakland Place. Further detail on the overall design of the overland flow path to cater for this overflow through the PPTS subdivision is provided in Section 5 of this report. In this section the discussion is limited to the potential effects from the higher than expected flood levels in Ngongotahā Stream.

To consider the possible effects of the elevated stream levels the Panel considered the key hydraulic characteristics of the flow from Oakland Place to Ngongotahā Stream. The key characteristics are the flow depth over Western Road (400 mm) and the hydraulic grade (water surface slope) from Western Road to Oakland Place from peak flood levels from the April 29 event (1:300 H: V). Using these characteristics, a backwater length[51] has been calculated[52] of approximately 85 m which

[51] The backwater length is the upstream distance that will be affected by the hydraulics of a particular location.

[52] Backwater Lenght (L) = 0.7 x Depth (D)/Slope (S) P.G. Samuels (1989). Backwater Lengths on Rivers. Proc. Instn Civv Engrs Part 2 1989, 87, Dec 571-582.

compares to the 300 m distance from Elliot Park to Oakland Place. This would suggest there would be little or no effect at Oakland Place in terms of peak flood levels being affected by the tailwater hydraulics of the overland flow path from this area where it re-enters Ngongotahā Stream. This is due to the shallow depth of flow across Western Road and the steep hydraulic grade upstream of this location.

Recognising the complexity of the hydraulics in this location the Panel requested RLC to run sensitivity tests in the 2-D hydraulic model that they are currently working on as a second check on the tailwater sensitivity at this location. The sensitivity tests were undertaken with tailwater flood levels in Elliot Park of –

- 284.5 m (BOPRC modelled flood level – no freeboard);
- 285 m (BOPRC modelled flood level with 500 mm freeboard);
- 285.5 m (surveyed peak flood level of April 29, 2018).

Preliminary results from the 2-D hydraulic model suggest that there was no change in flood levels in Oakland Place under the range of tailwater conditions tested. This further supports the conclusion from the simplified backwater length analysis undertaken by the Panel that the higher than expected level in Ngongotahā Stream did not affect the outflow from the Oakland Place overland flow path.

It was also bought to the Panel's attention that the open drain in the Everard Developments property on the eastern boundary of the PPTS development had been filled in sometime in the past five years (see Figure 28). It is understood from discussions with RLC that no consent had been sought for filling in this drain. Prior to the earthworks and infrastructure of the PPTS subdivision being completed this drain, and its 450 mm outlet to Ngongotahā Stream at Elliot Park, served to drain the mostly rural catchments to the north of Western Road. The earthworks and stormwater infrastructure for the development, including the new 1200 mm diameter stormwater pipe into Ngongotahā Stream, in effect intercepted most of the upstream flows that would have previously entered this open drain.

Figure 28: Open Drain to east of Oakland Place 2006 aerial photo (left) & 2016 aerial photo (right) (Source – Google Earth)

Nevertheless, if the drain had been operational during the flood event, it may have provided some useful additional capacity to drain water from around Oakland Place once the levels in Ngongotahā Stream dropped. It is considered unlikely that the fact the drain was filled in contributed to the peak flood levels in Oakland Place as the only outlet once flood levels are high is over Western Road, so a drain below this level could only have contributed to storage. This storage would have likely already been filled in by backflow from Ngongotahā Stream at the time of peak levels in Oakland Place.

Although the filling of this drain is unlikely to have affected flood levels during this event, the reinstatement of the drain in conjunction with other earthworks in this area to increase storage capacity and to increase the capacity of the overland flow path to Western Road are options that should be considered as part of reducing flood risk in this area in the future. This is discussed further in Section 6 of this report.

4.4.3 Reserves Bordering Ngongotahā Stream

As well as maintenance of the stream channel the reserves bordering the stream are important, especially in areas where flood waters overflow from the channel. There is a mixture of land ownership bordering Ngongotahā Stream with private titles as well as RLC managed Local Purpose Reserves and Esplanade strips. There is also the LINZ hydro parcel covering the main channel in places where it has remained in the same location as when it was surveyed.

The RLC Open Spaces Team has advised the panel that they carry out mowing of the reserves on a regular basis with grass mostly kept under 150 mm long and tree work done when required, but that no regular maintenance checks are undertaken. Inspection of recent aerial photographs suggests that most of the reserve areas bordering the stream are kept mown and reasonably clear. There are however some locations, which would in some cases be difficult to access, where there is very thick vegetation as shown in Figure 29.

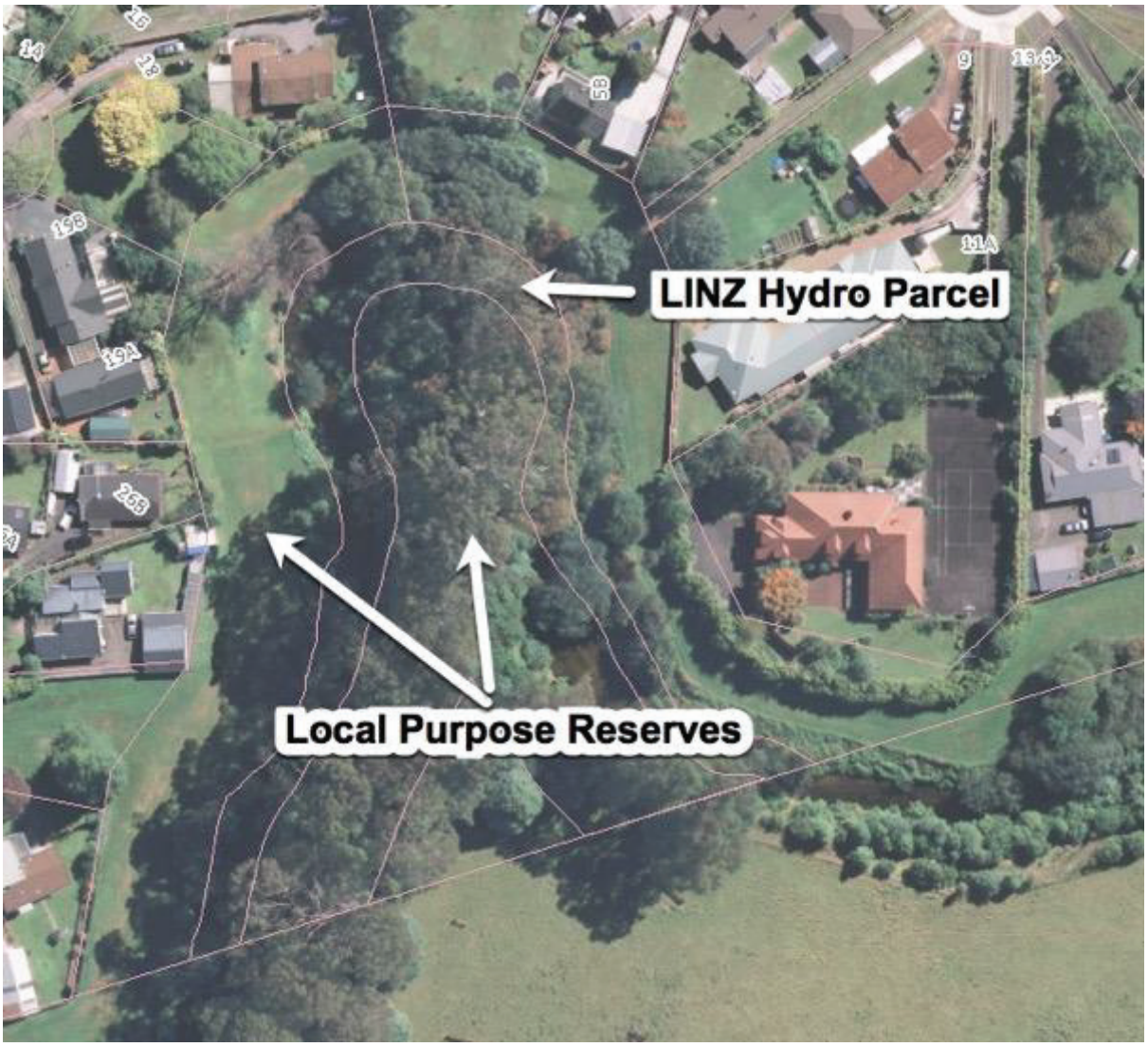


Figure 29: Local purpose reserves bordering Ngongotahā Stream

The maintenance of areas that operate as flood flow paths adjacent to the main stream channel is an important consideration which needs a coordinated approach between BOPRC, RLC and private landowners to ensure they function as required. This is an item highlighted as needing further work as part of the development of a future plan to improve flood risk management in the Ngongotahā Catchment. This is discussed further in Section 6 of this report.

4.4.4 Stability of Ngongotahā Stream Bed and Banks

Another important consideration in the management of flood hazard is monitoring of cross sections to see if the channel capacity is changing, particularly if there is ongoing deposition of sediment (aggradation) occurring. A selection of cross sections has been provided by BOPRC of Ngongotahā Stream which suggests the channel bed is relatively stable and is not changing in level substantially. The cross sections as SH5 Bridge and at Brake Road are shown in Figure 30 and Figure 31 below.

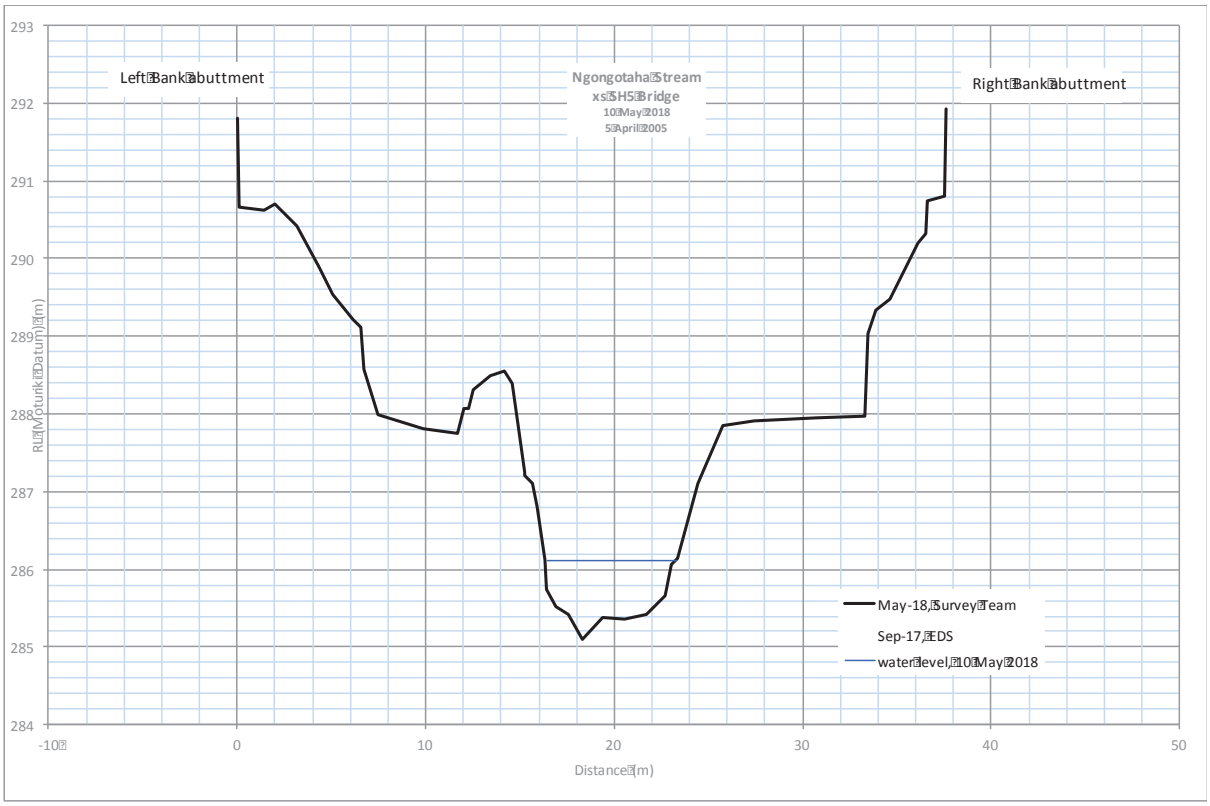


Figure 30: Ngongotahā Stream Cross Sections at SH5 Bridge (Source BOPRC)

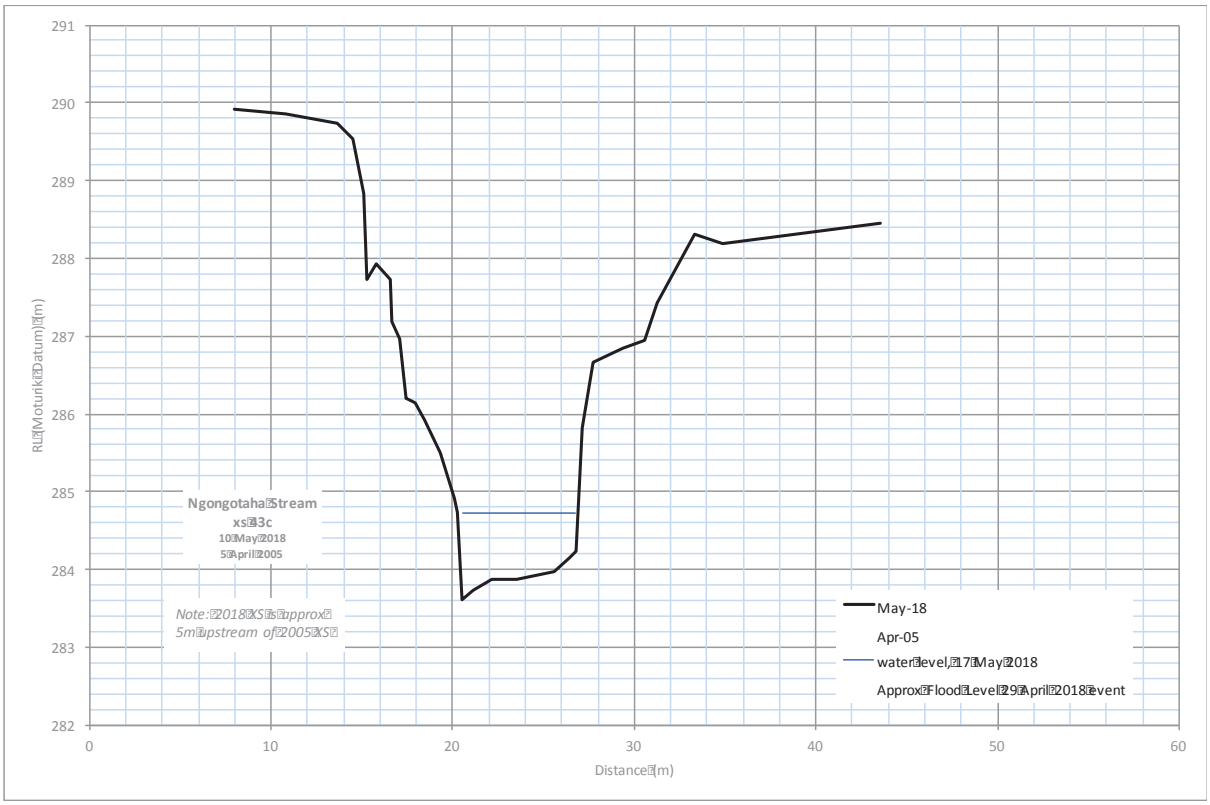


Figure 31: Ngongotahā Stream Cross Sections upstream of Brake Road (Source BOPRC)

During the stream walkover the only evidence of notable deposition within the system was where Ngongotahā Stream joins Lake Rotorua. There is a natural delta formation in this area due to the reduction in energy as the stream enters the lake which results in sediment being deposited. Observations and discussion with adjacent landowners suggests that prior to the flood there had been sediment building up in this area with it being possible to drive a 4WD vehicle across the mouth during normal flow conditions. Inspection after the flood suggested that the force of the flood waters had scoured out the area around the stream mouth and pushed sediment further out into the lake.

The Panel concludes that it is unlikely that there is any adverse, in terms of channel capacity, aggradational trends apparent in Ngongotahā Stream that contributed to higher than expected flood levels.

It was oberved that there were a number of areas of bank erosion (See Figure 32) that would likely require some remedial works to stabilise. These were especially on the outside of bends and not unexpected given the magnitude of the flood event. The Panel suggests that consideration is given to remedial works that flatten the slopes of the failed banks and then use appropriate smaller vegetation such as carex grasses on the lower banks to provide stablising effects and native trees/shrubs on the upper bank. In some areas rock rip-rap may be required to provide stability to the toe of the bank to allow the upper bank areas to be stabilised as vegetation grows.

Figure 32: Bank erosion right bank upstream of Ngongotahā Road

4.4.5 Monitoring and Maintenance of Stormwater Network

RLC have provided the Panel with records of maintenance and monitoring of the stormwater network within the PPTS development. This included CCTV investigations which were reviewed by consultants with recommendations for remedial works made. The remedial works were largely due to differential settlement of stormwater pipes and issues identified at pipe joins and lateral connections.

It is understood from discussions with RLC that the identified issues are yet to be rectified but progress is being made on confirming the scope of works and making the necessary contract arrangements. The Panel does not consider that any of the defects are substantial enough to have made a significant detrimental effect on the performance of the stormwater network during the flood event. The design and performance of the PPTS subdivision stormwater network during the April 2018 flood event is discussed in detail in Section 5.

4.4.6 Ngongotahā Stream Channel Upstream of SH5 Bridge

The Ngongotahā Stream upstream of SH5 Bridge is not within an area actively managed by RLC or BOPRC but the Panel understands that BOPRC undertake work in conjunction with landowners to manage vegetation and obstructions in the channel on a property by property basis. It is acknowledged that there were serious losses and disruption to rural properties, dwellings and businesses within this reach but without any specific funding or plans for management or maintenance there is no standard to provide a basis for comparative analysis. For this reason, a detailed assessment of Ngongotahā Stream upstream of SH5 has not been undertaken.

The Panel would like to acknowledge the Paradise Valley Catchment Group (PVCG) and the Community Catchment plan they have prepared. The goals of the group are listed as –

a) Improved water flow and water quality;
b) Well managed roadside and stream banks;
c) Clear and regular communication from organisations and within the community.

These goals with an active and engaged community will contribute to positive outcomes for this upper catchment area of the Ngongotahā Stream and the Panel encourages the PVCG in working towards their goals.

4.5 Structural Works

The main structural works within Ngongotahā Stream are within the flood protected area of the Upper Kaituna River Scheme downstream of Ngongotahā Road (See Figure 29). These assets are primarily stopbanks, largely on the right (south) bank with two flood channel overflow paths. There are also several flood channel overflow paths upstream of Ngongotahā Road Bridge as well as rock linings[53].

Figure 33: BOPRC Structural Flood Management Infrastructure Ngongotahā Stream

The short length of stopbank on the left (north) bank of the lower reach of the stream appeared to perform to its design standard of the 100-year flood + 500 mm freeboard. The longer and main stopbank in this reach on the right (south) bank generally performed adequately along most of its length but it was noted by the landowner that it was very close to overtopping along the section adjacent to the flood channel and the dwellings in this area. Further downstream from here, close to the lake this stopbank reduces in height as it transitions into the natural ground level (See Figure 34). Within this area the stopbank was completely eroded during the flood. This failure didn't have significant consequences in this particular area and it is understood that there are plans for the stopbank to be reinstated beyond the new widened channel section reach rather than in its previous position which is now within the main channel.

[53] BOPRC includes rock lining within their definition of structural works whereas the Panel has preferred to include rock lining with the stream channel maintenance section of the report.

Figure 34: Right bank stopbank near Lake Rotorua

The flood channel downstream of Ngongotahā Road is kept clear of significant vegetation and is mowed by the RLC Open Space Team (See Figure 35). This is likely to have performed as intended during the event and somewhat reduced flood levels in the main channel by diverting some of the flow through a more efficient path.

The stopbank on the right bank immediately downstream of Ngongotahā Road Bridge did not appear to provide the required design 100-year + 500 mm freeboard level of protection as evidenced by the flooding that occurred on the property at 268 Ngongotahā Road. It was fortunate that flood waters did not enter the dwelling so damage on the property was less severe than it otherwise could have been.

Figure 35: Floodway downstream of Ngongotahā Bridge

Overall it is considered that the structural works within the Upper Kaituna Flood Protection Area downstream of Ngongotahā Road performed adequately and where they did fail the consequences were not severe. Further investigations will be required to confirm the appropriate design height of stopbanks in this reach, especially if there is a change in design flows due to other structural works upstream, and the inclusion of an allowance for climate change.

4.6 Planning Controls[54]

The TOR for our review appropriately included a consideration of "Regional and District planning matters". In that regard, section 6(h)[55] of the RMA requires as a matter of national importance that all persons exercising functions and powers under the Act, in relation to managing the use, development, and protection of natural and physical resources, recognise and provide for the management of significant risks from natural hazards. This reflects the fact that planning controls are an essential element of integrated flood risk management and are used to direct development away from high risk areas and to ensure appropriate mitigation is provided in low risk areas.

4.6.1 Regional Policy Statement

The Panel begins by examining the operative Bay of Plenty Regional Policy Statement (RPS) because the Rotorua District Plan (RDP) must give effect to an operative RPS[56] and have regard to a proposed RPS.[57] The RPS contains provisions on natural hazards[58] that became operative on 5

[54] A draft version of this section of our report was helpfully reviewed by RLC planning staff to ensure that the Panel had interpreted the RLC documents correctly.
[55] Inserted into the RMA in April 2017.
[56] Sections 73(4) and 75(3) of the RMA.
[57] Section 74(2) of the RMA.

July 2016.[59] It promotes a risk based approach.[60] Relevantly here, this means the extent to which a flooding hazard is managed will depend on the risk it presents. Risk is a combination of an event's likelihood (i.e. the chance of the event occurring) and its potential consequence (i.e. amount of damage the event would cause should it occur).

Rather than repeating all the relevant RPS provisions, we have instead attempted to distil the main themes relevant to our review:

- Flood risk should be assessed and categorised as High, Medium or Low using the methodology set out in Appendix L[61] of the RPS[62] by either those undertaking land development or through the provisions of district or regional plans;[63]
- The effects of climate change (rainfall and storm frequency and intensity) are to be incorporated into flood hazard assessments;[64]
- The locations where flooding could affect people, property or lifeline utilities should be mapped;[65]
- Prior to RLC assessing and categorising flooding risks in their district plan, for subdivisions exceeding 5ha in size or where a development site is in a known flood hazard area, the flood hazard risk should be assessed by the developer;[66]
- A Low flooding risk is to be achieved on development sites after completion of a development;[67]
- Regional and district plans should consider flood risk reduction measures, including where practicable for existing land use activities, and those plans should control the location, scale and density of the subdivision, use, development.[68]

As we discussed in Section 4.2 of this report, the RPS also addresses roles and responsibilities. RLC is to undertake flood hazard susceptibility mapping for natural water courses inside urban areas with reticulated stormwater networks, including Ngongotahā, and RLC is also responsible for developing land use rules relating to flood risks.

4.6.2 Regional Policy Statement Conclusions

The RPS provides very clear direction to both BOPRC and RLC regarding flood hazard management. Relevant to this review, the RLC is responsible for mapping the flood hazard within the affected Ngongotahā urbanised area and BOPRC is responsible for that mapping elsewhere in the catchment. The flood hazard assessment underpinning the mapping should consider climate change. The RLC is responsible for putting in place appropriate land use controls relating to flood hazards. For new subdivisions or developments, the flood risk should be reduced to a Low level. The flood risk should be reduced, where practicable, for existing properties in areas known to have a risk of flooding.

In situations like that at Ngongotahā, where the 100-year event flood risk has already been modelled, we consider it would be sufficient to simply delineate High and Low risk areas, rather than seeking to apply the formulaic three-tier approach set out in Appendix L to the RPS.

---

[58] Chapter 2.11 Natural hazards.
[59] In total the RPS contains one objective, 14 policies and 27 methods of implementation for natural hazards.
[60] Consistent with New Zealand Standard AS/NZS ISO 31000:2009.
[61] Appendix L specifies the use of two different risk metrics; the maximum possible risk from each hazard and the annual individual fatality risk. It sets out a very complicated formulaic procedure for assessing risk. We question its practicality in situations such as that applying in Ngongotahā.
[62] Policy NH 2B and Policy NH 8A
[63] Policy NH 4B Explanation clarifies that whatever and whenever new urban developments (or redevelopment) occurs it should be designed and built to achieve a Low natural hazard risk.
[64] Policy NH 11B
[65] Policy NH 7A
[66] Policy NH 9B
[67] Policy NH 4B. The RPS states that Low risk generally occurs where both likelihood and consequence of the event are relatively low.
[68] Policy NH 12A

4.6.3 District Plan Flood Hazard Provisions

We now examine the current Rotorua District Plan (RDP) which was made operative in June 2016. We acknowledge that the current RDP was not in place at the time that the PPTS was initially approved and that the RDP predates section 6(h) of the RMA. However, the purpose of this Review includes recommending measures which may prevent or minimise the risk and effects of future flood events. Having robust flood management provisions in the current RDP is one key means of achieving that outcome.

The Ngongotahā area inundated in the April 2018 event comprises three land use zones.[69] The area containing houses is zoned Residential 1 (Low Density Living) while the commercial and shopping area closer to Lake Rotorua is zoned Commercial 1 (Ngongotahā Centre). The land west of Brake Road and including Paradise Valley is zoned Rural 1 (working rural). We focus on the Residential 1 land as we understand there was no significant inundation of commercial buildings and limited inundation of buildings in the rural zone

The RDP contains a chapter titled "Part 1 Matters of National and Strategic Importance". Section 1.2.8 notes

> The District Plan specifically manages land use affected by natural hazard risks through fault line rules and performance standards relating to flooding, geothermal activity and fault lines where appropriate mitigation measures are available and are not sufficiently managed under other national legislation such as the Building Act 2004. All-natural hazards identified on Maps 208 to 213 will be addressed when considering resource consent applications, guided by the natural hazard provisions of this part of the plan.

District Plan maps 208 to 213 do not address flooding from rivers or streams.[70]

Part 1 contains one objective and two policies on natural hazards.[71] The provisions seek to minimise or reduce the risks from natural hazards to an 'acceptable level' through the design and location of activities. 'Acceptable level' in relation to inundation (flooding) is not defined.

The Residential 1 zone is addressed in Part 4 of the RDP and land use is regulated through either permitted activity rules or the requirement for land use consents. There are no objectives or policies dealing with inundation risks (flood hazards), although as we discuss below, those matters are dealt with in Part 13 of the RDP dealing with subdivisions. In the Residential 1 zone one household unit per site[72] is a permitted activity, as are buildings and alterations accessory to a household unit.[73] Additional household units on a site are a controlled activity.[74] If permitted activity performance standards are not met the activity defaults to a restricted discretionary activity.[75] Earthworks are a permitted activity.[76]

Section 4.6 contains performance standards that permitted activities must comply with, including 13(d)[77] which is:

> Development of Land or Buildings Susceptible to Inundation from Surface Water
> i. Any habitable additions to existing buildings shall be constructed on a building platform filled to above the 2% AEP flood level.
> ii. Any replacement building shall be provided with a building platform filled to above the 2% AEP flood level and be located entirely within the existing building footprint.

[69] District Plan maps 313 to 315
[70] Map 208 addresses Lake Rotorua and Lake Rotoiti flood levels
[71] Objective 1.3.9 and Policies 1.3.9.1 and 1.3.9.2
[72] "Site" is defined in the RDP Part 17 – Definitions. Relevantly here, and in general terms, it is a single lot or two or more adjoining lots in one certificate of title
[73] Part 4.5, Rules 4 and 6 contained in Table 4.5: Activities in the Residential 1 – 5 Zones
[74] Ibid, Rule 9
[75] Part 4.8, Rule 3
[76] Part 4.5, Rule 96
[77] Under a heading of 'Natural Hazards'

There are no inundation performance standards for new buildings.

Performance standard 13(d) addresses the building platform, not the habitable floor level. It is arguably the habitable floor level that is more important in terms of flooding. It is also unclear how, on a plain reading of the RDP, one would know that land or buildings were susceptible to surface water inundation as the RDP does not contain flood hazard maps for rivers and streams.

For more than one household unit on a site, section 4.7.1 matter of control[78] 6(b) is:

> A flood risk assessment by a suitably qualified person/s, that includes an evaluation of the likelihood and consequences of an appropriate range of events to establish the maximum risk, may be required for activities subject to flooding. This applies primarily for significant developments

If permitted activity Performance Standard 13(d) is not complied with the activity is assessed as a restricted discretionary activity under Part 4.8. Section 4.8.1 matter of discretion 1(b) mirrors matter of control 6(b) set out above.

Performance standards for earthworks are set out in Appendix 10 of the RDP. Section A10.2.1 sets out nine general performance standards applying in all zones. However, under section A10.2.1(10) earthworks incidental to an approved subdivision are exempt from the earthwork's general performance standards. We understand from discussions with RLC planning staff that earthworks forming part of a subdivision are considered during the subdivision approval process.

Subdivisions are addressed in Part 13 of the RDP. Section 13.2.2 identifies surface water inundation as a natural constraint which could lead Council to decline subdivision consent. Part 13 contains one objective and two policies addressing natural hazards.[79] Those provisions seek to ensure that the natural hazard risk a subdivision is exposed to does not exceed 'acceptable levels'. If the risk exceeds the 'acceptable levels', then subdivision is to be restricted. As noted previously, the RDP does not define what 'acceptable levels' are, but we presume they are meant to be the 2% AEP flood (50-year event) as that is referred to in the Section 4.6 performance standard 13(d) quoted above.

Further policies require applications for subdivision to demonstrate an effective system for the collection, treatment and disposal of stormwater suitable for the maximum potential number of household units allowed for as a permitted or controlled activity.[80]

In terms of subdivision rules, in the Residential 1 zone subdivision is a controlled activity[81] defaulting to a discretionary activity[82] if performance standards set out in sections 4.6 or 13.5.2 are not met. Performance Standard 13.5.2.2 requires that a subdivision meets the performance standards in sections 13.12 to 13.16 as well as the performance standards for the zone. Of interest, standard 13.12.1 is titled *Subdivision of Land or Buildings Susceptible to inundation from Surface Water* and performance standard 13.13 is titled *Site Serviceability Performance Standard Applicable to all Zones*.

Standard 13.12.1 relates to surface flooding caused by a 2% AEP storm event. It specifies:

a) that no vacant lots shall be created on land susceptible to inundation if [the lot] cannot be filled above the inundation floor level; and

b) the subdivision of lots containing existing lawfully authorised buildings located on land susceptible to inundation may be undertaken where future replacement or habitable additions to the buildings require building platforms to be filled to above the inundation flood level.

Performance Standard 13.13.1 sets standards for subdivision earthworks, foundations, and land stability. Clause 1 requires that all sites within the subdivision have an area with a foundation suitable for the intended future use, which will be free from inundation, erosion, subsidence and slippage'

[78] A matter of control denotes a matter that a consent decision-maker can have regard to and set consent conditions for
[79] Objective 13.3.3 and Policies 13.3.3.1 and 13.3.3.2
[80] Policies 13.3.5.6 and 13.3.5.10
[81] Part 13.5, Table 13.5.1 Subdivision in Residential Zones, Rule 2
[82] Ibid, Rule 3

None of the provisions examined above:

a) refer to High, Medium or Low risks from flooding;
b) refer to the 100-year flood event;
c) address the impacts of climate change on rainfall or flood events; or
d) address flood freeboard.[83]

The Rural 1 zone provisions ("Part 9 – Rural" of the RDP) are similar to those of the Residential Zone in many relevant respects. Part 9 contains no objectives and policies on natural hazards or flooding except (oddly) for the Waikato River catchment (Objective 9.3.7 and Policy 9.3.7.1) and no environmental outcomes relating to natural hazards or flooding. One household unit is permitted per lot and extensions to habitable buildings and replacement buildings must have building platforms above the 50-year return period flood level. As with the Residential Zone, there do not appear to be any similar requirements for new habitable buildings. Interestingly, in the Waikato River catchment any building is required to have a building platform above the 100-year return period flood level.

For activities requiring resource consent Part 9 states "*Activities subject to flooding may be required to have a flood risk assessment by a suitably qualified person that includes an evaluation of the likelihood and consequences of an appropriate range of events to establish the maximum risk. This applies primarily for significant developments. The report shall identify the potential risk from flooding, any recommendations for floor levels, earthworks or engineering works*"

4.6.4 District Plan Conclusions

The RDP does not have a specific chapter (or Part) dealing with natural hazards. Grouping natural hazard matters (and in this case flooding matters) in a single chapter of the RDP would assist with focusing both the Council and consent applicants on those matters in the future.

The RDP does not contain any flood hazard maps for rivers and streams.

The RDP does not appear to give effect to the RPS natural hazard provisions for flooding.

The Ngongotahā area flooded in April 2018 is primarily zoned Residential 1 or Rural 1 and one household unit can be established on an existing site with no flood related controls on building platform or habitable floor levels required by the RDP, although we note that the RLC is able to address those matters as part of the building consent process. Under the zone rules only habitable additions to existing buildings and replacement buildings need to have a building platform above the 50-year flood event.

In the Residential zone, if more than household unit per site is sought, or if a building platform for a habitable addition to an existing building or a replacement building is not above the 50-year flood level, the RLC can have regard to a flood risk assessment undertaken by a suitably qualified person and impose consent conditions relating to that assessment. However, under the RDP such an assessment is not mandatory,[84] although we note that the absence of such as assessment may give the RLC grounds for declining the application.

In the Residential zone subdivisions are a controlled activity (for which consent must be granted) provided all relevant performance standards are met, including those relating to inundation from flooding in a 50-year storm event. If those standards are not met the subdivision is assessed a discretionary activity, which may be granted or refused. Section 106 of the RMA[85] enables the RLC

[83] Freeboard is an allowance made for flood prediction modelling errors or the effects of vehicle induced waves (for example). Typical freeboard levels are 300mm to 500mmabove the modelled flood level

[84] That would be the case if the controlled activity and restricted discretionary rules had as an 'entry condition' requiring a flood risk assessment to be undertaken. Consent applicants would then need to undertake such an assessment before they could utilise the rules. That is not the case here.

[85] Section 106 of the RMA also states that the Council may may refuse to grant a subdivision consent if it considers that there is a significant risk from natural hazards.

to refuse to grant a subdivision consent, or to impose conditions on the consent, if it considers that there is a significant risk from natural hazards, including from flooding.

Once a subdivision is approved any earthworks incidental to the subdivision are a permitted activity as are foundations. There are no earthworks performance standards relating to flood hazards.

The RDP provisions relating to subdivisions should ensure that flooding hazards from a 50-year flood event are avoided. However, once the subdivision is approved it appears that new houses would not be required to be built above that flood level.

These conclusions are important given our understanding that the area surrounding Ngongotahā village is indicated as a residential growth area in the RLC 2017 Draft Spatial Plan.[86] We understand that prior to any rural land being rezoned (noting there are some undeveloped areas that are already zoned residential) there would need to be an assessment against the RPS natural hazard policies.

4.6.5 District Plan Recommendations

- The Panel recommends that the RDP provisions relating to the urban area within the Ngongotahā catchment are reviewed to -
  a) give effect to the RPS natural hazard provisions;
  b) include flood hazard maps of the 100-year event climate change adjusted Ngongotahā Stream flood event (inclusive of a 500mm freeboard) and maps of High[87] and Low[88] Risk floodable areas;[89]
  c) set clear and consistent flood avoidance standards for new buildings (as well as additions to existing buildings and replacement buildings);
  d) ensure that the RDP's flood risk provisions in the Residential 1 Zone, subdivision and earthworks chapters are internally consistent.
- The Panel recommends that the RDP is examined to determine if similar amendments are required for urban areas outside of the Ngongotahā catchment or for rurally zoned areas.

The Panel acknowledges that any review of the RDP will necessitate extensive community consultation and robust technical and planning analysis and will be subject to LTP and annual plan constraints. It is also clearly beyond the scope of this Review to recommend detailed outcomes for such a process. However, by way of example only, a planning approach such as that set out below would build on the current content of the RDP while arguably also giving effect to the operative RPS:

a) categorising new subdivision, use and development:
   i. in High risk floodable areas as a prohibited or non-complying activity;
   ii. in Low risk floodable areas as a discretionary activity;
b) requiring proposals for subdivision, use and development (including habitable building platforms and subdivision earthworks) in Low risk areas to demonstrate by way of a mandatory Flood Risk Assessment undertaken by a suitably qualified and experienced engineer that the risks from at least the 100-year climate change adjusted flood event will be avoided or mitigated;
c) requiring the floor levels of any new habitable buildings in High and Low risk area, as well as habitable additions to existing buildings and replacement buildings, to be above the 100-year climate change adjusted flood event (inclusive of a 500mm freeboard) unless a mandatory Flood Risk Assessment undertaken by a suitably qualified and experienced engineer demonstrates that the risks from at least the 100-year climate change adjusted flood event will be avoided or mitigated.

[86] Page 33.
[87] For example, in the document titled Flow Hazard Regimes for People Chapter 7, Book 6 Australian Rainfall Run-off Guidelines, in Table 6.7.1 high risk is defined in terms of depth x velocity > 0.6 m^2/s or depth > 1.2 m or velocity > 3 m/s which is defined as "Extreme Hazard" for children and "Moderate Hazard" for Adults.
[88] Ibid, Low Risk is defined in terms of depth x velocity < 0.6 m^2/s and depth < 1.2 m and velocity < 3 m/s which is defined as "Low Hazard" for Adults.
[89] See section 4.6.6 of this review which highlights that the RLC Code of Practice specifies a 1% AEP flood and a 300mm freeboard.

4.6.6 Engineering Code of Practice

The Panel also reviewed the Rotorua Civil Engineering Industry Standard 2000 Version 2004 *(Engineering Code of Practice)*.[90] We refer to this document as 'the Code of Practice'. It states:

> This Engineering Code of Practice has been developed as a Means of Compliance with Subdivision and Development Performance Standards contained in the Rotorua District Plan.

The operative RDP is dated June 2016 whereas the Code of Practice appears to have been last updated in 2004.[91] It is inconsistent with the operative RDP, but we understand that it has been under review for quite some time now. [92] For example, it purports to contain in its Appendices 13 to 19 "Subdivision and Development Standards and Associated Performance Levels" from the RDP. Those Code of Practice appendices refer to Parts (chapters) of the RDP that no longer exist.

Nevertheless, the Code of Practice contains some useful guidance on managing flood hazards.

Chapter 2.1 addresses 'Information Requirements' and it states that Council will not approve any subdivision or development unless the specified information requirements are complied with.[93] That includes all applications for subdivision providing sufficient detail to demonstrate that the site is suitable for the proposed activity having regard to, amongst other matters, "inundation".[94]

Chapter 3 titled "Geotechnical Requirements" contains a section addressing subdivision of land or building on land susceptible to flood levels.[95] It states that nnew subdivisions adjacent to major water courses, including the Ngongotahā Stream, shall be specifically designed to provide building platforms above the predicted 100-year flood event. Somewhat confusingly, in that same section it also states that filling to above the 50-year flood event is required in order to provide a flood free building platform.

The Panel were informed by RLC staff that the practice for subdivisions has been to protect against external flooding (namely flooding from streams) to the 100-year flood level and provide drainage (of stormwater) within the subdivision to the 50-year flood event.

Chapter 3 of the Code also contains a section titled "Protection of Property from Inundation from Surface Water".[96] We were informed by RLC staff that this part of Chapter 3 relates to stormwater management in areas not prone to flooding from streams. It requires that new primary stormwater systems are sized for the 10-year flood event; that secondary flow paths are sized for the 50-year flood event to ensure that surface water does not enter buildings in a storm of that magnitude; and that low lying areas prone to inundation in a 50-year flood event are identified and restricted from building.

Chapter 3 of the Code mirrors the RDP requirement that any additions to habitable buildings or replacement buildings on land subject to inundation have building platforms above the 50-year flood level where the building is located entirely within the existing building footprint.

Chapter 5 titled "Utility Services Stormwater and Land Drainage" addresses flooding in section 5.4.2 titled "Protection from Flooding". It sets out a process for undertaking a Flood Risk Assessment,

[90] Section 1.6 of the RDP refers to a "Code of Practice for Subdivision and Development." We were informed by RLC staff that there is no such document and the document titled Rotorua Civil Engineering Industry Standard 2000 Version 2004 is what is being referred to in the RDP.
[91] We were informed by RLC staff that Chapter 3 of the Code of Practice regarding Geotechnical requirements was updated in 2012.
[92] We were informed by RLC planning staff that a review of the Code of Practice commenced some 18 months ago, and a revised draft was completed some 12 months ago. There is no target completion date for the review and a proposal has been sought from external consultants to complete it.
[93] Section 2.1.1
[94] Section 2.1.11
[95] Section 1.14 of Chapter 3
[96] Section 1.15 of Chapter 3

which we presume relates to the RDP matters of control and discretion outlined in section 4.9 of this report.[97] The assessment process seems thorough.

Importantly, Chapter 5 of the Code goes on to state that new subdivisions adjacent to major watercourses, including the Ngongotahā Stream, shall be specifically designed to have a floor level no less than 300 mm[98] above the predicted 100-year event flood level. Secondary flow paths are to be identified and where appropriate, catered for by specific design.[99]

We were informed by RLC staff that the Code of Practice is not consistent with "NZS 4404:2010 and development and subdivision infrastructure"[100], but it is currently being reviewed with the intention being to align the Code of Practice with NZS 4404:2010 where appropriate.

4.6.7 Engineering Code of Practice Conclusions

The Code of Practice requires a review to ensure that it is consistent with the operative RDP and NZS 4404:2010. It would be helpful if 'protection from flooding' was addressed in a single section in the Code as it is currently (and confusingly) addressed in several sections.

The Code usefully (and contrary to the District Plan) addresses the risk posed by a 100-year event flood level inclusive of freeboard.

Despite having areas for improvement, the Code of Practice contains some important guidance for RMA resource consent decision-makers that should ideally be contained in the RDP itself. This includes:

- declining subdivision and development proposals that do not supply appropriate flood hazard identification information;[101]
- specifying the requirements for a Flood Risk Assessment;
- requiring habitable floor levels in new subdivisions adjacent to surface watercourses to be above the 100-year flood level inclusive of freeboard;[102]
- restricting building in low lying areas subject to stormwater inundation in a 50-year flood event.

4.6.8 Engineering Code of Practice Recommendations

The Panel recommends that -

- The current review of Rotorua Lakes Council Engineering Code of Practice is completed without further delay and flood hazards are addressed in a single section in the Code.[103]

[97] It specifies taking account of the characteristics of the total catchment, relevant historical information on flooding (including records held by relevant bodies, discussions with the local inhabitants or appropriate field tests) The assessment should address the proximity and nature of any river, stream or watercourse and associated flood plains; the capacity of culverts or watercourses downstream of the site and likelihood of upstream ponding resulting from under capacity or from blockage by debris or slips; upstream culvert and watercourse conditions and the location of the secondary flow path for flood water in the event of blockage or under capacity. Calculations based on professional judgement are to determine the expected runoff and show that the design flood levels at the site satisfy the Performance Standards.

[98] We consider 300 mm to be too low in this particular situation, due mainly to the significant variation in the channel roughness caused by vegetation growth. 500 mm would be the more generally accepted standard for this type of system.

[99] Section 5.4.2 also cross-refers to "clause 3.8 Protection of Property from Inundation". We assume that to be section 1.15 in Chapter 3 that we discussed above.

[100] NZS 4404:2010 provides local authorities, developers, and their professional advisors with criteria for design and construction of land development and subdivision infrastructure. The Standard encourages sustainable development and modern design. It is applicable to greenfield and infill development, and brownfield redevelopment projects. The Standard incorporates up-to-date design principles such as low impact design (LID) solutions to stormwater management.

[101] Section 2.1.1

[102] Chapter 3, section 1.14

[103] It would be helpful to reorder and reformat its contents into a more readily accessible layout that avoids duplication and internal inconsistencies and has correct internal cross-references.

4.7 Emergency Management

Emergency management is a vital but often overlooked element of flood risk management. A well formulated emergency management plan can significantly reduce flood damage to property, especially vehicles and other high value mobile items and reduce the risk to life. The Panel has not found any evidence of planned emergency management activities within the Ngongotahā Catchment. It is noted that the actual emergency response including provision of welfare is outside the scope of this review, but some brief discussion about emergency management is provided below for the purpose of assisting with future work to improve flood risk management in Ngongotahā Catchment.

The BOPRC hydraulic modelling of Ngongotahā Stream from 2007 highlighted that there was likely to be overflows at Brake Road and Brookdale Drive during a large flood event. Inspection of the BOPRC modelled flood levels at Brake Road (cross section 43) suggest that the threshold for overtopping (including 500 mm of freeboard) to spill over the bank/road at 289.10 mRL would be around a 20-year flood of around 43 m^3/s.

Also, within the 2007 BOPRC modelling report there was a flood map that could have been used to identify vulnerable properties, particularly the existing properties on Western Road and Brookdale Drive. This information could have been used to assist vulnerable property owners in raising their awareness, so they could make their homes and belongings more resilient to flooding. In addition to increased awareness and resilience the provision of advanced flood warnings that an overflow was possible would give people the opportunity to evacuate safely and take critical items with them.

In addition to improved resilience and safety with planned evacuations there could also have been emergency temporary works such as sandbags or mobile flood pumps to reduce the impact in the most vulnerable areas.

As stated at the start of this section there were no planned emergency works plans in place at the time of the April 2018 event and it is extremely fortunate that there was no loss of life from the flood. The development of an emergency works plan should be given the highest priority as it is something that can be implemented relatively quickly and easily compared to large scale flood management structures which may take several years to design, obtain consents for and to construct.

Even though there were no specifically planned emergency works for the Ngongotahā Catchment there was of course flood management activities undertaken by BOPRC, RLC and CDEM during the event. In the information provided in the briefing from BOPRC to the Panel it was highlighted that the BOPRC Flood Room was operational from 0750 on the day of the flood and there was liaison with RLC staff during the day including a major teleconference at 6:55pm when the overflow was occurring at Brake Road. At 2216 BOPRC advised RLC that the Ngongotahā Stream had dropped 1 m and the overflows from Brake Road should cease within another hour.

It was also highlighted by BOPRC during their briefing to the Panel that the structures controlling the levels at Lake Rotorua (Ohau stoplog weir) and Lake Rotoiti (Okere Gates) were opened prior to the event when threshold levels were exceeded. The BOPRC have advised the Panel that the Ohau stoplogs were removed at 1500 on 28 April (day before the flood) and that the Okere Gates commenced opening on 27 April to be almost fully open at 2330 on 28 April and 100% open by 1050 on 29 April.

Inspection of the BOPRC water level record from Mission Bay in Lake Rotorua shows that at around the time of the peak flow in Ngongotahā Stream (29 April 1730) the lake level was 280.089 mRL, slightly above the consented maximum of 280.076 mRL. The peak lake level of 280.176 m occurred the following day at around 1930. It is noted that the peak lake level is 100 mm higher than the consented maximum but that one of the conditions[104] of the consent specifically allows for the

[104] Condition 8.5 of BOPRC Consent 65980.

maximum level to be exceeded in emergencies and during extreme weather events such as the 29 April 2018 flood. In 2017 there were 10 days when the consented maximum was exceeded (BOPRC, 2017).

The slightly elevated lake level would have had no effect on the flooding of dwellings within the Ngongotahā catchment. This is due to the relatively steep grade of the channel with a 3 m difference in flood levels between the lake and Ngongotahā Road and a 10 m difference in flood levels between the lake and SH5.

Figure 36: Lake Rotorua Water Levels 2018 (Source – BOPRC Live Monitoring Website)

In terms of improvements to future planned emergency management it is noted that since the 29 April 2018 flood BOPRC has installed a new rain gauge site within Ngongotahā Catchment (at Relph Road) to assist with the provision of advanced warnings of overflows and flooding of Ngongotahā Stream. It was also highlighted by community members that RLC undertook sandbagging at the Brake Road overflow site during the smaller flood event that occurred subsequently in June 2018. These are positive steps towards improved flood risk management within the catchment and further thought should be given to other emergency management elements in conjunction with possible structural and stream maintenance works. This is discussed further in Section 6 of this report.

5 Pioneer Property Trust Subdivision

The Pioneer Property Trust Subdivision, which is colloquially referred to by some local people as the 'Pioneer Road and 'Western Road' subdivision, now comprising Pioneer Road, Mohi Crescent and Oakland Place and several properties situated at the western end of Western Road, was the worst affected residential area during the 29 April 2018 flood event. In this section of the report an assessment is provided of the process by which the Pioneer Property Trust Subdivision (PPTS) was established as well as the design and performance of key flood management infrastructure within this development during the 29 April 2018 flood event.

The assessment is based on a review of RLC files and documentation provided by RLC and BOPRC, discussions with current and former RLC and BOPRC staff, and a meeting held with an engineer from MTEC Consulting (now Forbay Limited) who worked on the design of the PPTS flood management infrastructure. In addition to this, detailed eye-witness accounts of the flooding as well as experiences of local community members has been considered and incorporated into the assessment.

The Panel recognises that this part of our Report relates to a subdivision application and approval that was undertaken twelve years ago. Both best practice and RLC processes have advanced since this time so we include analysis of what was done at the time as well as a summary of current practices particularly regarding conflicts of interest and external peer review of land development (subdivisions) proposals.

The Panel notes that the PPTS required consents from BOPRC for earthworks and the discharge of stormwater[105] to the Ngongotahā Stream. However, although BOPRC personnel were involved in discussions with RLC staff and the PPTS consultants regarding the flood hazard from the Ngongotahā Stream, they did so in an advisory capacity and the two BOPRC consents could not address flooding matters.[106] Accordingly, we do not discuss the BOPRC consents further.

5.1 Background to PPTS Process

The PPTS land originally formed part of a proposed Everard Developments Ltd subdivision that was focussed on Hall and Western Roads and which was being progressed by Canmap Consultants on behalf of the land owners. In September 2004 the PPTS land was sold to the Pioneer Property Trust (PPTS).

By early 2005 a four-stage subdivision proposal was being advanced by the PPT.[107] Everard Developments retained ownership of the land immediately to the north and east of the PPTS. Rural land to the west was (and is) owned by the Brake family. MTEC Consultants[108] undertook the planning, surveying and engineering work for the applicant.

One of the RLC Resource Engineering staff involved with reviewing the construction of assets to be vested in Council through the subdivision process was the spouse of one of the MTEC engineers working on behalf of the applicant. RLC has confirmed that any interactions between the relevant RLC Engineer and the MTEC Engineer were reviewed by the RLC Consents Manager and recorded in writing. The Panel found no evidence that this potential conflict of interest contributed to the flooding that occurred within the PPTS.

[105] Relating to stormwater generated from rainfall falling on the subdivision, together with rainfall generated runoff from the Brake owned farm land to the west of the PPTS. Stormwater in this context does not include flood water from the Ngongotahā Stream.
[106] The earthworks consent addressed on-site erosion control and sediment runoff, dust control and site stabilisation. The stormwater discharge consent addressed discharge water quality and the design and construction of the outlet structure.
[107] The subdivision application for Lot 1 DP 336769 was lodged by MTEC on 14 March 2005 and received by RLC on 21 March 2005. The subdivision was to provide 78 vacant lots in four stages on 14.2 ha of land. The Panel understand that once the PPTS was approved and underway the sections were marketed by real estate agent who was a sitting RLC councillor at that time.
[108] MTEC Consultants Limited changed their name in December 2012 to Forbay Limited.

It was also noted by the Panel that the principal PPTS applicant was a sitting councillor at the time which raises an issue regarding perceptions of a potential conflict of interest. The Panel was informed by the RLC that the councillor was not involved in the decision to approve the subdivision and the Panel has found no evidence that this potential conflict of interest contributed to the flooding that occurred within the PPTS.

The PPTS was approved by the RLC under delegated staff authority on 13 February 2006[109]. The subdivision application was categorised as a controlled activity (for which consent must be granted[110]) and was processed without public notification or notification to (or 'service on' as it was called then) potentially affected parties.

5.1.1 Current RLC Conflict of Interest Policy and Processes

The Panel acknowledges that this subdivision process occurred over twelve years ago and that RLC policies and processes have developed in the intervening period. RLC have provided the Panel with the following documents which describe the current processes particularly related to conflicts of interest:

- Rotorua Lakes Council – Code of Conduct (2016 – 2019 Elected Members) *Section 3.10 Conflicts of Interest;*
- Elected Member Induction Guide *Declaration of Members Interest (Conflict of Interest);*
- Elected Members Induction Programme (2016 – 2019) *Includes LGNZ Training*;
- Managing Conflicts of Interest: Guidance for Public Entities. Good Practice Guide Controller & Auditor General 2007. *RLC stated to Panel that this document is provided to all elected members;*
- Draft Conflict of Interest Policy (For Staff).

RLC also provided information about their current processes for independent technical peer review which is discussed in later sections of our report where the engineering design elements of the subdivision process are analysed.

Overall the Panel considers that the current RLC policies and processes are adequate with regards to managing conflicts of interest going forward.

5.2 Known Flood Risk

Landowners who have lived in Ngongotahā and on Western Road in particular, discussed with the Panel how in large flood events water would spill out of Ngongotahā Stream across Western Road and fill in the ponding/swamp area in this location before draining through the rural drains and the outlet culvert at Elliot Park. This is understood to have occurred most significantly in 1966, but with a number of smaller flood events in recent years including in 2012. Based on the memory and observations of local residents the April 2018 event was as similar as the 1966 flood event or greater.

The Panel's review of RLC files revealed that as early as May 1999 the PPTS land was formally identified as being in the Ngongotahā Stream floodplain and there was a documented need to consider the risk posed by the 100-year flood event as the Ngongotahā stream was considered to be a 'significant stream'[111]. Regarding the PPTS, in March 2005 MTEC had been advised by BOPRC that potential overflows from the Ngongotahā Stream would be in excess of the stormwater flows that the PPTS floor levels were being designed for.[112] There was also concern from BOPRC that the

[109] Approval letter to MTEC dated 13 February 2006 signed by Director, Environmental Services, RLC. The Panel have not been able to sight the final recommendation and approval report as it appears to be missing from the RLC files.
[110] Section 104A of the RMA a at 2006.
[111] Letter from RLC to Canmap Consultants, 11 June 1999 [File Volume 1 Part 1 page 45 of 50].
[112] Letter from BOPRC to Pioneer Property Trust care of MTEC dated 4 March 2005.

PPTS earthworks could obstruct overland flows emanating from the Brake owned rural land to the west, potentially affecting properties at the western end of Western Road.

In the April 2018 flood the Ngongotahā Stream overflowed its banks a few hundred metres east of the intersection of Brake Road and Western Road. That was where modelling undertaken by BOPRC in 2007 had predicted an overflow would occur.

While not significantly contributing to the April 2018 flood event, we also note that the properties on the west end of Western Road were prone to surface flooding arising from high flows in the Ngongotahā Stream causing backflow into the stormwater drain[113] servicing those properties. This had led to a flap gate being installed on the outlet pipe. The Panel heard from residents how at times that flap gate became blocked with debris and on occasion the residents had cleared it themselves.

5.3 Pioneer Property Trust Subdivision Flood Risk Management

On 29 April 2018 Ngongotahā Stream flood waters spilled out of the main channel east of Brake road and proceeded to flow across Western Road, through and around the houses at the western end of Western Road, through the Brake family farmland and into the PPTS. From there it flowed across vacant Lot 31 (18 Pioneer Road), into an RLC reserve area, along Oakland Place, across Lot 80 (7 Oakland Place) and into the Everard Developments Ltd rural land, finally crossing Western Road again by Elliot Park reserve before flowing back into the Ngongotahā Stream.

As noted above, MTEC had specifically designed an overland flow path for the purpose of conveying this known overflow from Ngongotahā Stream through the PPTS without inundating floor levels. As evidenced by the April 2018 flood this clearly did not function as intended by the design with 22 dwellings within the PPTS being inundated with flood waters and subsequently being issued with insanitary notices. In order to understand the contributing factors which led to the flooding the design of the overland flow path is examined in detail along with key information that became available after the resource consent was approved but before 223 and 224 certificates[114] were issued. This analysis focuses on how this overland flow path could be expected to perform under design conditions. The actual performance of the overland flow during the April 29 event is then summarised using available information.

As well as considering the design and performance of the overland flow path a detailed assessment of key stormwater infrastructure within the PPTS has been undertaken. This focuses on the main 1200 mm diameter stormwater line that serves as an outlet for the entire PPTS. The assessment follows the same process as used for the analysis of the overland flow path. This includes review of the engineering drawings and calculations submitted as part of the resource consent, followed by consideration of updated information on key design levels provided by BOPRC in 2007 and then finally some observations and calculations on how the stormwater system actually performed in the April 29 event.

The design of both the overland flow path and the stormwater network are critical for determining the minimum floor levels required to ensure the habitable floor levels of dwellings are kept above flood waters. Overland flow paths will generally be operating once the capacity of the stormwater network is exceeded and the design of the overland flow path requires consideration of what flow could be generated within the catchment that cannot enter the stormwater network as well as what might be back flowing or surcharging from the network. This is in addition to any overland flow of stormwater or flood water entering from catchments outside of the reticulated stormwater network catchment.

[113] The drain (originally an open drain and latterly a pipe drain) discharges to the Ngongotahā Stream by way of a pipe under Western Road.

[114] Section 223 of the RMA provides for, in this case, RLC to approve a survey plan for a consented subdivision. Section 224 of the RMA provides for a certificate to be lodged with the Registrar-General of Land, signed by the CEO of RLC in this case, stating that amongst other things all conditions of the subdivision consent have been complied with.

This information can then be used to estimate depths of flow and ponding, and with the addition of appropriate freeboard, minimum floor levels.

In complex situations it is very common to use a digital hydraulic model, particularly a 2-dimensional model that can more accurately determine the depth and velocity of flood water when it is flowing through complex urban geometry such as around houses, across roads, and through parks.

It is clear that the accuracy of the design or modelling of the stormwater network and overland flow paths is fundamental to the determination of accurate minimum floor levels. On this basis, following the detailed review of the overland flow path and stormwater network design a review of the resulting minimum floor levels is undertaken. This part of the review highlights how any errors in the design of the overland flow path and stormwater network will have contributed to errors in determining appropriate minimum floor levels. Information is also provided on how the minimum floor levels compare to the actual flood levels that occurred during the event.

The overland flow path is the most critical structural element in the overall flood hazard management for the PPTS. Given the complexity of the PPTS situation including its low-lying topography, existing constraints and the large flow rate anticipated from a flood breach of the Ngongotahā Stream, this would have presented a significant challenge in terms of design. Accordingly, the overland flow path would have required design and review by engineers with specialist knowledge and skills in hydraulic engineering to ensure it was likely to perform as required during flood conditions. This would have, at the time of this design (2005/06), normally involved the use of some form of 1-D hydraulic modelling tool (e.g. MIKE-11 or HEC-RAS) or detailed manual backwater calculations.

The Panel has not found evidence that any hydraulic engineering specialists were involved in the design or review of the overland flow path and no hydraulic modelling or detailed backwater calculations were provided as part of the design. RLC advised that their engineers' who were responsible for reviewing the design were land development engineers who would not normally be expected to have specialised skills in hydraulic engineering of open channels. The Panel acknowledges this, but emphasises that with this being the case, then prudence and best practice would dictate that external, independent specialists would be necessary to review the engineering elements that were outside the areas of expertise of the RLC land development engineers.

The following sections of our report provide review and analysis of what was provided in terms of the design of flood management infrastructure for the subdivision resource consent application followed by an analysis of how this infrastructure performed during the April 2018 flood. Comments are provided on the engineering review process that was undertaken at the time of the subdivision application followed by a summary of current RLC practices with specific regard to peer review of specialist engineering information that is submitted as part of subdivision consent applications.

It is acknowledged that wisdom of foresight is a lot more difficult than wisdom of hindsight and it is difficult to recognise complexity if you don't have the necessary specialist knowledge to see the complexity. Nevertheless, the following review of the flood management infrastructure has been undertaken from the perspective of what information and technology, in terms of modelling, was available at the time and what would have been considered best practice.

5.3.1 Overland Flow Path Design

The need for an overland flow path was specifically identified and defined in terms of a design flow in the 24 August 2005 BOPRC memorandum – Ngongotahā Hydraulic Model, Potential for Spilling at Brake Road – Further Modelling. The result being the prediction of a 5.3 m^3/s overflow from Ngongotahā Stream across Western Road adjacent to Brake Road. A copy of this memorandum was sent to MTEC consultants for consideration of it in their design.

Following receipt of this information there was concern raised by the MTEC engineers to the RLC engineers - *"…. there is no way our pipes will carry this through the subdivision and to carry this via*

overland flow would require an 8 m wide x 0.5 m deep flow channel (approx.)" [115]. The concerns raised by MTEC went on to say *"…we will have to consider alternative means of stopping the 1% flood flows leaving the stream (i.e. stopbank or alternate flow channel across the Agrodome land)."*

The above highlights the difficulties and risks recognised by MTEC associated with designing an overland flow path for such a high volume of water through what was proposed to be a developed urban area. With these issues highlighted, MTEC pursued the construction of a stopbank at the Brake Road overflow point and wrote to the RLC with a recommended draft consent condition *"A 1% AEP stop bank shall be designed by a suitable qualified Professional Engineer and constructed prior to the issue of the 224 certificate to the satisfaction of the District Engineer, in accordance with the flood level data provided by Environment Bay of Plenty[116]"*.

At around this time there was also a letter[117] from RLC to BOPRC suggesting that the Kaituna flood protection scheme should be extended from Ngongotahā Bridge to SH5 with reference to "upstream overflows", no doubt referring to the overflow point at Brake Road. This message was acknowledged by BOPRC who stated[118] - *"I believe that such a stopbank can be formulated, we would just need to do a quick check that retaining water in the river does not adversely affect anyone in the reach from that bend to where the water re-enters the Ngongotahā*".

It appears that by January 2006 this issue had not been resolved, so MTEC proposed to proceed on the basis that they would accept the overflow volume as calculated by BOPRC and design and construct an overflow path through the subdivision until a stopbank at Brake Road could be designed, consented and constructed. As part of the overflow path design lots on the western (Lot 31) and eastern (Lot 87) boundaries were set aside to provide flow paths in and out of the development with the idea that once the stopbank was developed that Lot 31 could be released for development[119] as Lot 87 was to be a reserved for wastewater pump station.

The hydraulic design of the overland flow path was provided to RLC in correspondence from MTEC dated 12 January 2006. The calculations presented were undertaken at four discrete cross sections (See Figure 37) within the subdivision and were effectively a calculation of the hydraulics at that particular point without specific consideration of hydraulic connectivity between each location or of backwater effects between the eastern boundary and Western Road. In general terms this methodology is very approximate, and its use could result in an overland flow path that would not perform to the required design standard.

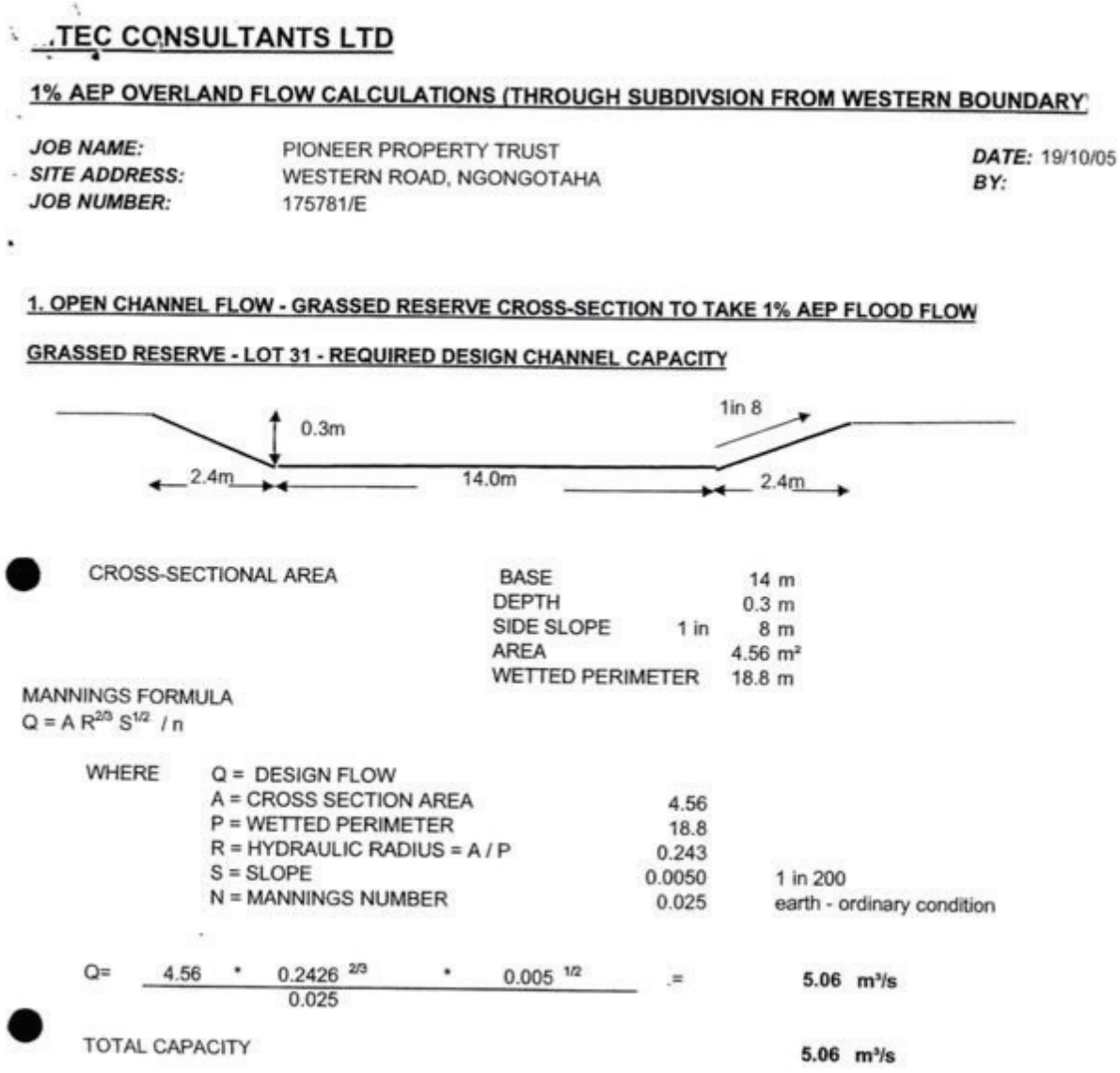
[115] MTEC personal communication, 1 September 2005.
[116] MTEC personal communication, 3 October 2005.
[117] RLC personal communication, 23 September 2005.
[118] BOPRC, personal communication, 17 October 2005.
[119] Condition 41 RLC Resource Consent 6305026

Figure 37: Outline plan of overland flow path and locations where calculations were undertaken (Source – MTEC Drawing 175781-R-P-D002 N.B. colours added by Review Panel for clarity)

At this point it is worth highlighting that engineering design for the consenting phase of a project can often be more approximate as long as it is sufficient to understand the effects and to demonstrate that a feasible solution exists. If this is the case, then furthermore detailed design is required and will typically be included as a condition of the consent. No conditions requiring detailed design of the overland flow path were included in the consent and the Panel has not been provided with any calculations, design reports or drawings with regards to the detailed design for the overland flow path.

Highlighting the approximate nature of the overall MTEC design methodology submitted as part of the subdivision consent application, a review of key parameters and the calculations used at each location as shown in Figure 38 are described below.

Location 1. – Grassed Reserve Lot 31



MTEC CONSULTANTS LTD

1% AEP OVERLAND FLOW CALCULATIONS (THROUGH SUBDIVSION FROM WESTERN BOUNDARY)

JOB NAME: PIONEER PROPERTY TRUST
SITE ADDRESS: WESTERN ROAD, NGONGOTAHA
JOB NUMBER: 175781/E
DATE: 19/10/05
BY:

1. OPEN CHANNEL FLOW - GRASSED RESERVE CROSS-SECTION TO TAKE 1% AEP FLOOD FLOW

GRASSED RESERVE - LOT 31 - REQUIRED DESIGN CHANNEL CAPACITY

CROSS-SECTIONAL AREA

BASE		14 m
DEPTH		0.3 m
SIDE SLOPE	1 in	8 m
AREA		4.56 m²
WETTED PERIMETER		18.8 m

MANNINGS FORMULA

$Q = A R^{2/3} S^{1/2} / n$

WHERE

Q = DESIGN FLOW		
A = CROSS SECTION AREA	4.56	
P = WETTED PERIMETER	18.8	
R = HYDRAULIC RADIUS = A / P	0.243	
S = SLOPE	0.0050	1 in 200
N = MANNINGS NUMBER	0.025	earth - ordinary condition

$$Q = \frac{4.56 * 0.2426^{2/3} * 0.005^{1/2}}{0.025} = 5.06 \text{ m}^3\text{/s}$$

TOTAL CAPACITY 5.06 m³/s

Figure 38: MTEC design cross section and calculations at location 1

This is the most upstream location of the overland flow path near the western boundary of the PPTS. The slope used in the calculation of 1 in 200 appears appropriate based on the post development earthworks contours, but the Manning's n of 0.025 would appear to be too low, especially for shallow flow conditions. Inspection of Figure 4-5 in Henderson (1966), with appropriate conversion of length units, would suggest a more realistic Manning's n in the range 0.04 – 0.05. Increasing the Manning's n to 0.04 would result in an additional 100 mm of flow depth. There is also a lack of freeboard added to allow for uncertainty, particularly in recognition of the very crude method of analysis. Using a Manning's n of 0.04 with the width and side slope dimensions provided for by the MTEC channel along with the provision of 300 mm freeboard would have seen a channel 0.7 m deep with a bank full (no freeboard) capacity of approximately 15 m^3/s.

As well as the lack of capacity from a channel that is too shallow, there does not appear to be any consideration of whether all of the upstream flow would be concentrated and channelled to this particular point. With no works proposed on the upstream adjoining Brake property it was not clear that all of the overland flow would arrive at Lot 31 to be conveyed through the subdivision. Furthermore, there did not appear to be any consideration of how the design channel profile would transition from running through Lot 31 to cross perpendicular to Pioneer Road and then along Mohi Crescent before entering the local purpose reserve where cross section two is located.

In respect to the continuity of the channel profile the plans for Pioneer Road (MTEC Drawing No. 175781-R-E-D001) show the location of where the overland flow crosses perpendicular to Pioneer Road with a standard road grade of 1:200 compared to the 1:8 required to contain the flood overflow. With this standard road profile at 1:200, flood waters would be expected to spread out to over a 100 m width across Pioneer Road.

Location 2. – Grassed Reserve Lot 88

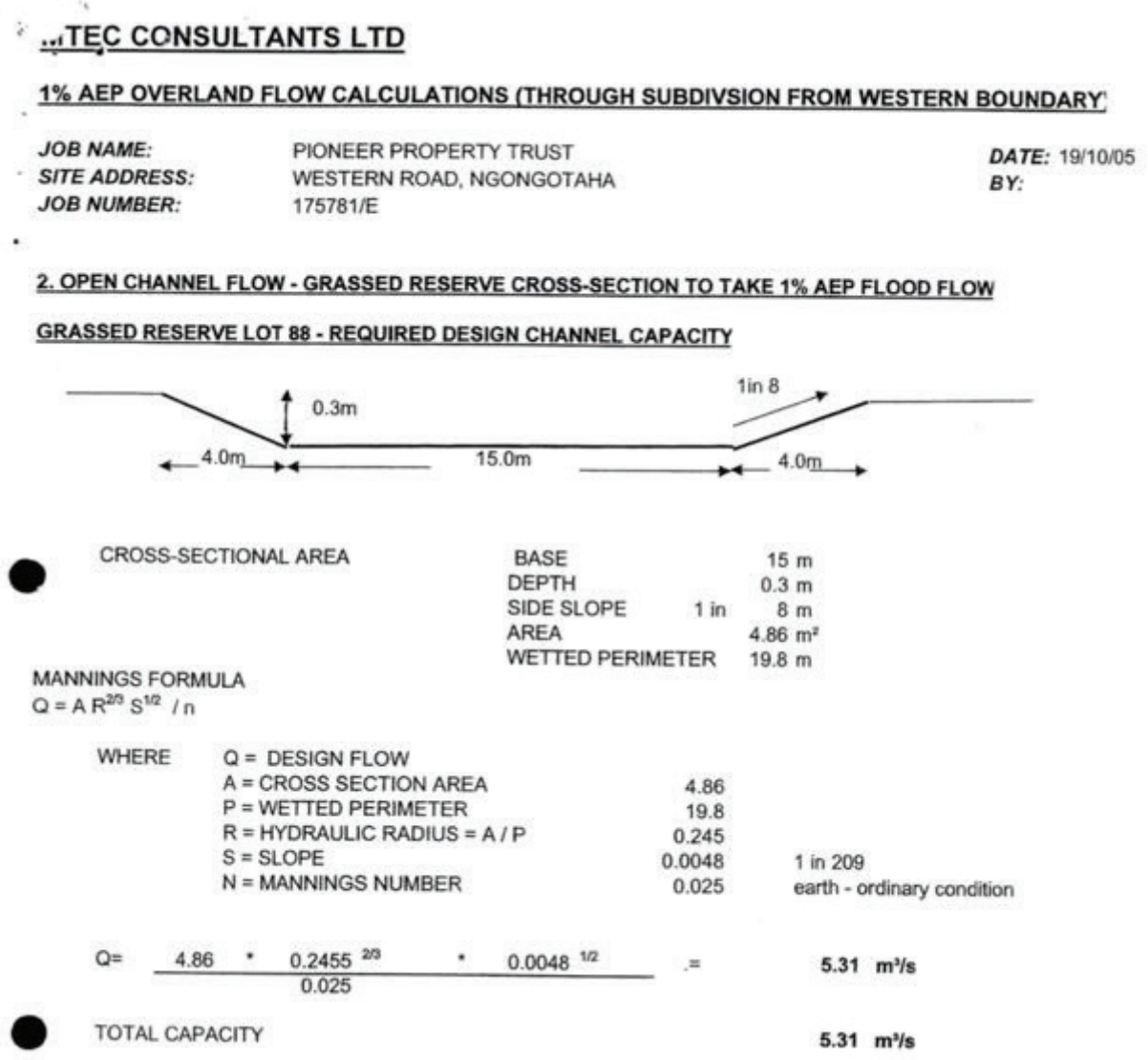


Figure 39: MTEC design cross section and calculations at location 2

The calculations at this next downstream location also indicated an over optimistic Manning's n of 0.025, no freeboard and no consideration of upstream and downstream connectivity. There also appears to be some inconsistency between the dimensions on the sketch and those in the calculations particularly with regard to the side slopes of the channel (1 in 8) and the horizontal distance of 4 m with a depth of 0.3 m which would provide a distance of 2.4 m. This discrepancy is not material compared to the optimistic Manning's n and the lack of freeboard.

Location 3. – Road Cross Section

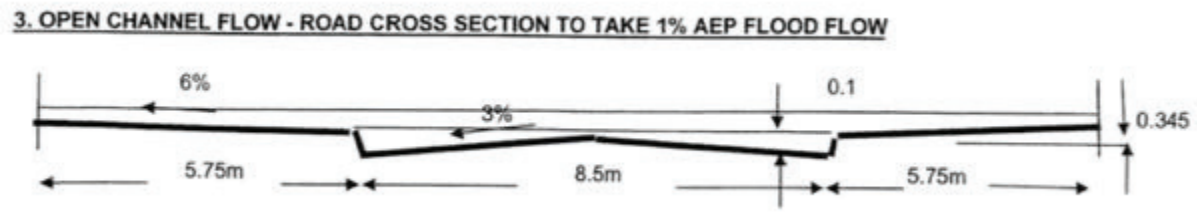
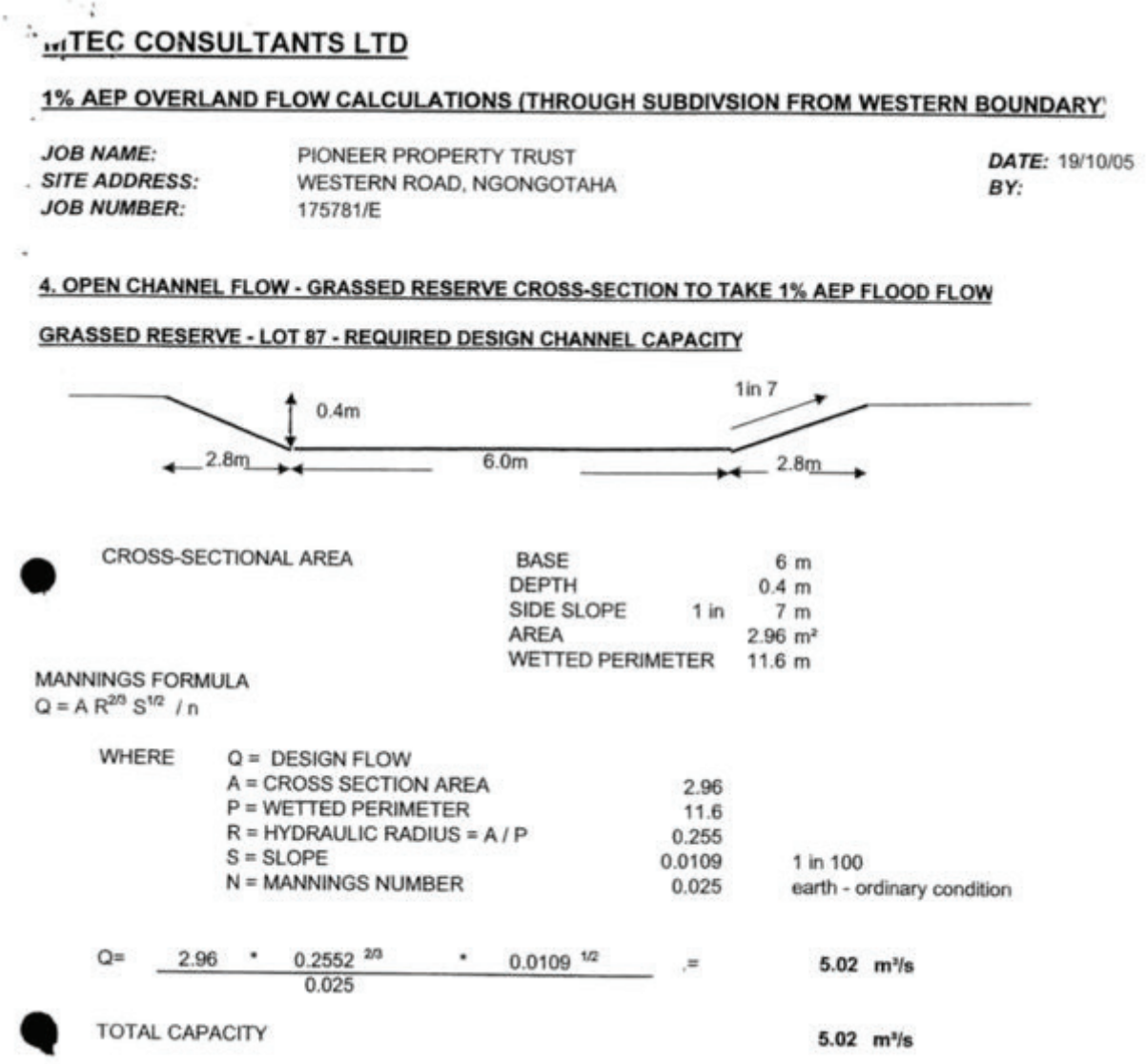


Figure 40: MTEC design cross section at location 3

At this location the calculations have been split between the portion of flow on the road and that on the berms, with a maximum depth on the road (at the bottom of kerb) of 0.5 m reducing to 0.345 m at the road crown with a section average velocity of approximately 1.1 m/s. This provides a depth times velocity range of 0.38 – 0.55 m^2/s which exceeds the typically expected range from a vehicle stability and safety perspective. The limits presented in section 7.2.4.2 of the Australian Rainfall & Run-Off Guidelines suggest limits of 0.3 to 0.45 m^2/s for small and large passenger cars respectively. Large 4WD drive vehicles have a limit of 0.6 m^2/s. As designed, using the road and berms to pass this amount of flow would present safety issues for people trying to egress the site in a vehicle during a flood.

Further to the above, and similar to the calculations at the upstream cross section, the Manning's n used for the berms of 0.025 would appear to be optimistic and there was also a lack of consideration of freeboard. Both of these factors would have increased the overall required design depth and further worsened the safety of the road when operating as an overflow path.

Location 4. – Grassed Reserve Lot 87



MTEC CONSULTANTS LTD

1% AEP OVERLAND FLOW CALCULATIONS (THROUGH SUBDIVSION FROM WESTERN BOUNDARY

JOB NAME: PIONEER PROPERTY TRUST
SITE ADDRESS: WESTERN ROAD, NGONGOTAHA
JOB NUMBER: 175781/E
DATE: 19/10/05
BY:

4. OPEN CHANNEL FLOW - GRASSED RESERVE CROSS-SECTION TO TAKE 1% AEP FLOOD FLOW

GRASSED RESERVE - LOT 87 - REQUIRED DESIGN CHANNEL CAPACITY

CROSS-SECTIONAL AREA

BASE		6 m
DEPTH		0.4 m
SIDE SLOPE	1 in	7 m
AREA		2.96 m²
WETTED PERIMETER		11.6 m

MANNINGS FORMULA
$Q = A R^{2/3} S^{1/2} / n$

WHERE	Q = DESIGN FLOW		
	A = CROSS SECTION AREA	2.96	
	P = WETTED PERIMETER	11.6	
	R = HYDRAULIC RADIUS = A / P	0.255	
	S = SLOPE	0.0109	1 in 100
	N = MANNINGS NUMBER	0.025	earth - ordinary condition

$$Q = \frac{2.96 \cdot 0.2552^{2/3} \cdot 0.0109^{1/2}}{0.025} = 5.02 \text{ m}^3/\text{s}$$

TOTAL CAPACITY 5.02 m³/s

Figure 41: MTEC design cross section and calculations at location 4

The calculations at this location again indicate an optimistic Manning's n, no freeboard and lack of consideration of connectivity with upstream and downstream sections. This is particularly evident in the slope that has been used for the calculations at this location. The slope on the calculation sheet suggests 1 in 100 but the actual number used in the calculation of 0.0109 is in fact even steeper at 1 in 92. There is nowhere within the site or anywhere in the surrounding floodplain topography where a slope of that magnitude, in terms of steepness, exists.

Further to this in the calculation of minimum floor levels, provided in the same letter from MTEC, it is stated that this area is in fact a pond with a flat slope at a level of 285.3 mRL being 200 mm above the minimum road centreline of Western Road some 300 m downstream. The hydraulics at this location cannot be both a pond and a steep channel with a slope of 1 in 92. It is also noted that the existing manhole (SWMH A4 - MTEC Drawing No. 175781-R-E-D002) just beyond the eastern boundary of Lot 87 has a lid level of 284.33 mRL being some 0.77 m lower than the crest of Western Road where the overland flow path was intended to discharge back into Ngongotahā Stream.

With regard to the concept of this area being a pond all the way down to Western Road, inspection of MTEC Drawing "Flood Levels and Downstream Critical Levels During Flood Flows" (Drawing No. 175781-R-E-D001) clearly shows the confined and vegetated nature of the area between the subdivision and the spill area across Western Road. To fully understand the nature of flow in this reach of the overland flow path would require consideration of the hydraulic grade between Western

Road and the subdivision. It was unlikely that there was going to be a pond with a flat (zero slope) water surface all the way from Western Road.

The use of a slope of 1 in 92 to calculate the outlet hydraulics from the overland flow path on the eastern boundary does not reflect the likely water surface slope in this reach and is contradictory to the calculations used by MTEC for determining the minimum floor level for the subdivision. Within the same set of calculations MTEC state there is in fact a pond (flat slope) from Western Road to the subdivision which, from inspection of the confined downstream topography and the likely hydraulic grade is not correct.

5.3.2 Summary of Overland Flow Path Design at time of Consent

The overall summary of the design of the flow path at the time of the consent is that the design of the overland flow path includes:

- Optimistic Manning's n roughness values for shallow flow on grass berms;
- No freeboard;
- Lack of consideration of reach connectivity;
- Lack of consideration of interface across roads;
- Lack of consideration of depth of flooding on roads from a safety perspective;
- Flawed in terms of the outlet hydraulics at the eastern end of the subdivision.

Discussions with RLC engineers [120]involved at the time suggested that they did not consider that they had the required level of specialist expertise to assess this part of the design and were relying on the applicant's consultant (MTEC) to provide the correct design. The Panel considers that it would have been prudent and best practice to seek independent (from the applicant) specialist advice on the design presented by MTEC. This was not undertaken, and it is beyond the scope of this review to assess whether this was common practice at the time.

In a discussion that the Panel had with the MTEC engineer who undertook the design it was stated that the design was reviewed by one of the MTEC directors before being issued to RLC. The Panel has not been provided with any information to demonstrate whether MTEC had the appropriate level of specialist expertise to be undertaking or reviewing this type of design work.

The Panel also specifically requested that BOPRC check their files and archives for any record of receipt of the MTEC design of 12 January 2006. No records were found and BOPRC stated in correspondence with the Panel that they had not previously seen or reviewed the overland flow path design. The design as presented by MTEC was approved by RLC as part of the resource consent for the subdivision.

5.3.3 Post Consent Overland Flow Path Design Information

Following approval of the subdivision in 2006 it appeared that the preferred option was still the stopbank at Brake Road as opposed to the overland flow path provided for in the resource consent. The option of a stopbank was again suggested[121] by MTEC with the offer, on behalf of PPTS, to pay the full costs of the stopbank and construct it in conjunction with the Stage 3 civil earthworks and to obtain the resource consent if BOPRC were not going to do so. A response[122] to this request was provided by BOPRC stating that the new stopbank would require resource consent and that without mitigation the downstream flood levels would increase by 69 mm in the existing Brookdale Drive subdivision. It was also explained that BOPRC did not intend to construct any new flood protection works on the Ngongotahā Stream and there was no obligation for the BOPRC to do so upstream of the 100-year flood event scheme boundary at Ngongotahā Road Bridge. Further discussion with

[120] Ex RLC Engineer personal communication, 4 August 2018.
[121] MTEC personal communication, 15 June 2007.
[122] BOPRC, personal communication, 27 June 2007.

regard to BOPRC improving the flood management standard upstream of Ngongotahā Road Bridge is provided in Section 4.3 of this report.

It was as part of this correspondence that BOPRC provided both MTEC and RLC with an updated version of the BOPRC Report – Hydraulic Modelling of the Ngongotahā Stream (BOPRC, 2007) which included details of the re-calibration undertaken following the notable 33 m^3/s flood in December 2005 as well as utilising the 2007 LiDAR survey of the floodplain.

A significant issue was raised in the 2007 BOPRC report that fundamentally affected the feasibility of the consented overland flow path, being that the spill flow at Brake Road could reach 15 m^3/s (pg. 23 Section 5.2 of BOPRC report) being some three times greater than the earlier estimate provided by BOPRC of 5.3 m^3/s.

This should have raised significant concern for all parties involved and triggered consideration by RLC as to whether the conditions of the subdivision consent could be reviewed. In that regard the Panel notes that s128(1)(c) of the RMA enables a consent authority (in this case RLC) to review the conditions of a subdivision consent[123] "*if the information made available to the consent authority by the applicant for the consent for the purposes of the application contained inaccuracies which materially influenced the decision made on the application and the effects of the exercise of the consent are such that it is necessary to apply more appropriate conditions*."

Also in the BOPRC report was a figure (See Figure 42 below) which depicted the head difference from the overflow point on Western Road (285.29 mRL) to the approximate centreline of Oakland Place (286.27 mRL). This represents a head difference of almost 1 m across the 300 m distance from the subdivision to Western Road. The information in this figure from BOPRC was significantly different from that provided in the MTEC design with regard to the slope of the overland flow path for which MTEC had designed, somewhat confusingly with both a slope of 1 in 92 and as a flat slope (pond).

Figure 42: 100-year flood levels with PPTS based on 2007 survey information (Source – BOPRC Modelling Report)

Whether the information in the 2007 BOPRC report with regards to the increased design flow and the slope of the overland flow path constituted the resource consent application material being considered "inaccurate" and therefore enabled RLC to review and make changes to the consent conditions through s128(1)(c) of the RMA is a complex legal question and beyond the scope of this report to answer.

With regard to the stopbank proposal, the correspondence from BOPRC highlighted that the stopbank at Brake Road would require a resource consent and would need to account for any required mitigation in terms of managing the increased flood levels and flows in the downstream channel, particularly for affected parties in the Brookdale Drive area. The correspondence from BOPRC was quite clear in that they did not intend to progress a resource consent for the works and even though MTEC had stated in their correspondence that they would prepare the resource

[123] Under s87(b) RMA a subdivision consent is a resource consent.

consent, this did not occur. The PPTS construction and subsequent issuing of 223/224 certificates were completed on the basis of providing an overland flow path as defined by the MTEC design approved by the 2006 resource consent.

5.3.4 Performance of Overland Flow Path during April 2018 Flood Event

To assist in the visualisation of what happened during the flood an aerial image has been created by RLC at the request of the Review Panel. Initially it was requested that the peak flood levels surveyed by BOPRC were translated to flood depths and extents using a digital elevation model (DEM) of the ground surface based on the 2011 LiDAR survey.

When attempting to do this it became apparent that there were issues with the accuracy of the DEM. In some locations surveyed flood levels were below the apparent ground level from the DEM. This either suggests that there have been changes to the ground surface since the 2011 LiDAR survey or that there were some other forms of errors or inaccuracies in the LiDAR data. The comment from the RLC Geographic Information Systems team was the LiDAR was captured for the purpose of creating orthophotography with specifications for level of +/- 0.25 m to +/- 0.5 m on clear ground for the 1 m and 2 m DEMs respectively.

As an alternative to using the surveyed flood levels, recent preliminary flood mapping produced for RLC for a similar sized event has been used. This flood mapping is based on the same LiDAR and resultant DEM accuracy as described above so can only be considered to provide an indication of what happened during the event. From inspection of the flood extents it appears that the preliminary flood mapping underestimates the actual flood extent of the 2018 flood. It is understood that further work has been commissioned by RLC on the underlying hydraulic model in an attempt to replicate the peak flood levels and extent of the 2018 flood more accurately.

Notwithstanding the above, the preliminary flood modelling and mapping is considered useful for demonstrating the performance of the overland flow path and it is shown for two areas along with properties inundated during the April 29 event and subsequently issued with insanitary notices in Figure 43 and Figure 44.

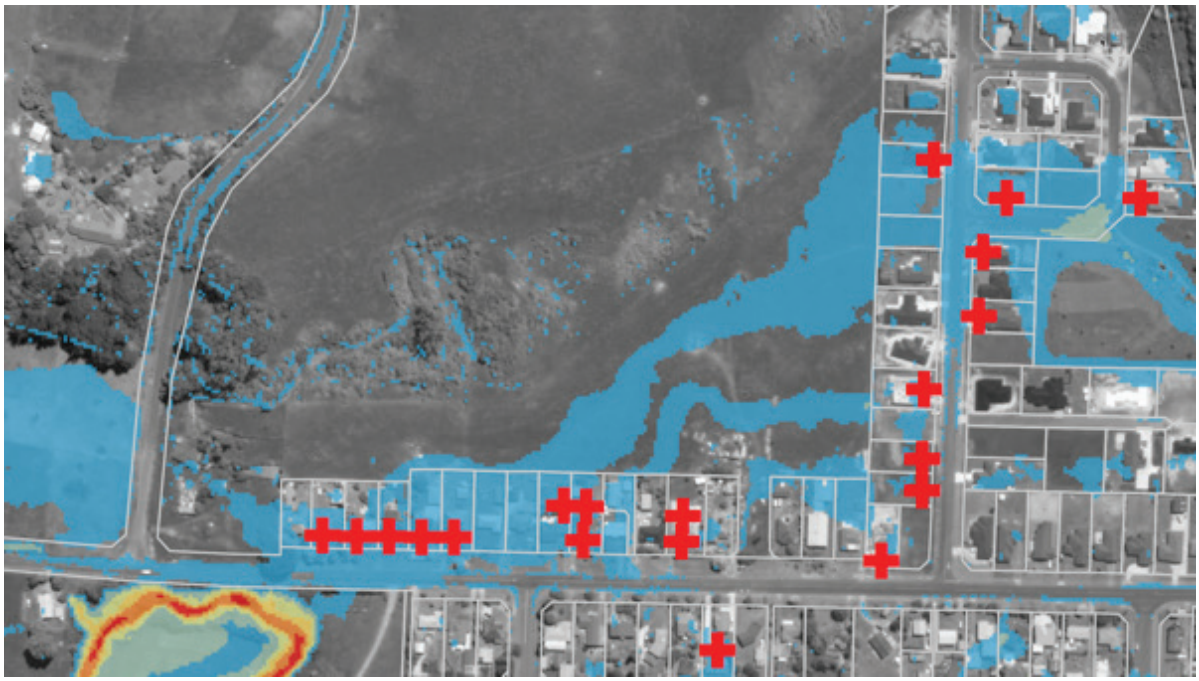


Figure 43: Approximate extent of overland flow path Western Road – Pioneer Road – Mohi Crescent for 72 m3/s flood event in Ngongotahā Stream (Red crosses denote dwellings inundated during April 29 event and subsequently issued with insanitary notices)

Inspection of Figure 43 shows the issues at the upstream end of the overland flow path with flow dispersed along the boundary at three discrete locations and being some 100 m wide where it enters the 20 m wide overland flow path at the eastern edge of the PPTS. The overland flow is clearly not contained or conveyed within the 20 m wide channel as it passed through the dwellings on Pioneer Road & Mohi Crescent before entering the RLC reserve at the western end of Oakland Place. A total of nine dwellings within the PPTS were inundated and issued with insanitary notices in this area.

The issues highlighted with the overland flow path design at the consent phase, in terms of a lack of capacity and inadequate consideration of upstream and downstream connectivity, are well illustrated. The increased design flow from 5.3 m^3/s to 15 m^3/s is also likely to be a contributing factor. Approximate calculations undertaken by the Panel using surveyed flood and ground levels at the Brake Road overflow site suggest a flow of around 7 m^3/s to 10 m^3/s with possibly another 1 m^3/s to 2 m^3/s coming from other catchments to the north of Western Road and the west of Brake Road.

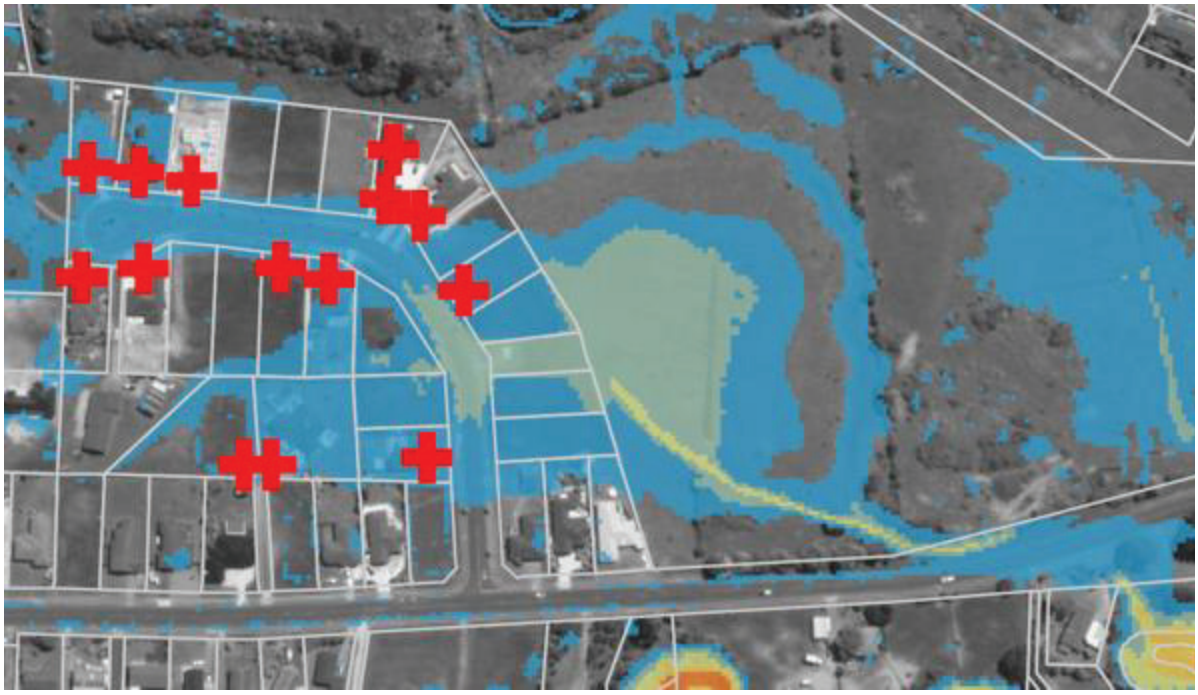


Figure 44: Approximate extent of overland flow path Oakland Place - Western Road (Elliot Park) for 72 m3/s flood event in Ngongotahā Stream (Red crosses denote dwellings inundated during April 29 event and subsequently issued with insanitary notices).

Moving downstream to the next reach of the overland flow path shown in Figure 44 the flows do appear to be reasonably confined within the road, but the flood mapping in this area is most likely to be underrepresenting the actual flooding that occurred as evidenced by the 14 insanitary notices issued in this area. Attention in particular is drawn to the nature of the flood extent downstream of Oakland Place with the notable ponding area on the adjacent property but with the confined outlet flow on the north of Western Road. It is within this area where most of the hydraulic grade between Western Road and Oakland Place will have been generated.

The overland flow path extent and resulting flood depths in this area are far in excess of those estimated by the MTEC design. The key issues being those highlighted in the review of the design in terms of a lack of consideration of the hydraulic grade between Western Road and Oakland Place, no freeboard, optimistic Manning's n roughness as well as the increased design flows. In addition to the 8 m^3/s to 12 m^3/s estimated by the Panel to be coming from the upstream reach of the overland flow path into this area there is also the possibility of backflow from the 1200 mm stormwater culvert to consider in this area. This is discussed in the next section.

5.4 Stormwater Network

Although not as critical as the overland flow path, the design of the stormwater network is a still an important element of the overall flood management infrastructure for the PPTS. The design of the stormwater system is less complex than that of overland flow path but still requires the nature of the hydraulics to be correctly identified as being controlled by the tailwater level in Ngongotahā Stream. An assessment of the key elements of the design, focusing on the main 1200 mm outfall pipe is provided below.

5.4.1 Design of Stormwater Network for Consent

The Review Panel has given consideration of the design of the stormwater network focusing on two key elements

- The expected tailwater levels in the Ngongotahā Stream at the outlet of the 1200 mm diameter pipe servicing the development;
  The subsequent hydraulic design of the 1200 mm diameter pipe from the outlet in Ngongotahā Stream to the PPTS boundary.

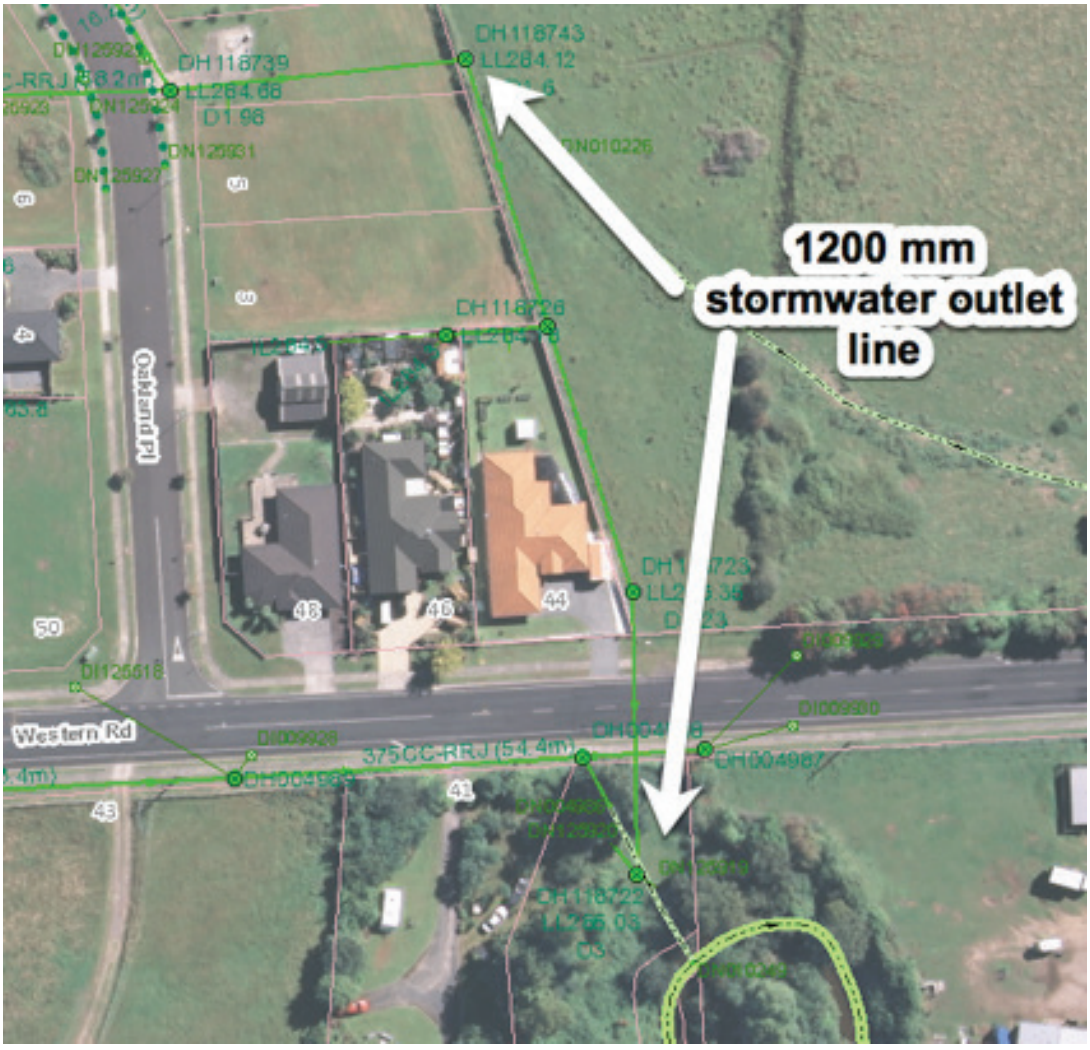
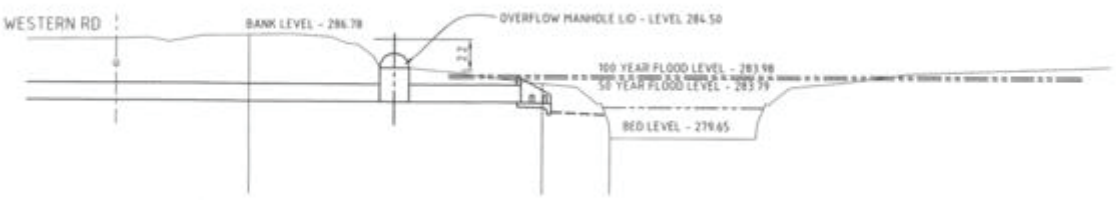


Figure 45: Plan view of 1200 mm stormwater outlet line from PPTS development



MTEC Consultants

CATCHMENT ANALYSIS

JOB NAME:	PIONEER TRUST	***DATE:*** 28-Apr-05
SITE ADDRESS:	WESTERN ROAD, NGONGOTAHA	***BY:***
JOB NUMBER:	175781/E	
		REV B
		AMENDED 07/07/05

NGONGOTAHA STREAM OPEN CHANNEL FLOW -

CROSS - SECTION NGONGOTAHA STREAM AT OUTLET OF PROPOSED STORMWATER PIPE

MANNINGS FORMULA

$Q = A R^{2/3} S^{1/2} / n$

1%AEP = 67
2%AEP = 60

WHERE	Q = DESIGN FLOW		
	A = CROSS SECTION AREA	69	
	P = WETTED PERIMETER	35	
	R = HYDRAULIC RADIUS = A / P	1.971	
	S = SLOPE	0.002	0.0025
	N = MANNINGS NUMBER	0.08	

$$Q = \frac{69 * 1.9714^{2/3} * 0.002^{1/2}}{0.08} = 67.5 \text{ m}^3/\text{s} \quad \text{OK} > Q_{100}$$

STREAM BED LEVEL	279.65		
WATER DEPTH - 1% AEP	4.33	WATER DEPTH - 2% AEP	4.14
WATER LEVEL - 1% AEP	283.98	WATER LEVEL - 2% AEP	283.79
0.5m FREE BOARD LEVEL	284.48	0.5m FREE BOARD LEVEL	284.29
TOP OF BANK	286.78		286.78
FREEBOARD	2.30		2.49

Figure 46: MTEC cross section and calculations at 1200 mm PPTS stormwater outlet

The calculations for the tailwater level at the outlet were completed by MTEC, with a calculation sheet dated 28 April 2005 provided to RLC. The calculations use what looks to be a surveyed cross section at the location of the outlet, along with a stream bed slope of 1 in 500 and Manning's n roughness value of 0.08.

It is not stated where the slope of 1 in 500 has come from and it is interesting to note that calculations on the same page for a stream cross section further upstream (opposite Brake Road) use a flatter slope of 1 in 770. It is likely that the slope of 1 in 500 used in the calculations is too steep to accurately reflect that actual slope of the flood water surface at this location of the Ngongotahā Stream. This overestimate in slope will result in an underestimate (i.e. too low) of flood level at this location.

Likewise, the Manning's n value of 0.08 would appear to be somewhat optimistic when compared to Table 4-2 in Henderson 1960 for natural channels that are very weedy, winding and overgrown (n = 0.075 to 0.15) and also the measured Manning's n of 0.09 for a flow of 28 m^3/s downstream of SH5 as presented in Hicks & Mason 1998. The underestimation of Manning's n will also contribute to an underestimate (i.e. too low) of the flood level at the outlet. Notwithstanding the above, the following design levels were determined by MTEC at the outlet of the 1200 mm stormwater pipe servicing the development:

100-year flood level = 283.98 mRL
500 mm freeboard level = 284.48 mRL

50-year flood level = 283.79 mRL
500 mm freeboard level = 284.29 mRL

The addition of 500 mm freeboard would go some way towards addressing the likely overestimation of slope, underestimation of Manning's n and the inaccuracy in using a single cross section to quantify the hydraulics of a channel with complex geometry.

To now consider the hydraulic design of the 1200 mm stormwater pipe from the outlet in Ngongotahā Stream to manhole reference – SWMHA4 located immediately beyond the eastern boundary of Lot

87 (MTEC drawing – Proposed Subdivision Detail Plan No. 175781-R-E-D002). The lid level of this manhole provided on the MTEC drawing is shown as 284.33 mRL and effectively sets the maximum level at which the stormwater system can operate at before uplift pressure will be exerted on the manhole lid and further increases in head could result in the lid "popping".

The MTEC design calculations for this section of stormwater network dated 11 January 2005 show a required design capacity of 3.0 m^3/s for the 50-year return period event and a calculated capacity of 2.98 m^3/s. Hydraulic calculations are presented where it appears that the capacity of pipe is based on the grade of the stormwater pipe of 0.46%, the pipe diameter of 1200 mm and a roughness of n = 0.013.

The use of a slope-based calculation in a situation where the outlet of the pipe is affected by a tailwater level is not correct. The appropriate method of calculation is to consider an outlet control scenario and to calculate the head loss due to friction, manholes, bends, inlet and outlet losses and add that to the design tailwater level to see whether the total upstream head (water level) exceeds the available head at the upstream manhole. If surcharging does occur, then consideration of overland flow paths would then follow.

In terms of checking this design the Panel has completed simplified calculations looking at the entire section of stormwater line from the stream outlet to the manhole at the boundary with a single inlet and outlet loss using Equation 2 from Section 5.3.2 of The Ministry of Works & Development Culvert Manual.

Key parameters used in these calculations are as follows:

Length = 135 m
Diameter = 1.2 m
Entry Loss Coefficient = 0.5
Outlet Loss Coefficient = 1
Manning's n = 0.013

Using the MTEC calculated 50-year flood level with no freeboard and allowing the upstream head to equal the manhole lid level provides a total available head of 0.54 m with an associated capacity of 1.9 m^3/s being only 63% of the required design capacity of 3 m^3/s.

If freeboard is added to the 50-year flood level in Ngongotahā Stream, then the available head reduces to 0.04 m with an associated capacity of 0.5 m^3/s being only 17% of the required design capacity of 3 m^3/s.

Based on the above it is considered that the design of this section of the stormwater network was insufficient to pass the design stormwater flows generated within the development when the tailwater in the Ngongotahā Stream was operating at the equivalent flood return period (i.e. 50-year) without causing manholes to surcharge.

In terms of hydraulic design, the identification of tailwater control and undertaking calculations appropriate to those circumstances is considered a fundamental of the design of stormwater systems.

5.4.2 Post Consent Stormwater Network Information

Further to the above, the BOPRC hydraulic modelling report sent to MTEC and RLC in June 2007 provided updated design levels at the outlet[124] of the 1200 mm stormwater pipe as below:

100-year flood level = 285.39 mRL (MTEC 283.98 mRL)
500 mm freeboard level = 285.89 mRL

[124] These levels are indentifed from cross section 04xs32 at Chainage 2455 m in Table 7 pg 24 of BOPRC Modelling Report.

50-year flood level = 285.22 mRL (MTEC 283.79 mRL)
500 mm freeboard level = 285.72 mRL

These levels were over 1.4 m higher than those calculated by MTEC and for the 100-year flood event without freeboard were now 1 m higher than the manhole lid level at the boundary of the subdivision. Based on these design levels the stormwater network would now in fact backflow from Ngongotahā Stream into the development during a large flood.

In a 100-year flood with no freeboard there is the potential for 1.06 m of head driving a flow of 2.7 m^3/s back into the subdivision. With the inclusion of freeboard this head differential would increase to 1.56 m and a flow of approximately 3.2 m^3/s back into the subdivision. These flows would reduce as water ponded in the subdivision to rise above the level of the manhole lid at 284.33 mRL.

With this updated information on tailwater levels in Ngongotahā Stream the design of the stormwater system was now flawed. At this point it would have been prudent for RLC to consider pumping, non-return valves and the provision of storage for the flows generated within the subdivision as well as those coming from the overland flow and whether the conditions of the resource consent could be reviewed and changed under s128(1)(c) of the RMA. As previously discussed, with regard to the overland flow path, this is a complex legal question beyond the scope of this review. The 223 and 224 certificates were signed off in September 2007 by RLC based on the consented stormwater design.

5.4.2 Performance of Stormwater Network During April 2018 Flood

The peak flood level at the outlet of the 1200 mm pipe during the April 2018 flood has been interpolated from upstream and downstream surveyed flood levels provided by BOPRC. The peak flood level at this location is 285.85 mRL which is within the range (including freeboard) of the 100-year BOPRC modelled flood levels at this location, but is nearly 2 m higher than the MTEC 100-year design level (without freeboard) and is over 1 m above the upstream manhole lid level and 500 mm above the minimum floor levels at the south end of Oakland Place.

At this peak level, there would be the potential for backflow from Ngongotahā Stream of up to 3 m/s into Oakland Place. Based on observations from residents' the Panel interviewed or heard from, water was flowing out of the sumps and manholes on Oakland Place prior to the main flood overflow path from further upstream occurring. This is likely to be an accurate observation and supported by the approximate calculations undertaken by the Review Panel. It is likely that as flood levels in Ngongotahā Stream rose to be above the manhole and sump lid levels in Oakland Place that backflow started occurring. Based on the measured hydrograph at the SH5 bridge presented in Section 2.2 of this report the backflow would have likely occurred for 2 – 3 hours prior to the overflows from Brake Road occurring and entering the overland flow path towards the PPTS.

Once the overland flow path was in operation the flood levels in Oakland Place would have increased rapidly to be above the level in Ngongotahā Stream and a positive hydraulic gradient (flow towards stream) would have been created. At the peak of the flood, levels at the south end of Oakland Place reached 286.6 mRL being 0.75 m above the peak flood level in Ngongotahā Stream. This head would have provided an outflow capacity in the 1200 mm pipe of approximately 2.4 m^3/s in addition to outflow that was occurring through the overland flow path further downstream across Western Road into Elliot Park.

Importantly, the flood level of 286.6 mRL at the south end of Oakland Place is 1.3 m above the minimum floor levels recommended by MTEC for the southern end of Oakland Place. A detailed discussion of minimum floor levels is provided in the following section.

5.5 Minimum Floor Levels

The setting of minimum floor levels requires the underlying overland flow path and stormwater infrastructure design to be correct and accurate. Given the previous discussion on the design and performance of the overland flow path and stormwater network it is to be expected that there will be issues with the minimum floor levels set for the PPTS.

It is standard practice to require habitable floor levels to be built above known flood levels, including an allowance for freeboard. The RLC Engineering Code of Practice[125] for subdivisions addresses this matter. As we noted in section 4.5.6 of this report, Chapter 5 of the Code of Practice states that new subdivisions adjacent to major watercourses, including the Ngongotahā Stream, shall be specifically designed to have a floor level no less than 300 mm above the predicted 100-year flood level. Secondary flow paths are to be identified and where appropriate, catered for by specific design.

In March 2005 RLC[126] sought further information from the PPTS under s92 of the RMA to "demonstrate that there are no adverse effects on the subdivisions under s106 RMA from a 100-year flood in the Ngongotahā Stream as required under Clause 5.4.2 RCEIS." BOPRC, as early as April 2005, had also advised RLC that it would need to ensure that houses in the proposed PPTS were located above flood flow paths.[127]

As discussed earlier the minimum floor levels for Oakland Place were set based on the area being a pond with the level set at 200 mm above the Western Road crest level approximately 300 m downstream. There was no consideration of any backflow from the surcharged 1200 mm stormwater network nor were there any storage calculations to support the level of 285.3 mRL being the top water level of the assumed ponding area.

Proper storage calculations would have required using incoming flows (5.3 m^3/s to 15 m^3/s) with an outflow rating curve based on the hydraulics of the overland flow path plus both inflow and outflow from the 1200 mm diameter culvert. This information combined with knowledge of the volume of storage available at specified levels would have provided a basis for establishing a maximum flood level plus the addition of freeboard (300 mm from RLC Code of Practice) for the setting of minimum floor levels in this area of Oakland Place.

This was not done, and the minimum floor levels were set at a level 200 mm above the crown level of Western Road some 300 m downstream with no hydraulic grade and no freeboard, resulting in a minimum floor level of 285.3 mRL for only three lots within the entire development. It is understood that it was thought by MTEC that the general site earthworks would be providing ground levels within identified building platforms higher than this elsewhere in the development and above the overland flow path (with no freeboard) further upstream.

It is interesting to note that the draft resource consent conditions from December 2005 prepared by RLC staff stated, "That Lots 15, 16 and 64 – 86 shall have building platforms at or above the Environment Bay of Plenty 1% AEP flood levels". This covered all Lots within PPTS Stage 2 (64 - 86) and 2 Lots within Stage 1 (15 & 16). Following receipt of the MTEC calculations of minimum floor levels the condition was changed to "That Lots 84, 85 and 86 shall have building platform levels at or above the Environment Bay of Plenty 1% AEP flood level of 285.30 metres Moturiki Datum".

There are multiple issues arising from these changes to the draft conditions. First and foremost, there were errors in the MTEC calculations to determine the minimum floor levels based on the overland flow path and stormwater network design discussed earlier. Secondly the Panel has not been provided with any written evidence of checking by the RLC engineers of the calculations from

[125] Rotorua Civil Engineering Industry Standard 2000 Version 2004.
[126] Letter from RDC (unsigned – Senior Resource Management Advisor) to MTEC dated 29 March 2005.
[127] Letter from BOPRC to RDC dated 6 April 2005 [File Volume 1 Part 1 page 23 of 50].

MTEC, nor was there any evidence to suggest that the calculations were provided to BOPRC for checking. The Panel specifically requested BOPRC to check their archives for any record of receiving the MTEC January 2006 calculations, no record was found.

Thirdly, the reference in the final consent conditions to the level of 285.30 mRL being an Environment Bay of Plenty 1% AEP flood level is incorrect as this was in fact an MTEC determined flood level determined by their hydraulic design of the overland flow path and stormwater network.

Fourthly, within the Building Code compliance document – *Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 – Surface Water* section 4.3 it is stated that –

> "4.3.1 The secondary flow estimated to arrive on the site shall be directed into the surface water drainage system designed for the site. The height of the secondary flow shall be used as a basis for determining the building floor level necessary to comply with the requirements of NZBC E1.3.2.
>
> The level of the floor shall be set at the height of the secondary flow plus an allowance for freeboard. The freeboard shall be:
>
> - 500 mm where surface water has a depth of 100 mm or more and extends from the building directly to a road or car park, other than a car park for a single dwelling.
> - 150 mm for all other cases.

It is acknowledged that the requirements of NZBC E1.3.2 are for a 50-year flood event to not enter dwellings, but NZBC E1.3.1 provides for an exception if required under the Resource Management Act 1991. The consent conditions for the subdivision consent clearly refer to the 100-year event, so in this case it is clear that the higher flood standard exception should have been applied. Putting aside the numerous issues with the design of the overland flow path, the calculated depth of overland flow presented by MTEC was 300 – 400 mm, clearly above the 100 mm threshold for applying a minimum of 150 mm freeboard to the calculated depth in the overland flow to determine minimum floor levels throughout the subdivision. In any locations where it was predicted that 100 mm depth would be evident adjacent to a dwelling with a direct path to the road, that freeboard should have been increased to 500 mm to allow for wave action.

It is not clear why minimum floor levels were not set throughout the subdivision based on an allowance for freeboard above the calculated depth in the overland flow path. Furthermore, the RLC Engineering Code of Practice (Chapter 5) in force at the time requires new subdivisions to be specifically designed to have a floor level no less than 300 mm above the 100-year flood level.

The MTEC letter of 12 January 2006 shows (incorrect) calculations of a flood level of 285.3 mRL without the addition of any freeboard as the basis of setting minimum floor levels for the subdivision. The calculations also suggest that this area is a pond, but as discussed previously, there are no storage calculations presented to determine how deep the pond would be during a flood event.

Further to this no calculations were provided for the flood level within the overland flow path or the required (by RLC Engineering Code of Practice) 300 mm freeboard above that level to set minimum floor levels for the remainder of the subdivision bordering the overland flow path.

The above discussion of the inadequacy of the minimum floor levels is relevant to the period up to approval of the resource consent in February 2006. The following discussion is based on the subsequent updated flood design information provided by BOPRC in 2007 and the on-going provision of minimum floor levels by MTEC for individual lots.

5.5.1 Post Consent Minimum Floor Level Information

On 27 June 2007 MTEC and RLC were provided with a copy of the updated hydraulic modelling report from BOPRC. As referred to in previous sections, this contained information that affected the necessary capacity of the overland flow path and the resultant minimum floor level requirements.

The most critical piece of information was that the design flow rate in the overland flow path could now be as much as 15 m^3/s, vastly greater than the consented 5.3 m^3/s design which did not include any allowance for freeboard.

Within this BOPRC report there was also a map showing design flood levels inclusive of freeboard through the overland flow path of the development. These design flood levels had been estimated based on ground levels from LiDAR flown in early 2007 which was likely prior to significant completion of the earthworks for Stage 2 of the development. The flood levels within the development would therefore more likely represent the pre-development conditions and not reflect the changes due to earthworks. It is noted from the earthworks plan (MTEC Drawing No. 175781-R-E-D001) that fill of 0.0 – 1.5 m was proposed along the downstream (eastern) boundary of the development so the pre-development flood levels from the BOPRC report would likely be lower than the post development case.

Notwithstanding the above, the model results shown in Figure 9 of the BOPRC report (Figure 42 presented in Section 5.3.3) show the significant head difference from the overflow point on Western Road (285.29 mRL) to the approximate centreline of Oakland Place (286.27 mRL). The minimum floor levels around Oakland Place were set 1 m lower than this at 285.30 mRL. It would have been prudent for RLC to consider their options for changing the consent conditions to recognise the significant difference in the MTEC determined minimum floor levels in the approved consent and the BOPRC determined flood levels presented in the 2007 report. In the event no changes were made and the information in the BOPRC 2007 modelling report was not accounted for with the minimum floor levels remaining at the same MTEC determined levels as contained in the approved resource consent.

In March 2009 MTEC provided Tonkin & Taylor with 100-year flood levels for all Lots within Stage 3 of the development (Lots 24 – 63) along with a recommendation of an additional 200 mm freeboard to be added to this level for minimum floor levels that had been agreed[128] at an earlier meeting. In this communication MTEC described the methodology for determining the 100-year flood levels including the establishment of depths in the primary flow paths required to pass "a potential spillover from the Ngongotahā Stream upstream of the site". In addition to managing this spillover there was consideration of overland flows from stormwater originating from the site if the stormwater network was completely surcharged, presumably due to high tailwater levels at the outlet in Ngongotahā Stream.

No calculations have been provided to support the 100-year flood levels calculated by MTEC, so it is not clear whether the design flow was the updated 15 m^3/s or the original 5.3 m^3/s. The other major issues with the consented overland flow path design would still also apply to this situation as at this point there did not appear to have been any significant changes to the earthworks, roading or layout to provide for a continuous, connected flow path of appropriate capacity to Western Road.

At this point the BOPRC 2007 modelling was still relevant, especially for the upstream flood levels along Pioneer Road. The level from the BOPRC report (Figure 9) shows a level with freeboard of 287.20 mRL around Lot 32 whereas the MTEC calculations provide a minimum floor level of 286.75 mRL (including 200 mm freeboard) at this location. As previously mentioned, the BOPRC level should have been considered as an absolute minimum as it was likely that the subdivision earthworks had probably increased flood levels due to subdivision earthworks raising the pre-development ground level at the eastern boundary.

It appeared from correspondence provided to The Panel by RLC that MTEC continued to provide minimum floor levels throughout the development of the PPTS, including in November 2009 when MTEC provided a minimum floor level for Lot 75 (29 Oakland Place) based on their calculated 100-year flood level of 285.85 mRL + 200 mm to give a finished floor level of 286.05 mRL.

[128] MTEC, personal communication 4 March 2009.

Overall the setting of minimum floor levels relied on the deficient design of the overland flow path and the stormwater network, most notably the lack of consideration for the updated design flow of up to 15 m^3/s and the inadequate consideration of the hydraulics from the subdivision to the ultimate outlet across Western Road. In addition to this, the minimum freeboard of 300 mm from the RLC Engineering Code of Practice has not been applied to the calculated flood levels.

5.5.2 Performance of Minimum Floor Levels during 29 April 2018 Flood Event

The minimum floor levels determined for the PPTS were not adequate to avoid inundation in a 100-year flood and 22 dwellings were significantly affected and subsequently issued with insanitary notices. The peak flood levels (as surveyed by BOPRC) are shown in Figure 47 along with typical minimum floor levels advised near where the flood levels were measured.

Figure 47: Figure Surveyed peak flood levels PPST April 2018 flood event (Source – BOPRC)

The worst affected area was at the eastern end of Oakland Place with the April 2018 flood level being 1.3 m higher than the recommended minimum floor level. At the western end of Oakland Place the difference has reduced to 650 mm but this is still enough to cause substantial damage within a dwelling. Further upstream at Pioneer Road the difference is 350 mm, but again this depth of inundation will still cause notable damage within a dwelling and was clearly sufficient for insanitary notice to be issued to four properties within this vicinity.

5.6 Current RLC Peer Review Process

As discussed throughout this section the lack of specialist expertise in the design and review of the overland flow path, stormwater network and setting of minimum floor levels was a significant contributing factor to the flooding that occurred within the PPTS. The Panel notes that it is best practice for RLC to seek independent peer review on technical matters that are outside the areas of expertise of the RLC engineers. Whether this was standard practice in 2005/2006 at the time of the PPTS application is beyond the scope of the Panel to comment on. Based on the two technical Panel members current work across New Zealand it is considered that independent engineering peer review is now reasonably common practice in Councils throughout the country.

It is with this context that the Panel has considered what the current RLC practices are with regard to external peer review and whether this is adequate to reduce the likelihood of engineering design

errors being missed at the consenting phase of similar subdivision proposals. RLC provided the Panel with the below information regarding its current land development engineering practice:

"Current Land Development Engineering Practice (addressing engineering proposals)

The Land Development team is now located within the Infrastructure Group. The Group includes engineering personnel managing the Transport, 3 waters and Waste services (about 50 staff).

When Land Development proposals are received the Land Development Team assess the proposal, its complexity and risks. Where inquiries of technical nature arise that can be assessed internally through our Infrastructure Group personnel skill set these are discussed and a collective engineering view is arrived at. Where the proposal contains complicated and/or special engineering features where specialist assessment is required the Land Development Team resorts to specialist advice from our panel of external consultants. These are;

1. ***PDP** – Generally for 3 Waters matters/proposals*
2. ***T&T** – Generally for Geotech and Geohazard matters*
3. ***OPUS** – Generally for Transport matters.*

The specialist advice is further considered in engineering team for a in Infrastructure and a response to development proposals is then formulated that forms the various proposal engineering conditions."

The Panel considers that the above practice is reasonable and adequate in terms of managing the risk of engineering errors not being picked up in the consenting phase of future subdivision and land development projects.

5.7 Pioneer Property Trust Subdivision Conclusions

In light of the matters discussed in section 5.1 to 5.6, the Panel has reached the following conclusions –

- There were potential conflicts of interest (or at least perceptions of such) associated with the Pioneer Property Trust subdivision application. The Panel found no evidence that these potential conflicts of interest contributed to the flooding that occurred on 29 April 2018;
- There were deficiencies in the design of the overland flow path, stormwater network and the setting of minimum floor levels at the consenting stage of the Pioneer Property Trust subdivision
- Further information provided by BOPRC in June 2007, prior to issue of 223 and 224 certificates by RLC, escalated the deficiencies in the design such that it was unlikely that the overland flow path and stormwater infrastructure would perform to the required design standards. In addition, that the minimum floor levels would not be adequate to avoid the inundation of dwellings;
- An assessment of the ability of RLC to review and change resource consent conditions under s128(1)(c) of the RMA is beyond the scope of this review, but there were clearly significant differences between the BOPRC information provided in 2007 and the MTEC design provided as part of the approved resource consent;
- The deficiencies in the design were evidenced by the inundation of 22 dwellings in the Pioneer Property Trust subdivision during the April 2018 flood event.
- The RLC practices and policies regarding conflicts of interest and technical review of engineering designs have progressed in the 12 years since the Pioneer Property Trust subdivision application process and are now considered adequate for managing the risk of design errors being missed through the subdivision application process.

5.8 Pioneer Property Trust Subdivision Recommendations

- The Panel recommends that a comprehensive flood risk assessment is undertaken in the early stages of substantial new developments by suitably experienced and qualified professionals, and peer reviewed. If high levels of flood risk are identified, then development should be avoided consistent with the national policy direction. If low levels of flood risk are identified that can be managed by setting minimum floor levels without reliance on new structural measures, then development may be considered.

6 Future Flood Risk Management Options

The purpose of this section is to discuss specific measures that RLC, BOPRC, stakeholders and the community can consider in managing the risk and effects of future flood events. While the Panel has undertaken significant research and analysis in preparing this report all options will require significant work to determine their feasibility, effectiveness and cost. Both BOPRC and RLC have confirmed to the Panel that they are currently working together to develop options for reducing flood risk in Ngongotahā and a brief summary of the current actions arising from this work is included below.

6.1 Improvements in Flood Risk Management Processes

Improvements in flood risk management are addressed under specific topics of stream maintenance, structural measures, planning controls and emergency management recognising that all of these elements need to work cohesively together to provide an effective solution. The Panel urges the councils to continue working together and consult with the community and stakeholders to develop and agree on a comprehensive long-term floodplain management plan. Implementation of that plan will be key to reducing the risk of a future weather event, similar to that on 29 April 2018, from having the same devastating impact.

6.2 Stream Maintenance Works

It is considered that significant opportunities for reducing flood risk, improving cultural values, creating habitat and opening up recreational opportunities exist within the stream maintenance category.

Firstly, capacity and bank stability improvements could be considered to reduce flood levels and to reduce sediment inputs from bank erosion. These works could include flattening bank slopes, which in many places are vertical, to 2-3:1 (H: V) to provide increased capacity and the opportunity for planting stabilising grasses on the lower banks and larger native trees and shrubs on the upper banks.

In conjunction with channel enlargement works, a comprehensive plan to manage vegetation in the channel and on the surrounding floodways/berms would also provide value. It is noted that there is a mixture of landownership and responsibilities to consider and that a clear understanding of standards and proactive monitoring and maintenance could provide improvements in flood capacity. It is suggested that obvious obstructions such as derelict structures and large trees growing in the channel should be removed.

In terms of adding value to habitat and the wider community when considering stream maintenance, the inclusion of walking/cycle paths could be considered in terms of managing the RLC reserves adjacent to the channel. There are already some areas where paths exist, but these could certainly be improved with better surfacing, vegetation clearance and inclusion of small pedestrian bridges to provide loop track options.

In addition to improving recreational access consideration could also be given to wetland areas. These may be purely for amenity or habitat value or could potentially include some urban stormwater treatment elements. This would be particularly so for wetlands or detentions areas within the PPTS development area or the adjacent undeveloped property to north of Western Road near Elliot Park. This is discussed further in terms of structural stormwater network solutions below.

6.3 Structural Works

Depending on the reduction in flood levels that can be achieved with a comprehensive channel management plan there may still be the need to consider structural works such as flood overflow channels and, as a last resort, stopbanks including potentially retrofitting or raising the existing stopbanks downstream of Ngongotahā Road.

The benefits of a flood overflow channel within the Agrodome land to divert a portion of flow away from the Brake Road overflow area would appear to be an option worthy of consideration. This of course would have to be in conjunction with consideration of the upgrades required to the downstream channel and stopbanks to mitigate the effects of the increased flows within the main channel. Figure 48 below provides an indicative arrangement for further consideration.

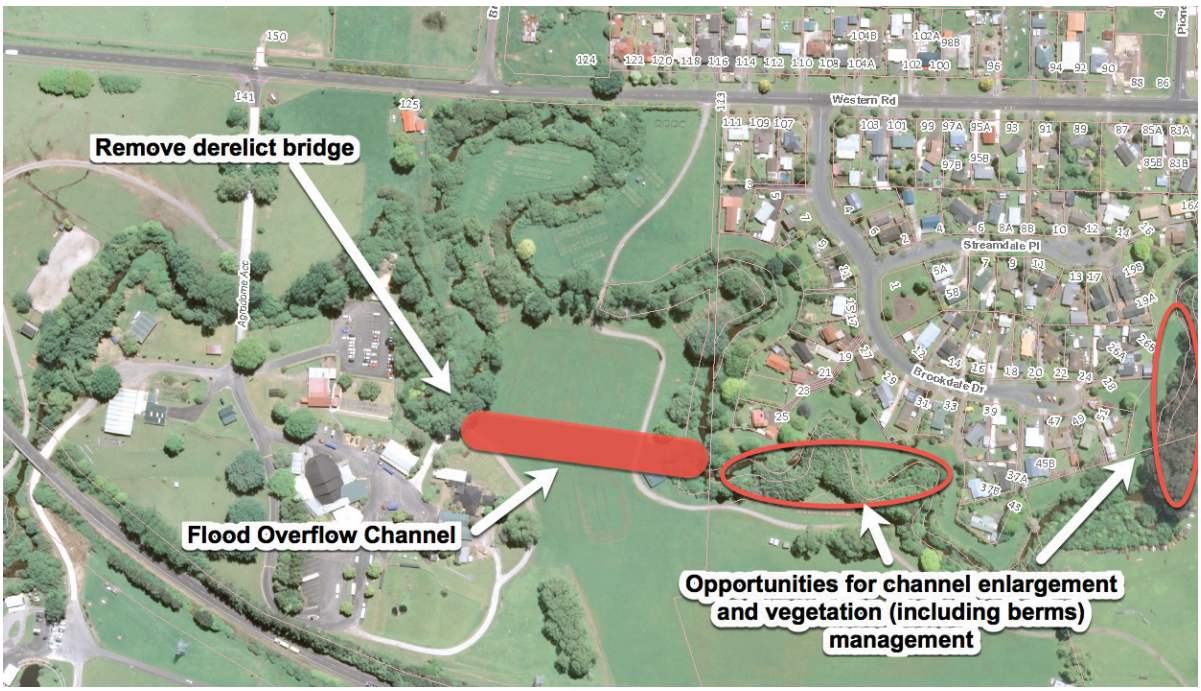


Figure 48: Structural works for consideration around Agrodome/Brake Road/Brookdale Drive

In terms of the stormwater infrastructure within the PPTS development it could be possible to retrofit the overland flow path and stormwater network to provide improved performance. This could be done in conjunction with works to reduce the incoming flows from the Ngongotahā Stream overflow at Brake Road and the extension of a defined overflow path around the existing Western Road properties.

As a minimum the structural elements could include –

- non-return valves on the stormwater outlets;
- improvements to the overflow path between Oakland Place and Western Road;
- reinstating the open drains on Everard Developments land to the east of the PPTS subdivision;
- one or more wetland areas;
- a dedicated overland flow path through the PPTS subdivision;
- stormwater pump station;
- culverts under Pioneer Road for the overland flow path;
- extension of the flow path to reduce inundation of Western Road properties.

Outline sketches of these elements are provided in Figure 49 & Figure 50. A thorough hydraulic design and assessment would need to be undertaken to determine the feasibility of these design elements and whether they could provide the required reductions in flood levels at a reasonable cost to the beneficiaries.

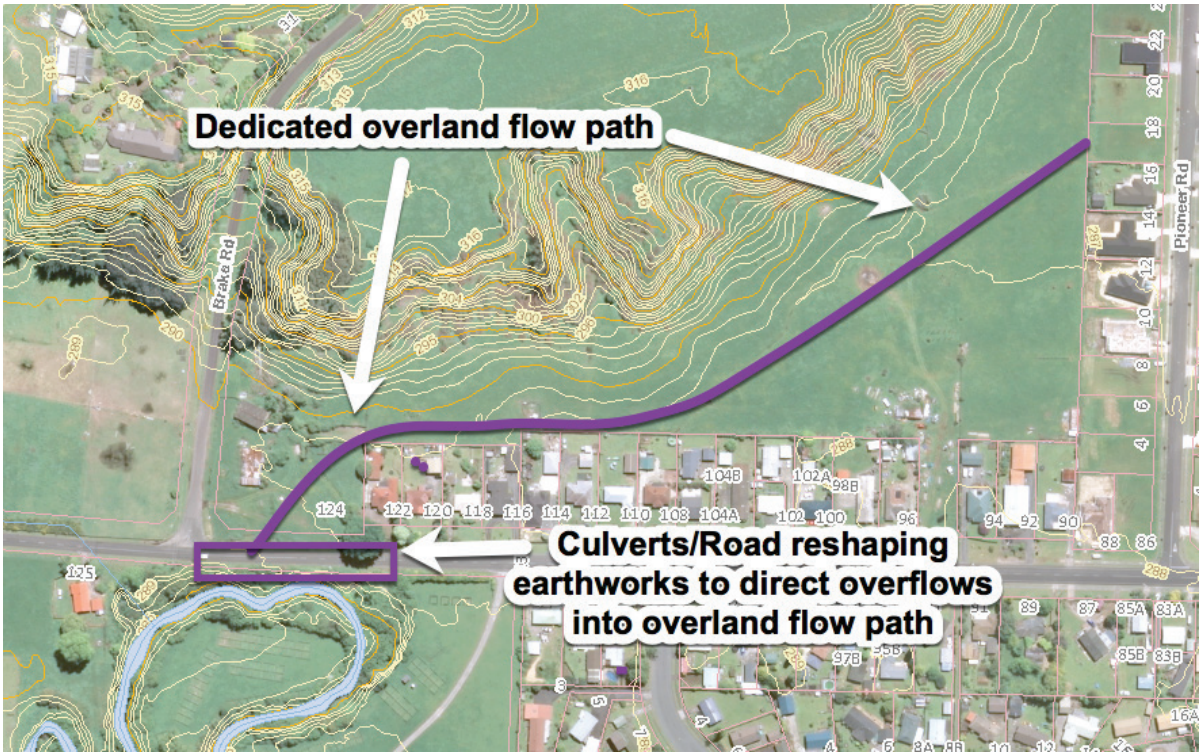


Figure 49: Possible dedicated overland flow path around existing Western Road properties and control/structure works interface with Ngongotahā Stream.

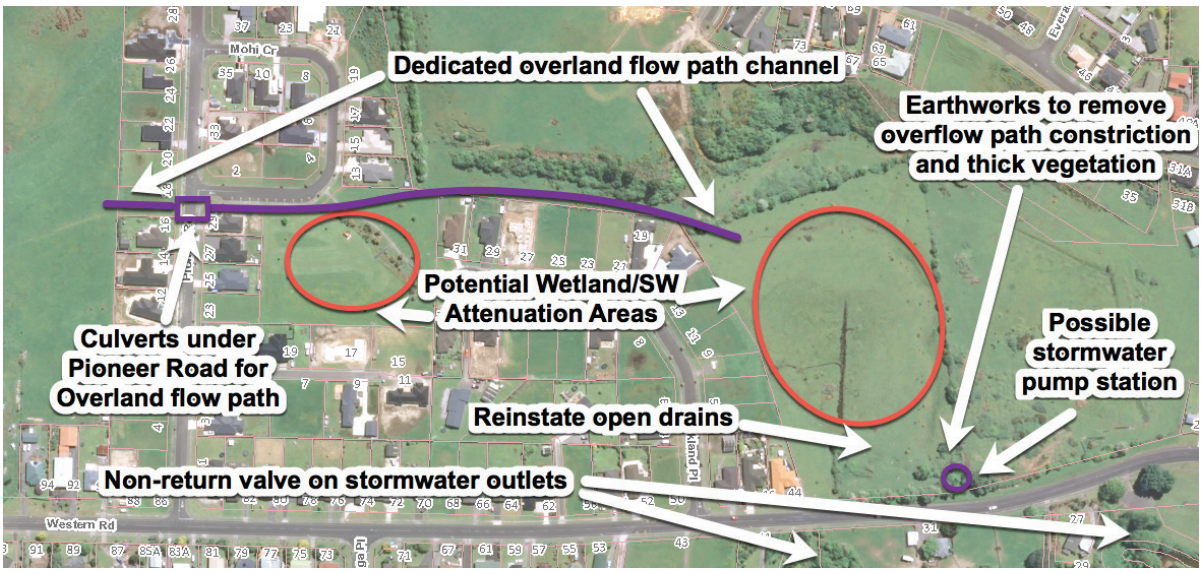


Figure 50: Possible structural works to improve performance of PPTS stormwater infrastructure

6.4 Planning Controls

Several recommendations regarding the RLC District Plan and Engineering Code of Practice are provided in Section 4 of this report. As with the stream maintenance and structural options described above, any changes to planning controls will take some time to implement and will only generally contribute to future flood risk reduction by not allowing development in areas subject to a high flood risk (or by reducing that risk to a low level), and seeking effective mitigation in areas where it is possible to manage low levels of flood risk.

The first step in achieving effective planning controls is about understanding where flood risk exists and the hazard that it presents. The Regional Policy Statement lays out the responsibility for flood hazard mapping with the RLC responsible for areas serviced by reticulated stormwater and BOPRC

for areas outside this. There will clearly be some overlap in these responsibilities with some smaller urban areas generating no flood hazard from their internal stormwater catchments, but possibly being affected by overflows from the larger river and stream systems.

This is certainly the case in Ngongotahā with there clearly being some issues with the stormwater network, but with the major issue being overflows from Ngongotahā Stream. It is acknowledged that BOPRC undertook modelling and mapping of the stream system and flood overflows in 2005-2007 and RLC is currently undertaking a modelling project to understand flood risk and options for reducing flood risk in the PPTS development area.

In terms of setting minimum floor levels in Oakland Place and Pioneer Road it is understood that RLC are currently seeking advice from BOPRC based on the observations during the April 2018 flood event as well as their existing (2007) hydraulic model. These levels are generally substantially higher than the previously recommended minimum flood levels for this area.

The Panel also noted that there was some inconsistency in how minimum floor levels were verified on site during construction as part of the building consent process. In some instances, Registered Surveyors were being used but in other instances building inspectors were using builder's levels (laser and dumpy) with datum's based on nearby manhole heights.

The accuracy in verifying minimum floor levels is critically important and it is recommended that all dwellings requiring a minimum floor level have that level established and certified by a Registered Surveyor. The Panel is aware of other local authorities who require the Registered Surveyor to certify the level of foundation boxing or piles before any concrete is poured.

As highlighted in Section 4 of our report, it is important that the current review of the RLC Engineering Code of Practice is completed without further delay.

Clearly there is work still to be done in developing comprehensive flood hazard information across the Rotorua District and having District Plan objectives, policies and rules that effectively manage the hazard supported by an up to date Engineering Code of Practice. Where substantial new developments are proposed it is recommended that a comprehensive flood risk assessment is undertaken in the early stages by suitably experienced and qualified professionals which is peer reviewed by equally experienced and qualified independent specialists. If high levels of flood risk are identified, then avoidance is recommended as best practice and consistent with national policy direction. If low levels of flood risk are identified that can be readily managed with minimum floor levels without reliance of new structural measures, especially stopbanks, then development may be appropriate.

6.5 Emergency Management

It is likely that it will take some time to develop and agree on the stream maintenance and structural solutions to reduce the level of flood risk in the lower Ngongotahā Catchment. In the meantime, planned emergency management actions can be considered to reduce the consequences of flooding. It is noted that BOPRC has recently installed a rain gauge within the mid Ngongotahā catchment to provide some advanced warning of flood events. With approximate rainfall based, triggers established, it will be possible to provide advanced warning, particularly of larger events where overflows at Brake Road and Brookdale Drive may occur. Rainfall forecasting information could also be used to allow initial alerts to be raised for the possibility of flooding.

A flood alert and warning system will allow more time for evacuations to take place prior to flood waters arriving, especially on Western Road, Pioneer Road, Brookdale Drive and Oakland Place. The community also now has a greater awareness of the areas most affected by floodwaters and can make their dwellings and belongings more resilient to flooding. There are a number of flood proofing products available for the protection of dwellings including waterproof doors, windows, and membranes and small scale, pumping solutions that property owners may wish to consider and that

RLC may wish to consider funding options given the issues we have identified with the design and consenting of the PPTS subdivision.

The possible deployment of portable flood pumps, especially in Oakland Place may also offer some reduction in flood levels in this area combined with sandbags to reduce inflows from Ngongotahā Stream. Sandbags could also be considered as an option around the overflow point in Brookdale Drive. It is suggested that care is exercised when considering the deployment of sandbags in that it might simply move the point of failure to the next lowest point in the system. For this reason, it is suggested that temporary sandbagged walls should be limited in height and be considered for the purpose of reducing overflows, especially for smaller flood events, rather than preventing them altogether.

6.6 Current/Ongoing Work by RLC and BOPRC

RLC provided the Panel with minutes of a meeting held on 6 August 2018 between engineers and managers from both RLC and BOPRC where principles of the desired outcome with regard to improving the flood hazard management for the Ngongotahā community were identified along with a wide ranging, discussion of options.

The principles of the desired outcome discussed during the meeting were as follows –

- Convey 1% AEP (100 year flood) past housing area and discharge into Lake Rotorua;
- Allowance for climate change;
- Take an adaptive approach if feasible.

The meeting included discussion of the following options for achieving these objectives –

- Raise Western Rd;
- Construct a stopbank opposite Brake Rd;
- Construct an overflow channel to the north;
- Construct an overflow channel to the south;
- Upper catchment detention;
- Raise houses;
- Side spilling into ponding areas upstream;
- Reduce stream roughness;
- Retreat;
- Create ecological corridors;
- Land use change;
- Stream straightening.

The actions arising were directed to BOPRC for updating the design hydrology for the catchment along with extending and updating the hydraulic model to assess the viability of the above options.

In addition to these actions BOPRC provided the Panel with the following list of actions including some immediate operational measures that have already been completed.

Table 4: Actions that have been taken following the 29 April Flood Event (Source: BOPRC)

ACTION	WHO	STATUS
Identify all flood repairs, vegetation clearing and obstruction clearance	BOPRC	Completed
Carry out urgent flood repairs, vegetation and obstruction clearances	BOPRC	Completed urgent rock works at Parawai Marae Cleared debris build up from, and significant desilting beneath, the railway bridge
Appoint a dedicated and experienced works foreman to supervise and manage repair works and proactive maintenance programme for Ngongotahā and other Upper Kaituna streams	BOPRC	Completed Appointed Daniel Batten
Carry out urgent vegetation clearing at multiple locations	BOPRC	Completed
Include specific additional funding for flood repair works in the scheme streams for Rotorua area ($250,000 per year for FY2018/19 and FY2019/20)	BOPRC	Completed
Hold a public open day for planting (1500 plants) and working closely with the Ngongotahā Stream care group to coordinate works and planting	BOPRC, RLC & other stakeholders	Completed
Stockpile of rock at Ngongotahā to commence rock repair works when ground conditions improved, and landowner agreements obtained	BOPRC	Commenced stockpiling Ready to commence repair works, engagement with landowners underway
Investigate floodway improvement options identified by the Review Panel	BOPRC	Underway, noting some options are straight forward whilst other options will need further investigation to confirm benefits
Preparation of a Comprehensive Stream Management Plan for Ngongotahā Stream (as an interim measure due to timeframe and process to develop a broader strategy for the floodplain)	BOPRC, RLC & other stakeholders	Scoping framework for stream management plan Note this plan likely to become part of an overarching Floodplain Management Strategy (FMS) as suggested by the Review Panel

6.7 Flood Risk Management Recommendations

The Panel acknowledges the work already underway by RLC and BOPRC and recommends the following to assist in improving flood risk management for the Ngongotahā catchment:

Overall Flood Risk Management

- A comprehensive flood risk management plan is developed, actioned and monitored for the Ngongotahā catchment through collaboration between BOPRC, RLC, Iwi, stakeholders and the community.. The New Zealand standard NZS9401:2008 Managing Flood Risk – A Process Standard provides a useful framework for the development of the flood risk management plan;
- The comprehensive flood risk management plan considers the extension of the 100-year flood protection area provided by the Upper Kaituna Scheme to include the residential areas upstream of Ngongotahā Road;
- The comprehensive flood risk management plan considers a range of flood events, including events larger than design standard of any flood protection structural works.
- Urgency is given to the design and implementation of measures that will improve the outcome for those in the high flood risk areas most affected by the 29 April 2018 floods;
- The comprehensive flood risk management plan utilises all four categories of flood risk management tools. Agreed stream maintenance and flood control standards, and each council's role and responsibility for monitoring and managing the various elements of the plan, are clearly documented;

Stream/ River Maintenance

- As part of the comprehensive flood risk management plan, a detailed plan for maintenance of Ngongotahā Stream is developed. This should include consideration of enlarging the channel to reduce flood levels along with flattening stream banks to reduce erosion and allow for appropriate planting and management of the existing vegetation;
- The Ngongotahā Stream maintenance plan should set out a clear understanding of who is responsible for managing the main stream channel as well as the berms where flood waters flow. This will include areas of RLC reserve and private property adjacent to the stream channel;
- Careful consideration be given to the development of the Ngongotahā Stream maintenance plan to ensure a functional stream system is provided that recognises cultural, ecological, recreational values and opportunities;

Structural Works

- Additional structural flood protection works are considered, particularly to reduce the flood risk to residential properties to the north of Western Road. These works could include the construction of new channels, wetlands (flood detention), culverts/bridges, pump stations and stopbanks;
- The effects of both the proposed stream maintenance works and the new structural works are assessed in terms of the capacity of the existing flood protection structures (stopbanks) downstream of Ngongotahā Road. Improvements to the existing structures may also be required;

Emergency Management

- An emergency management plan is urgently developed, in conjunction with the community, that includes clearly understood and communicated trigger levels for flood warnings and evacuations. In addition to flood warnings the planned deployment of flood pumps and sandbags is considered in order to reduce flood damage;
- RLC and BOPRC encourage affected parts of the community to take action to make their dwellings and belongings more resilient to flooding.

7 Conclusions

This section provides a summary of the high-level conclusions contained in the Report. The Panel urges readers to read the body of the report to allow consideration of the conclusions in context.

A sub-tropical weather system brought deep tropical moisture to the upper North Island with over 180 mm of rain falling on Rotorua in three hours on the morning of 29 April 2018. Although this rainfall was not centred on the Ngongotahā catchment there was still significant rainfall which resulted in a 100-year flood event in the Ngongotahā Stream, being the largest since records began in 1976.

The Ngongotahā Stream overflowed its banks at several locations near Brake Road, which resulted in twelve dwellings on Western Road, four dwellings on Brookdale Drive and 22 dwellings within the Pioneer Property Trust Development being inundated by the flood event. These 38 dwellings were subsequently issued with insanitary notices. Numerous other residential properties (gardens, yards etc) and commercial operations were also affected by the event. The Panel's engagement with the Ngongotahā community highlighted the significant distress, disruption and financial loss suffered by that community.

The main circumstances and contributing factors which led to the flooding were:

- This was a large flood event with approximately a 100-year return period. It would be expected that a flood of this magnitude would significantly test infrastructure designed to a 100-year return period standard. In areas without a 100-year design standard of flood management it would be reasonably expected that there would be flood inundation and erosion damage; (Section 2.2.)

- The Ngongotahā Stream upstream of Ngongotahā Road was not managed to any particular design standard. Floodwaters spilled out of the stream banks and inundated houses where it had been generally identified that it would do so by BOPRC in 2005 – 2007. Despite requests from RLC to extend the 100-year design standard to this upstream area BOPRC elected not to (Section 4.3);

- The stormwater infrastructure within the PPTS subdivision did not perform to the required 100-year design standard. Errors in the design were not identified in the subdivision consenting phase by RLC. Further information provided by BOPRC post-consent was significantly different to that provided in the consent application documents. Receipt of this new information did not result in RLC changing any of the subdivision consent conditions (Section 5).

Both RLC and BOPRC have responsibilities for the avoidance and mitigation of natural hazards as a core service to be considered in their roles under Section 11(a) of the Local Government Act 2002 and Sections 30 and 31 of the Resource Management Act 1991 furthermore it is a BOPRC function under Section 126 (1) of the Soil Conservation and River Control Act 1941 to minimise and prevent damage within its district by floods and erosion (Section 4.2).

However in terms of land use planning, within urban areas it is the role of the Rotorua Lakes Council to map floodable areas and impose land use rules to avoid or mitigate those flooding risks. The Rotorua District Plan does not have a specific chapter (or Part) dealing with natural hazards. Grouping natural hazard matters (and in this case flooding matters) in a single chapter of the RDP would assist with focusing both the Council and consent applicants on those matters in the future. The RDP does not contain any flood hazard maps for rivers and streams and nor does it identify areas having a High or Low risk of flooding. In that regard the RDP does not appear to give effect to the RPS natural hazard provisions for flooding. (Section 4.6)

The report outlines several Flood Risk Management options that can be implemented, covering stream maintenance, structural measures, planning controls and emergency management. All elements need to work cohesively together to provide an effective solution. While the Panel has undertaken significant research and analysis all options will require significant work to determine their feasibility, effectiveness and cost. Both BOPRC and RLC have confirmed with the Panel that they are currently working together to develop options for reducing flood risk in Ngongotahā. The Panel urges the councils to continue working together and consult with the community and stakeholders to develop and agree on a comprehensive long-term floodplain management plan for the Ngongotahā catchment and other catchments in the Rotorua District (Section 6).

In Section 8 the Panel summarises the recommendations on measures to prevent or minimise the risk and effects of future flood events.

8 Recommendations

In earlier sections of this report there are recommendations presented which are collated by topic below.

8.1 Roles and Responsibilities Recommendations (Section 4.2)

1. BOPRC ensure they are fulfilling their discretionary advisory and operational function to minimise and prevent damage by floods and erosion, especially with regard to areas where new residential development is proposed;

2. Bay of Plenty Regional Council and Rotorua Lakes Council ensure they are fulfilling their requirements to meet the current and future needs of communities by providing and planning for good quality local flood control and stormwater infrastructure in their Long Term Plans and Annual Plans;

3. Bay of Plenty Regional Council and Rotorua Lakes Council work collaboratively with each other and the Ngongotahā community and iwi to improve inter-council and public relationships and communication channels.

4. Bay of Plenty Regional Council and Rotorua Lakes Council revisit existing understandings and informal agreements regarding management roles and responsibilities for maintenance of the full length of the Ngongotahā Stream and document these in a formal and binding Memorandum of Understanding.

5. The agreed management roles and responsibilities are documented in an easy to understand format which is then distributed to residents and explained to 'front line' council staff;

6. Front line council staff to receive additional training on how to take calls from concerned residents and the proper procedure for recording and responding to those calls, based on the agreed Memorandum of Understanding.

8.2 Design Standard Recommendation (Section 4.3)

7. The flood management design standard (level of service) for Ngongotahā Stream be considered and determined as part of the options for reducing flood risk to the Ngongotahā community.

8.3 Process Matter Recommendation (Section 5)

8. A comprehensive flood risk assessment is undertaken in the early stages of substantial new developments by suitably experienced and qualified professionals, and peer reviewed. If high levels of flood risk are identified, then development should be avoided consistent with the national policy direction. If low levels of flood risk are identified that can be managed by setting minimum floor levels without reliance on new structural measures, then development may be considered.

8.4 Flood Risk Management Recommendations (Section 4 and 6)

The Panel acknowledges the work already underway by the Bay of Plenty Regional Council and Rotorua Lakes Council and makes the following recommendations to assist in improving flood risk management for the Ngongotahā catchment.

8.4.1 Overall Flood Risk Management

9. A comprehensive flood risk management plan is developed, actioned and monitored for the Ngongotahā catchment through collaboration between Bay of Plenty Regional Council, Rotorua Lakes Council, Iwi, stakeholders and the community. The New Zealand standard NZS9401:2008 Managing Flood Risk – A Process Standard provides a useful framework for the development of the flood risk management plan;

10. The comprehensive flood risk management plan considers the extension of the 100-year flood protection area provided by the Upper Kaituna Scheme to include the residential areas upstream of Ngongotahā Road;

11. The comprehensive flood risk management plan considers a range of flood events, including events larger than the design standard of any flood protection structural works.

12. Urgency is given to the design and implementation of measures that will improve the outcome for those in the high flood risk areas most affected by the 29 April 2018 floods;

13. The comprehensive flood risk management plan utilises all four categories of flood risk management tools. Agreed stream maintenance and flood control standards, and each council's role and responsibility for monitoring and managing and funding the various elements of the plan, are clearly documented.

8.4.2 Stream/River Maintenance

14. As part of the comprehensive flood risk management plan, a detailed plan for maintenance of Ngongotahā Stream is developed. This should include consideration of enlarging the channel to reduce flood levels along with flattening stream banks to reduce erosion and allow for appropriate planting and management of the existing vegetation;

15. The Ngongotahā Stream maintenance plan should set out a clear understanding of who is responsible for managing the main stream channel as well as the berms where flood waters flow. This will include areas of RLC reserve and private property adjacent to the stream channel;

16. Careful consideration be given to the development of the Ngongotahā Stream maintenance plan to ensure a functional stream system is provided that recognises cultural, ecological, recreational values and opportunities.

8.4.3 Structural Works

17. Additional structural flood protection works are considered, particularly to reduce the flood risk to residential properties to the north of Western Road. These works could include the construction of new channels, wetlands (flood detention), culverts/bridges, pump stations and stopbanks;

18. The effects of both the proposed stream maintenance works and the new structural works are assessed in terms of the capacity of the existing flood protection structures (stopbanks) downstream of Ngongotahā Road. Improvements to the existing structures may also be required.

8.4.4 Planning Controls

19. The Rotorua District Plan provisions relating to the urban area within the Ngongotahā catchment are reviewed to -

    a) give effect to the Regional Policy Statement natural hazard provisions;

b) include flood hazard maps of the 100-year event climate change adjusted Ngongotahā Stream flood event (inclusive of a 500mm freeboard) and maps of High[129] and Low[130] Risk floodable areas;[131]

c) set clear and consistent flood avoidance standards for new buildings (as well as additions to existing buildings and replacement buildings);

d) ensure that the Rotorua District Plan's flood risk provisions in the Residential 1 Zone, subdivision and earthworks chapters are internally consistent.

20. The Rotorua District Plan is examined to determine if similar amendments are required for urban areas outside of the Ngongotahā catchment or for rurally zone areas.

21. The current review of Rotorua Lakes Council Engineering Code of Practice is completed without further delay and flood hazards are addressed in a single section in the Code

8.4.5 Emergency Management

22. An emergency management plan is urgently developed, in conjunction with the community, that includes clearly understood and communicated trigger levels for flood warnings and evacuations. In addition to flood warnings the planned deployment of flood pumps and sandbags is considered in order to reduce flood damage;

23. Rotorua Lakes Council and Bay of Plenty Regional Council encourage affected parts of the community to act to make their dwellings and belongings more resilient to flooding.

8.4.6 Flood Risk Management in the District

24. Consideration is given to developing and actioning a comprehensive flood risk management plan for other catchments in the District.

[129] For example, in the document titled Flow Hazard Regimes for People Chapter 7, Book 6 Australian Rainfall Run-off Guidelines, in Table 6.7.1 high risk is defined in terms of depth x velocity > 0.6 m^2/s or depth > 1.2 m or velocity > 3 m/s which is defined as "Extreme Hazard" for children and "Moderate Hazard" for Adults.

[130] Ibid, Low Risk is defined in terms of depth x velocity < 0.6 m^2/s and depth < 1.2 m and velocity < 3 m/s which is defined as "Low Hazard" for Adults.

[131] See section 4.6.6 of this review which highlights that the RLC Code of Practice specifies a 1% AEP flood and a 300mm freeboard.

Appendix 1 Details of Panel members

Judith Stanway

- Professional businesswoman and consultant with extensive experience in
- both the corporate and not-for-profit sectors including charities and Maori trusts;
- Fellow of Chartered Accountants Australia and New Zealand and a Fellow of the Institute of Directors; Former managing partner of BDO Rotorua Ltd, Chartered Accountants and
- Advisors;
- Has lectured across the North Island at various Universities and
- Polytechnics;
- Former Chair and board member of BDO New Zealand, Lakeland Health
- Former/current Board member of several Boards including Charities Commission, Scion, Lakeland Health, Te Puia; Tauranga Art Gallery

Te Ururoa Flavell

- Consultant and politics lecturer/course assessor at Victoria and Waikato universities;
- Former Maori Party co-leader, Waiariki MP, Associate Minister Economic Development and Minister of Maori Development and Whanau Ora;
- Former member of Parliamentary Services Commission committee and select committees for Maori affairs, education and science, business, commerce, standing orders, privileges, officers of parliament.

Rob van Voorthuysen

- Director of Van Voorthuysen Environmental Ltd consultancy with 31 years' experience in environmental and resource management, policy analysis and senior corporate management in the central and local government sectors;
- Formerly on staff at Hawkes Bay Regional Council, Environment Waikato, Department of Conservation and Ministry of Works and Development.

Kyle Christensen

- Water resources engineer and consultant with 18 years' experience in river and stormwater engineering;
- Practice assessor for Engineering New Zealand and immediate past chair of Engineering New Zealand/Water NZ Rivers Group;
- Expert technical advisor for formal determination processes relating to flood hazard mitigation requirements under the Building Act;
- Expert engineer on 2017 Rangitaiki River Scheme Review Panel.

Appendix 2 Review Terms of Reference

Review Terms of Reference

Ngongotaha Flood Event

Background

An unprecedented level of rainfall (165 millimetres: 1.5 times the April normal in 36 hours) during the weekend 28-29 April 2018 caused the Ngongotaha Stream to overflow its banks causing widespread flooding in the Western Road area. Inundation of the sewerage system further exacerbated the situation through the direct contamination of flood waters.

These events triggered a Civil Defence Emergency and evacuation of approximately 85 homes and an adjacent tourism operation. Subsequently 328 homes across Rotorua and including 73 homes in Ngongotaha have since been inspected with 42 homes issued insanitary notices and now uninhabitable. These residents now face lengthy and costly rebuilds to enable them to return to their homes. There are others with partial notices issued.

This event and its effects have justifiably generated considerable concern about the level of risk to the wider community wellbeing.

Many Rotorua district residents were impacted by flooding during this period; however, the community impact in Ngongotaha stands out both in terms of the number of homes affected and the level of inundation experienced.

Current practice is for storm water infrastructure to be designed to cope with a 1 in 50 year event and for water courses within stop-banked urban river scheme areas to be designed to cope with a 1 in 100 year event. Whilst this has been seen as prudent approach in the past, climate change and the advent of more frequent extreme weather events raises a question as to the ongoing acceptability of this policy in the future. This is a serious issue and one which could have far reaching consequences for all Rotorua residents.

Purpose

The purpose of this work is to understand the circumstances and contributing factors which led to the flooding of the Ngongotaha subdivisions and to make recommendations to the Rotorua Lakes Council (RLC) and Bay of Plenty Regional Council (BOPRC) on measures which may prevent or minimise the risk and effects of future flood events.

It is also to provide clarity as to the various roles and responsibilities of RLC, BOPRC and landowners in relation to stormwater and waterbody management for future residential development.

Governance and Leadership

The RLC in conjunction with the BOPRC have c0-commissioned and approved the establishment of an independent and suitably qualified advisory panel for this work and are the approvers of this Terms of Reference.

The panel will be independently led by Judith Stanway and includes Te Ururoa Flavell, Rob van Voorthuysen and Kyle Christensen. This will ensure the review is impartial and objective.

The panel will be supported by senior Council staff - Stavros Michael (RLC) and Chris Ingle (BOPRC).

Scope

I. The review will primarily focus on the serious flooding which took place in the Ngongotaha area, however, it is expected that learnings relevant to others parts of the district will also be identified.

II.The advisory panel will consider Regional and District planning matters, engineering options, storm water, catchment management, mātauranga Māori, future land use and subdivision development considerations.

Exclusions

I.The effectiveness of the local and Group Civil Defence Emergency Management response.

II.The establishment and implementation of the recovery phase of the flood event.

Methodology

The panel will consider information provided by both Councils as well as undertaking community consultation to ensure a complete understanding of the event and pertinent contributing factors.

The panel will produce a report, which shall be made public, outlining key findings and making recommendations for future action to BOPRC and RLC.

Timeframe

There is a need to progress with some urgency, however, it is recognised the panel will require sufficient time to develop robust and valid findings. It is envisaged the work will start early June with a report being released by 1 September 2018.

Outcomes Sought

The panel will focus on the identification of potential improvements which may prevent and or minimise future flood events in the Ngongotaha catchment. In recommending potential improvements the panel will take into account the feasibility, cost effectiveness and funding alternatives of each option.

The applicability of any recommendations for other catchments in the Rotorua District will also be identified and incorporated into risk reduction planning.

Reference List

Acheson, A. R. (1968). *River control and drainage in New Zealand : and some comparisons with overseas practices.* Wellington: Ministry of Works.

Bay of Plenty Regional Council (2005). *Ngongotahā Hydraulic Model Potential for Spilling at Brake Road – Further Modelling.* Memorandum File Ref: 5600 05, 1370 63024, 2000 0452.

Bay of Plenty Regional Council (2006). *Hydraulic Modelling of the Ngongotahā Stream.* Bay of Plenty Regional Council Report May 2007.

Bay of Plenty Regional Council (2007). *Hydraulic Modelling of the Ngongotahā Stream Addendum I – Newly Available Aerial Survey Information.* Bay of Plenty Regional Council Report File Ref 200 04 52 27 April 2007.

Bay of Plenty Regional Council (2017). Consent Holder Annual Report – August 2017 Okere Gates (consent 65979) and Ohau Weir (consent 65980).

Bay of Plenty Regional Council (2018). Ngongotahā Flood Event 29 April 2018. Presentation to the Review Panel.

Bay of Plenty Regional Council (2018b). Design Flood Hydrology on Heavy Rainfall Event 29 April 2018. DRAFT Memorandum File Ref A2905939.

Ericksen, N. J. (1986). *Creating flood disasters? : New Zealand's need for a new approach to urban flood hazard.* National Water and Soil Conservation Authority by the Water and Soil Directorate, Ministry of Works and Development.

Greater Wellington Regional Council. (2015). *Guidelines for Floodplain Management Planning.* Greater Wellington Regional Council.

Hicks, D.M. & Mason, P.D. (1998). *Roughness Characteristics of New Zealand Rivers.* National Institute of Water and Atmospheric Research Ltd. Water Resources Publications, LLC.

Ministry for the Environment. (2010). *Preparing for future flooding: a guide for local government in New Zealand.* Ministry for the Environment.

New South Wales Government. (2005). *Floodplain Development Manual: the management of flood liable land.* New South Wales Government.

NIWA. (2018, April 29). Why all the heavy rain in New Zealand this weekend? [Twitter moment]. Retrieved from https://twitter.com/NiwaWeather/status/990519198488014849

Standards New Zealand. (2008). *NZS 9401:2008 Managing flood risk - A Process Standard*.