BEFORE the Hearings Commissioners
of the Queenstown Lakes District Council

RM100759 Rob Rosa

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	Of an application for a resource consent under the Resource Management Act 1991
BETWEEN	**WELLINGTON WATER LTD. ON BEHALF OF THE UPPER HUTT CITY COUNCIL** **Applicant**

STATEMENT OF EVIDENCE OF ROBERT JAMES HALL

THE 27 DAY OF July 2020

My full name is Robert James Hall. I am a Civil and Environmental Engineering consultant and I reside in Timaru. I am the sole director of R.J.Hall & Associates Ltd.

I have been engaged by Save Our Hills (inc) to assist them in their submissions in relation to the Wellington Water Ltd. – Upper Hutt City Council resource consent applications to which these procedings relate.

Qualifications and Experience

My relevant qualifications and experience are as follows Masters of Engineering (Natural Resources), Bachelor of Engineering (Civil), New Zealand Certificate in Engineering (Civil), Graduate Course in Surface Water Hydrology (University of NSW, Sydney, Australia), Member of Engineering New Zealand, Chartered Professional Engineer (Civil) Int PE (NZ) and a member of the NZ Society of Large Dams, NZ Hydrological Society and NZ Structural Engineers Society. I have 45 years experience in the area of water and soil engineering, 12 of which as a Director of R.J.Hall Civil and Environmental Engineering (Timaru). In October 2007 R.J.Hall Civil & Environmental Consulting Ltd. was purchased by GHD Ltd. who then employed me as a Civil and Environmental engineer and as manager of their Timaru office. My engagement with GHD Ltd terminated in early May 2011. At that point I established a new consultancy R.J.Hall & Associates Ltd.

Prior to establishing R.J.Hall Civil & Environmental Consulting Ltd I was employed by a number of catchment authorities in both the North and South Islands of New Zealand as a civil engineer. I was employed by the Canterbury Regional Council from its inception through to October 2005 when I resigned to establish R.J.Hall Civil & Environmental Consulting Ltd.. Whilst employed by the Canterbury Regional Council I held the roles variously of Principal Design Engineer and Hazards and Structures Engineer and Southern Area Office Manager.

1. A record of the engineering position I have are as follows

   Design Engineer (Hawke Bay Catchment Board and Regional Water Board), Chief Engineer (Waitaki Catchment Commission and Regional Water Board), Deputy Chief Engineer (Bay of Plenty Catchment Commission and Regional Water Board), Rivers and Drainage Engineer (Marlborough Catchment Board and Regional Water Board), Deputy Chief Engineer (South Canterbury Catchment Board and Regional Water Board) and Regional Design Engineer (Canterbury Regional Council).

   My responsibilities whilst employed by these various Authorities centred on the management of a wide range of river systems, the design of river protection and flood mitigation works (erosion control structures, detention dams, stopbanks), drainage systems (gravity and pumped), natural hazard assessments and flood plain mapping,(flooding, erosion, debris flow, rock slides), flood and low flow frequency analysis, assisting Territorial Authorities to develop natural hazards policies for District Plans, managing flood warning systems.

As a consultant I peer reviewed Opus Internationals report to Horizons on the 16 February 2004 floods. Collaborated with T.R. Davies (Natural Resources Engineering Lincoln University) on river related natural hazards at Franz Josef and with staff and elected members of West Coast Regional Council, and representatives from the Ministry of Emergency Management, Ministry for the Environment, Department of Conservation, NZTA and Westland District Council. I was engaged by the Fletcher , Dillingham, Ilbaua Consortium to develop flood warning and associated procedures for the Manapouri Power Station tailrace project. I was engaged by the MacKenzie District Council and subsequently Environment Canterbury to provide hydrological assessments in relation to the failure of the Opua Dam and to assist in the legal proceedings which arose from that failure. I provided the designs for the Mararoa River recovery project for the Southland District Council and provide flood mapping services and advice on flood management policies to jointly the Southland Regional Council and District Council. I provided engineering advice to the West Coast Regional Council in relation to the hydrology, and performance of the Grey River stopbank system at Greymouth and in relation to it's subsequent upgrades.

At present I have engagements with Environment Southland (river management issues on the Upokurora River,Te Anau), Otago Regional Council, river management issues, Clutha River at Albert Town and Environment Canterbury (peer reviewing internal flood hazard reports prepared by ECan for both the Waitaki District Council & Timaru District Council).

Code of Conduct

2. I have read, and agree to comply with, the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note 2006 in giving evidence to the Environment Court in this matter. All my evidence is within my expertise and I have considered and stated (where applicable) all material facts known to me which might alter or qualify the opinions I express.

3. I have no financial interest in the outcome of this hearing.

Ambit of Evidence

4. In my evidence, I will advise on

- An assessment I have made of the flood event that occurred on the Pinehaven Stream 8 December 2019 and in particular provide an estimate of the peak flow that occurred at the Chatsworth Rd. gauge site about 6.30 am that day in response to what is estimated to have had a two hour rainfall rain fall depth of some 53mm between 3 and 5 am that morning with an estimated two hour duration recurrence interval of 30 years, and

- A revised rating curve that I have developed for the Chatsworth Road gauge, and

- Footnote: Attached to and forming part of my evidence is a report to Save Our Hills (inc) in draft form, summarising the work I have undertaken at their request and the conclusions I have formed as a consequence of those investigations. It is intended that this work will form the basis of my contribution to the Expert Evidence conference set down for the week commencing Monday 27 July 2020. The final report will be available later this same week once the conferencing has taken place and any modifications which ae appropriate as consequence of the conferencing can be included.
- On the basis of the above using six empirical methods provide a series of flood frequency plots for the Pinehaven Stream at the Chatsworth Road gauge site, and
- Advise on a check method to assist in determining the efficacy of these six methods for the site and in the process rejecting one on the basis that it did not entirely satisfy the test criteria being employed, and
- Provide comment on the flood frequency curve (s) that have been developed for the Pinehaven Stream Catchment variously by the Greater Wellington Regional Council and their agents, MWH, SKM and Jacobs from 2008 to the present and which inform the flood plain mapping exercises that have been carries out and which form the design basis for the present resource consent applications.

From this I conclude that the flood frequency curves on which the presently proposed Pinehaven Stream upgrades are based and which previously provided a basis for the Upper Hutt City Council flood maps for the Pinehaven Catchment over estimate flood peaks and runoff volumes by a significant degree and should not be used as a basis for the current designs. This suggests that there is an immediate need not to proceed further with the consent application until such time as more appropriate flood frequency estimates are available and are adopted in order to more appropriately inform the proposed works in the Pinehaven Stream covered by the present resource consent application and to which these proceedings relate.

R.J.Hall

CMPENZ (Civil) CPeng Int PE (NZ)

ME (Nat Res.) BE (Civil) NZCE (Civil)

27 July 2020

Report: DRAFT 27 July 2020

Pinehaven Stream Flood 8 December 2019 at Chatsworth Road Gauge Site and Its Implications for Flood Frequency Estimates in The Catchment.

R.J.Hall

R,J.Hall & Associates Ltd.

27 July 2020

Peer Review:

G.Horrell, 27 July 2020

Contents:

A.I. McKerchar [Journal of Hydrology (NZ) 30 (2), 65 – 76].

f. Regional Flood Frequency Analysis for Small NZ Basins (1991) – Part 2. Flood Frequency Groups C.P. Pearson [Journal of Hydrology (NZ) 30 (2) 77 – 92]

g. Estimation of Mean Annual Floods in N.Z. (2019 G.A.Griffith & A.I.McKerchar [Journal of Hydrology (NZ) 51 (2) 111-120

h. A Method of Estimating Design Peak Discharges (Tech Publication 61) Planning & Technical Division, Water & Soil Division Ministry of Works (NZ).

i. G.Horrell (8 November 2018 Revised July 2020), " Assessment of Pinehaven Stream 23 July 2009 Flood Peak.

Acknowledgements

G.Horrell, Dr. G.Griffith, A.Ross, S.Pattinson, D. Longstaff

Preamble:

In the early hours of the morning 8 December 2019 a heavy rainstorm occurred In the Hutt River catchment resulting in an intense burst of some 53mm of rain falling on the Pinehaven Stream catchment between 3 am and 5 am. The duration of that rainfall matched the estimated time of concentration for the catchment as at the Chatsworth Rd. gauge site. The average annual recurrence interval for this events 53 mm in 2 hours is estimated from HIRDS V4 (Historic) at the Pinehaven Reserve to have been in the order of 30 years. As far as can be ascertained, the distribution of rainfall depths and resulting intensities were reasonably evenly distributed throughout the catchment.

This rainfall subsequently produced a significant flood event which resulted in flooding in Pinehaven. Flood profiles were surveyed in the vicinity of the Chatsworth gauge site [i.e. the Gauge], at the Dutch Reform Church footbridge weir [i.e. the Weir] some 3.6m downstream from the gauge. Information obtained from this survey work has enabled

1. estimates to be made of the peak flow that occurred around 6.30 am on the morning of 8 December 2019, and
2. enabled a revision to be made of the Greater Wellington Regional Council's rating curve for the Gauge, which previously had lacked a reliable high stage event or events., and
3. provided a basis on which to upgrade flood frequency relationships previously compiled (or reported) variously by the Greater Wellington Regional Council [GWRC] and MWH (2008, 2009) and Sinclair Knight Mertz [i.e SKM] (2010).

R.J.Hall & Associates Ltd. were engaged by Save Our Hills Upper Hutt Incorporated [SOH inc] to review the flood profile survey data that they had obtained from this event and use it to make the determinations identified in 1., through 3. above. This summary report is provided in response to that request.

Summary of Findings:

1.0 Flood Estimates - Chatsworth Rd, Gauge Site : 8 December 2020

An estimate of the peak flow over the Weir has been made based on first principles for critical flow conditions using the Euler Energy Equation and the methodology set out in F.M.Henderson (1966) " Open Channel Flow". Further to that an XL spreadsheet has been set up based on the cross section surveyed at the Gauge, again using the Euler Equation in order to relate the recoded Gauge height to the flow estimate obtained over the weir.

These calculations yield a peak flow in the order of **11.5 to 11.8** cumec for the 8 December 2019 flood event at the site. The maximum stage height for this event has been measured at **1510** mm on the Gauge.

2.0 Revised Rating Curve for the Pinehaven Stream at the Chatsworth Road Gauge Site.

A series of 11 gauging's have been undertaken are available for the Chatsworth Road site between 15 August 2008 and 30 August 2009. These gauging's have flows ranging from 876 l/s to 1685 l/s with gauge readings ranging from 408mm to 790mm. These gauging's are for all intents and purposes modest and well short of the likely mean annual flood. The GWRC rating curve provided to S.Pattinson [SOH] by GWRC dated 15 August 2008 includes a high stage value of 9104 l/s for a gauge height of 1600mm. It should be noted that this high stage value is simply an extrapolation of the gauging's previously undertaken at relatively modest flows and is not the result of actual measurement.
Accordingly, little confidence can be placed on the reliability of this particular rating curve.

The peak flow estimates made as part of this study have enabled an actual high stage discharge value and associated gauge height to be employed in order to obtain an improved rating curve for the site. It is opined that in the absence of an automatic water level recorder at this site the GWRC can use the methodology employed and described here to obtain further stage / discharge points in the future as flood events occur which will enable the revised rating to be further upgraded as information becomes available.

A significant flood event occurred in this catchment 23 July 2009 which had a gauge height recoding of 1577mm (GWRC). A stage reading of 1577 mm using the revised rating curve indicates a peak flow in the order of **12.5 cumec**. In the absence of measured flood depths over the Weir from this event it is not possible to directly check this result but based on the cross sectional geometry of the channel at the Gauge and estimate of the cross sectional area of the flow at the peak enables a uniform flow estimate to be made using the XL spreadsheet referred to in 1.0 above. This exercise yielded a peak flow of **13.0** cumec which given the uncertainties present is never-the-less reasonably consistent with the value derived from the revised rating curve. On that basis it is opined that the 23 July 2009 event would have peaked at between **12.5 and 13.0** cumec. A review of the Tasman Vaccine rain gauge record for this event in conjunction with that sites rainfall depth – duration – frequency estimates from NIWA HIRDS V4 (historic) data indicates that the rainfall recurrence interval for this event was in the order of 50 to 80 years depending on whether the critical duration of the 66.5mm of rainfall was 3 hours or 2 hours respectively.

3.0 Revised Flood Frequency Curve for the Chatsworth Road Gauge Site.

In order to assist in the design process and provided guidance on the likely frequency of occurrence of flood events it is customary to compile "at a site" flood frequency curves [FFC]. The most reliable FFC are those developed from hydrometric stations with long flow

records. In the absence of such records reliance has to be placed on empirical methods of which are many and varied. A critical requirement in either case is to ensure that the results obtained reflect reality. There are two broad tests that can be applied to assist this process

(a) Checking that the annual probability [AEP] of exceedance obtained for the flood peaks have reasonable parity with the annual exceedance of the rainfall event that gives rise to them recognising that they will not necessarily be the same, and

(b) Checking to see that the frequency with which out of channel flood spread predicted to occur from the FFC derived is consistent with what a knowledge of the capacity of channel being considered actually is and the typical frequency with which such flooding is known to have occurred historically.

[D.H.Pilgrim, I.Cordery; pers comm. *Graduate Course in Surface Hydrology University of NSW, Kensington, Australia (1979)*].

In the absence of such checks the reliability of the derived FFC can be very easily compromised leading unwittingly to either over design or under design with no ability to differentiate between either of such outcomes.

Given that the Pinehaven catchment at Chatsworth Road (or elsewhere for that matter) has an operational hydrometric station it is necessary to revert to empirical methods in order to obtain a workable FFC. To this end R.J.Hall & Associated Ltd. have used six different methods in order to develop a suitable FFC for the catchment at the Chatsworth Rd. Gauge site. These methods are

[A] Pinehaven FFC developed from the NIWA (2018) FFC for the Mangaroa River at Te Marua, using Rational Method runoff coefficient ratios obtained from both catchments and an area ratio raised to the power of 0.8, and

[B] Pinehaven FFC developed using " m " and " Qr " values derived from the Mangaroa River at Te Marua that were then modified using the Rational Method runoff coefficient

and area ratio relationship [Qm = 2.78E-3 x Cm x Ir x A], utilised in [A] above, and

[C] Pinehaven FFC using the MWH (2009) flood frequency estimates that were based on the McKerchar and Pearson (1989) procedure modified using the Rational Method runoff coefficient and area ratio relationship utilised in [A] above, and

[D] Pinehaven FFC using the McKerchar and Pearson (1989) procedure but using a mean annual flood value of 6.2 cumecs derived from both methods [A] and [B] above rather than that calculated from the mapped (Qma / A^0.8) and a q100 value set at 2.4, and

[E] Pinehaven FFC derived from Water & Soil Division MOWD Technical Memo 61 (1980), and

[F] Pinehaven FFC developed from the Rational Method using a runoff coefficient derived from an analysis of the 8 December 2019 flood event.

The results of these FFC are plotted in a log – normal form with the average annual recurrence interval T (years) plotted along the " X ' axis and with the corresponding flood peak, Q_T(cumecs) plotted along the vertical, " Y " axis. Refer Fig. 1. Shown also on this graph are the GWRC / MWH FFC developed from the Hystra rainfall – runoff model and their Rational Method obtained from the *GWRC Pinehaven Stream Flood Hydrology report 2009, Appendix B, Revision of Rainfall – Runoff Model and Design Flood Estimates (5 November 2009).*

Fig.2. Is a replication of Fig.1. but with the estimated peak discharges for the 23 July 2009 (12.5 – 13.0 cumec) and 8 December 2019 (11.7 cumec) added. In addition, the estimated recurrence intervals for each storm's critical duration and depth are plotted in order to provide for the Pilgrim/ Cordery check described above. In applying this test Method [C] above could not satisfy these criteria for the 8

December 2019 flood peak of 11.7 cumec and accordingly that particular FFC has been rejected.

Comment: It is readily apparent from the Pilgrim/ Cordery check that neither criteria can be satisfied by the GWRC / MWH flood frequency curves, there are significant discrepancies between the recurrence intervals for the rainfalls compared to the peak outflows on the one hand and that frequency with which these flood events might be expected are ridiculously high e.g. on average once or twice a year which clearly doesn't happen.

In contrast, the FFC developed as part of this study clearly do satisfy both criteria.

Footnote: Rainfall – Depth – Duration – Frequency estimates used in the above methods have been obtained from NIWA HIRDS V4 – Historical on line data for the Pinehaven Stream at the Pinehaven Reserve and the Tasman Vaccine site. No adjustment has been made for climate change.

Conclusions

1. The flood event that occurred in Pinehaven on the 8 December 2019 peaked at the Chatsworth Road Gauge site around 6.30 am. At a flow of 11.7 cumec and a gauge height of 1510mm.

2. It is estimated from the FFC developed in this study that this event had an average annual recurrence interval between 20 and 30 years and notionally adopted at 25 years (AEP 4%).

3. The actual extent of the flooding that occurred in Pinehaven on that occasion is considered to reliably represent what might be expected in an event with an average annual recurrence interval of 25 years (AEP 4%)

4. The peak flow associated with the 23 July 2009 flood event is provisionally set at 12.7 to 13.0 cumec with an average annual recurrence interval of 35 years to 40 years (2.5% < AEP < 2.8%)

5. In the light of this investigation the FFC's developed and reported variously by GWRC / MWH (2008 to present) and SKM (2010), relied upon by Becca in their audit (2015) and Jacobs (2016) reworking of the flood model in their 2016 review should be considered obsolete and do not form a reliable basis for flood modelling and mapping activities nor for the current stream upgrades being proposed for the lower reaches of the Pinehaven catchment through Pinehaven per se.

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27 July 2020

Appendix

Fig 1. GWRC flood frequency curves (2009) and R.J.Hall & Associates Ltd. Flood frequency Curves (2020).

Fig 2. Fig 1. Modified to include details of the 23 July 2009 and 8 December 2019 flood estimates at the Chatsworth Rd. Gauge site (peak flow and associated recurrence interval, gauge reading and the associated recurrence intervals for the rainfalls for each of these two events)

Fig 3. Updated Rating Curve for the Chatsworth Rd. Gauge incorporating the 8 December 2019 flow of 11.7 cumec.

Fig. 1.

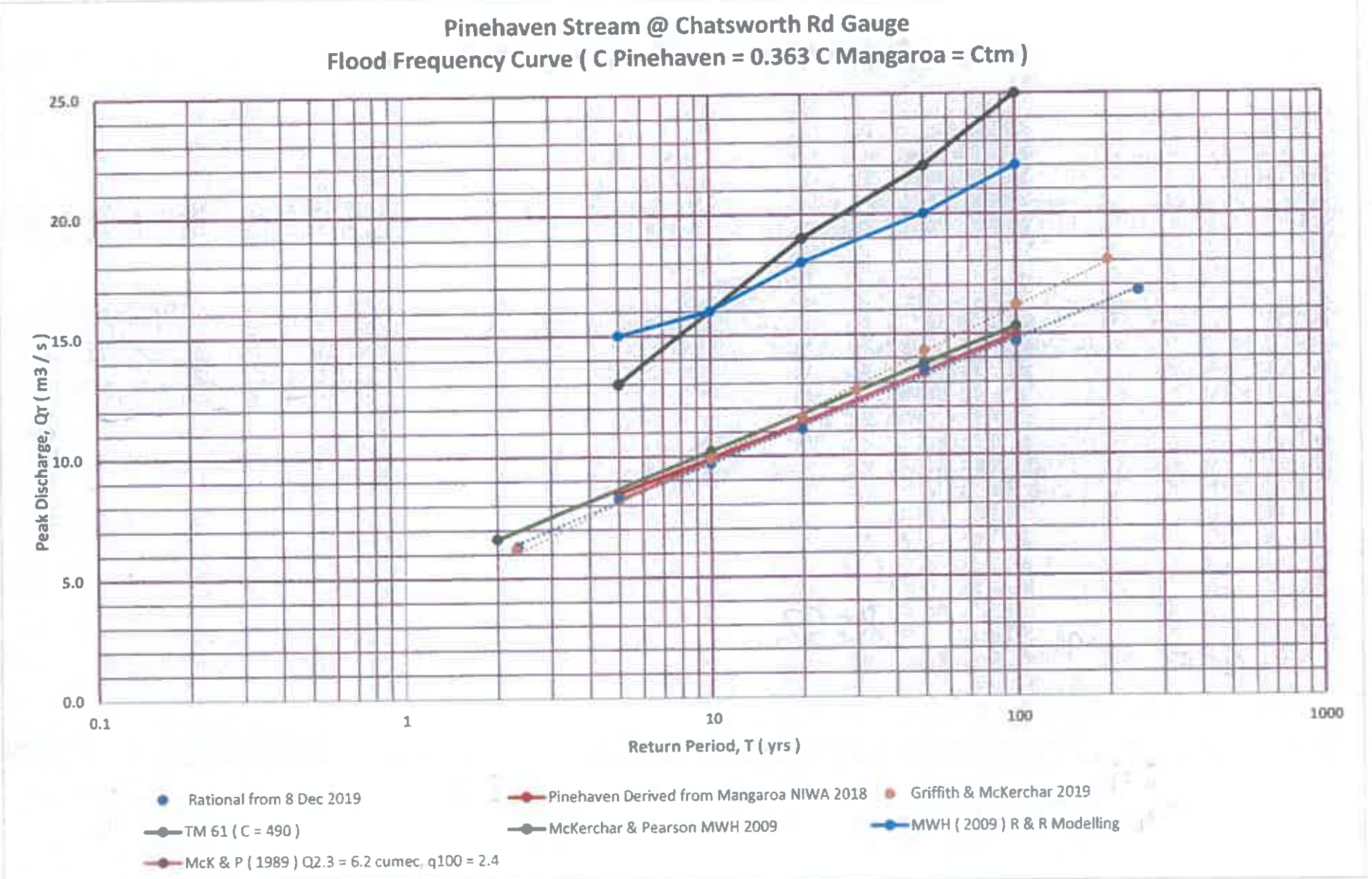

Pinehaven Stream @ Chatsworth Rd Gauge
Flood Frequency Curve (C Pinehaven = 0.363 C Mangaroa = Ctm)
Peak Discharge, Qr (m3 / s)
25.0
20.0
15.0
10.0
5.0
0.0
0.1
1
10
100
1000
Return Period, T (yrs)
Rational from 8 Dec 2019
Pinehaven Derived from Mangaroa NIWA 2018
Griffith & McKerchar 2019
TM 61 (C = 490)
McKerchar & Pearson MWH 2009
MWH (2009) R & R Modelling
McK & P (1989) Q2.3 = 6.2 cumec, q100 = 2.4

Fig. 2.

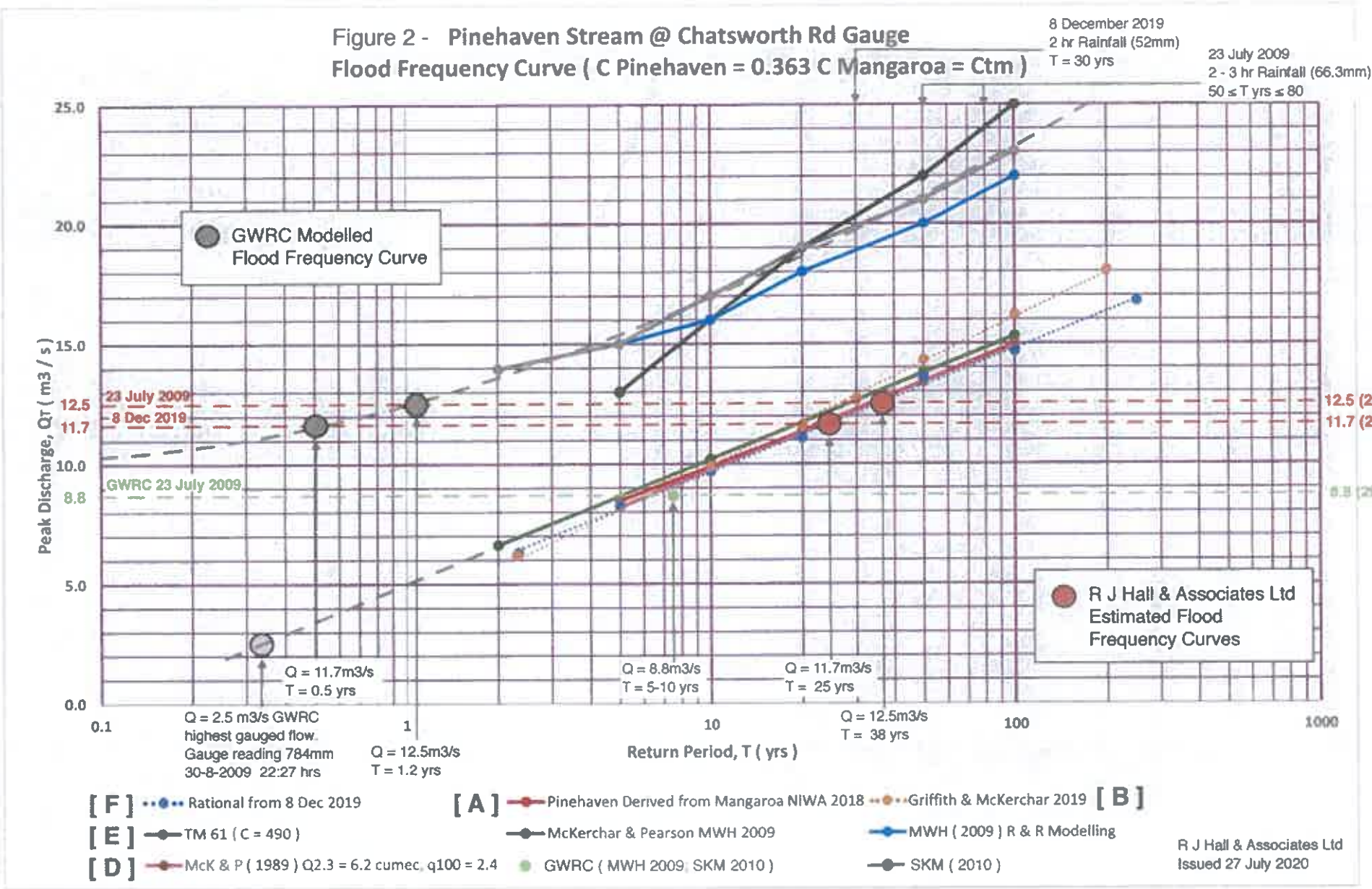
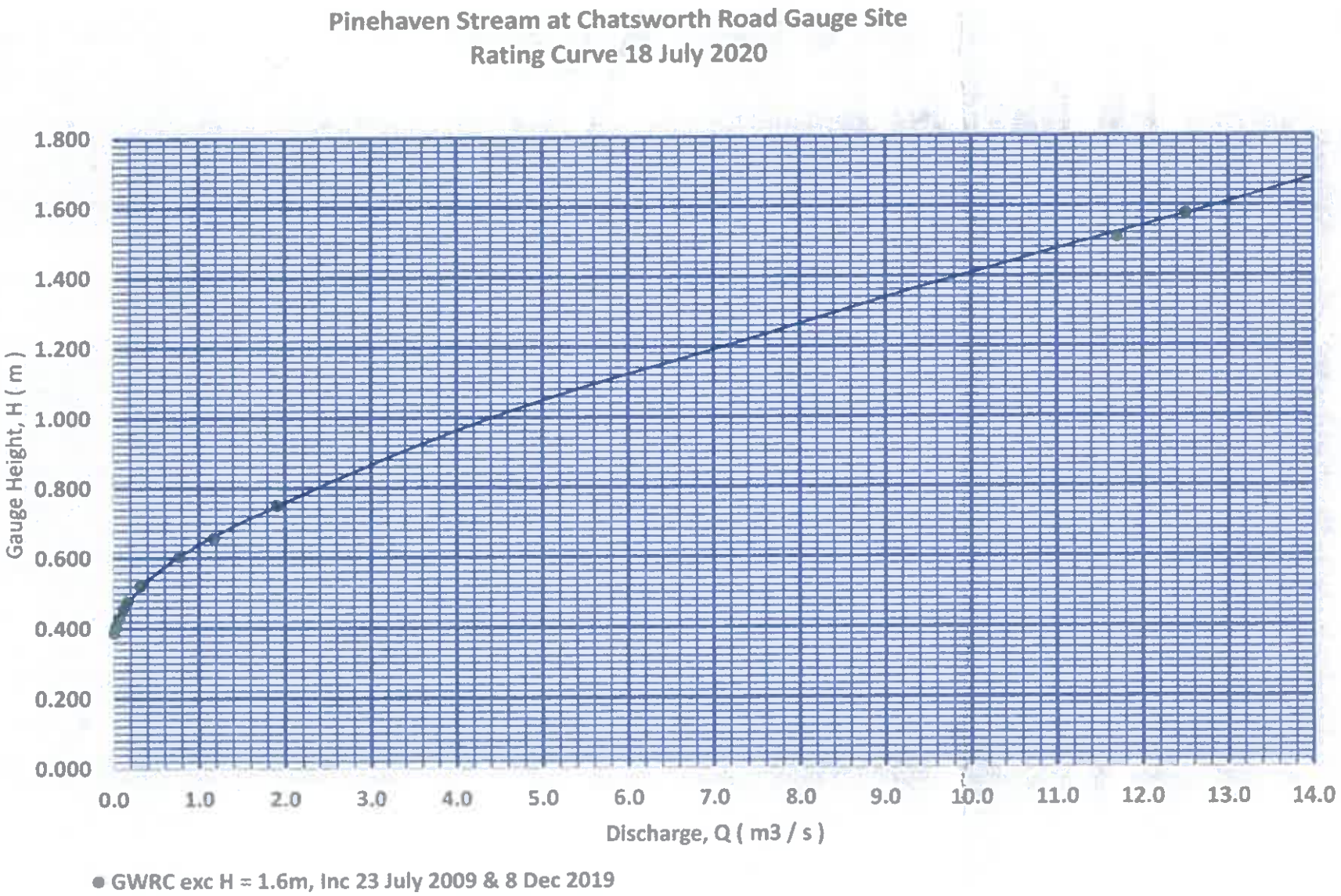


Figure 2 - Pinehaven Stream @ Chatsworth Rd Gauge
Flood Frequency Curve (C Pinehaven = 0.363 C Mangaroa = Ctm)
8 December 2019
2 hr Rainfall (52mm)
T = 30 yrs
23 July 2009
2 - 3 hr Rainfall (66.3mm)
50 ≤ T yrs ≤ 80
GWRC Modelled
Flood Frequency Curve
R J Hall & Associates Ltd
Estimated Flood
Frequency Curves
Peak Discharge, QT (m3 / s)
Return Period, T (yrs)
25.0
20.0
15.0
10.0
5.0
0.0
12.5
11.7
8.8
23 July 2009
8 Dec 2019
GWRC 23 July 2009
12.5 (2009)
11.7 (2019)
8.8 (2009)
0.1
1
10
100
1000
Q = 11.7m3/s
T = 0.5 yrs
Q = 2.5 m3/s GWRC
highest gauged flow.
Gauge reading 784mm
30-8-2009 22:27 hrs
Q = 12.5m3/s
T = 1.2 yrs
Q = 8.8m3/s
T = 5-10 yrs
Q = 11.7m3/s
T = 25 yrs
Q = 12.5m3/s
T = 38 yrs
[F] Rational from 8 Dec 2019
[A] Pinehaven Derived from Mangaroa NIWA 2018
Griffith & McKerchar 2019 [B]
[E] TM 61 (C = 490)
McKerchar & Pearson MWH 2009
MWH (2009) R & R Modelling
[D] McK & P (1989) Q2.3 = 6.2 cumec, q100 = 2.4
GWRC (MWH 2009, SKM 2010)
SKM (2010)
R J Hall & Associates Ltd
Issued 27 July 2020

Fig 3.


Pinehaven Stream at Chatsworth Road Gauge Site
Rating Curve 18 July 2020
Gauge Height, H (m)
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
Discharge, Q (m3 / s)
GWRC exc H = 1.6m, Inc 23 July 2009 & 8 Dec 2019