BEFORE THE ENVIRONMENT COURT

AT AUCKLAND

I TE KŌTI TAIAO O AOTEAROA

KI TĀMAKI MAKAURAU

IN THE MATTER	of appeals under Clause 14 of Schedule 1 of the Resource Management Act 1991
BETWEEN	**BOONHAM**
	(ENV-2021-AKL-000061)
	MANGAWHAI MATTERS INCORPORATED & OTHERS
	(ENV-2021-AKL-000062)
	Appellants
AND	**KAIPARA DISTRICT COUNCIL**
	Respondent

STATEMENT OF EVIDENCE OF JONATHAN LINDSAY WILLIAMSON ON BEHALF OF MANGAWHAI CENTRAL LIMITED

(WATER SUPPLY)

17 December 2021

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INTRODUCTION

Qualifications and experience

1. My full name is Jonathan Lindsay Williamson.

2. I have a Bachelor of Science (BSc) in Earth Science (1993), and a Master of Science and Technology first class honours (MSc(Tech)[I]) (1995) in Hydrology and Geology from the University of Waikato.

3. I am the Managing Director of Williamson Water & Land Advisory ("WWLA"), a firm founded in January 2015 and currently employing 23 staff specialising in water, rural and contaminated land related resource management. From the year 2000 until 2015 I held various technical and managerial roles in the water resource management and irrigation sectors within the Auckland office of Sinclair Knight Merz (now Jacobs). Prior to that, from 1995 to 1999 I was employed by a global multidisciplinary consulting firm in Sydney and undertook a range of hydrogeological work in the mining and municipal water supply sectors.

4. I have 25 years of specialist technical expertise in hydrogeology, hydrology and irrigation engineering covering a wide spectrum of services and client types, including regional councils; district councils; central government agencies such as the Ministry of Business, Innovation and Employment (MBIE), Te Puni Kōkiri (Ministry of Māori Development), Waka Kotahi (NZ Transport Agency), Ministry For The Environment, and the Department of Conservation; sector interest groups such as Horticulture New Zealand; water management groups such as Wairarapa Water Users Society; agricultural and horticultural businesses; energy companies; mining; and beverage companies.

5. I am familiar with the Plan Change 78 ("PC78") site and the surrounding locality, having undertaken a region-wide groundwater assessment for the Northland Regional Council in 2005 (SKM, 2005), and drilling and aquifer testing to support the preparation of an application for resource consent to take groundwater from the Tara Basalt in the mid-2000s.

6. With regard to the Mangawhai Central PC78 site, I have personally visited the site on four occasions over the last two years while various phases of work were being undertaken by my firm.

Code of Conduct

7. I confirm that I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note (2014) and I agree to comply with it. In that regard, I confirm that this evidence is within my expertise, except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

8. In my evidence, I provide a summary of the surface water monitoring, modelling, and reservoir water balance assessment undertaken to demonstrate the reliability of the proposed water storage supply for Mangawhai Central (PC78).

OVERVIEW

9. In 2019 WWLA were commissioned by Mangawhai Central Ltd ("MCL") to assess water supply options for the proposed PC78 residential and commercial development.

10. As part of this assessment, WWLA was tasked with assessing the viability of surface water resources for water supply to the residential and commercial development. An initial assessment was presented in evidence at the Kaipara District Council Hearing on PC78.[1]

11. My evidence presents an updated hydrology analysis undertaken to demonstrate supply reliability for the PC78 residential and commercial development. My evidence is summarised from the WWLA reported titled "*Water Supply Assessment Hydrological Modelling Report*" dated 10 December 2021.

[1] Refer in particular to: Statement of Supplementary Evidence of Jon Williamson (water supply), 18 December 2020.

12. My evidence is structured in five parts:

(a) The first part outlines the current setting in regards to existing consented water takes and the proposed water storage reservoir.

(b) The second part summarises water level monitoring data collection undertaken to support the verification of the catchment flow model.

(c) The third part details the verification of the catchment flow model.

(d) The fourth part contextualises the operation of the proposed high-flow takes in comparison to measured water levels and simulated flows.

(e) The fifth part presents a reservoir storage water balance modelling assessment demonstrating the reliability of the reservoir based on the existing water take consents (paragraphs 13 and 14), and current water storage reservoir design.

CURRENT SETTING

13. Resource consents (AUT.042407) authorising the take of water from two streams that flow through the property were granted on 8 January 2021. The location of the two takes, and their upstream catchment areas are displayed in **Figure 1**.

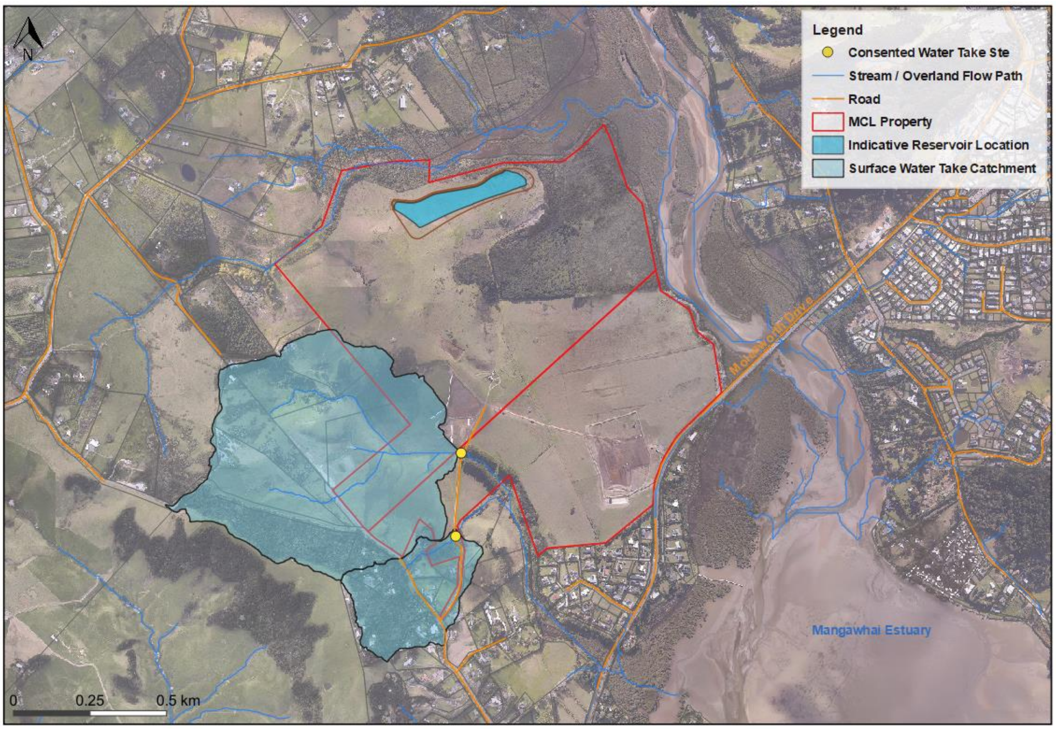

***Figure 1. Consented high-flow surface water takes*[2].**

14. The consents authorise the taking of surface water during times of high-flow, defined as periods when streamflow is above median flow. The consented median flow and maximum take rate for the two locations is presented in **Table 1**.

Table 1. Consented surface water take criteria.

Location	**Median Flow (L/s)**	**Maximum Take Rate (L/s)**
Take Site 1	4.3	40
Take Site 2	1.0	7.0

15. The two water takes will be used to fill a 100,000 m^3 capacity water storage reservoir located on the northern boundary of the property (**Figure 1**). An application for resource consent for the reservoir was lodged on 3 November 2021, and is currently being processed by Kaipara District Council and Northland Regional Council.

[2] *Figure 1 shows streams outside of the PC78 area and the streams within the PC78 area relating to the two consented water take sites. All streams within the PC78 area are addressed in the evidence of Dr Neal and Mr Montgomery.*

STREAM MONITORING

16. Stream water level monitoring was undertaken for the purposes of verifying the catchment flow model, developed to support the resource consent application for the two water takes. Ultrasonic water level sensors (brand/type: Waterwatch LS1) were installed on 28 May 2021 at the two consented surface water take sites (**Figure 1**), and both are still operational at present. The water level sensors were configured to record water levels on a five-minute interval, and transmit the measured data to the cloud on a three-hourly interval.

17. Take Site 1 is the larger of the two sites, and the water level sensor was installed on the upstream side of the culvert under the causeway of the private driveway accessed by Old Waipu Road. The culvert at this location is 1,100 mm in diameter. Take Site 1 is characterised by dense vegetation both upstream and downstream of the culvert, with a thick layer of soft silt and mud inside the culvert.

18. Take Site 2 was installed on the downstream side of the culvert under the private access track. Take Site 2 is characterised by dense wetland vegetation upstream of the culvert, and debrisladen ground (leaves and branches) downstream. The culvert at this site is 925 mm in diameter.

19. Measured water levels at Take Site 1 are presented in **Figure 2**. These levels exhibit a flashy response to rainfall events, with levels rising quickly, and recession post rainfall. The Largest change in water levels occurred on 23 September 2021, where water levels rose approximately 0.6 metres.

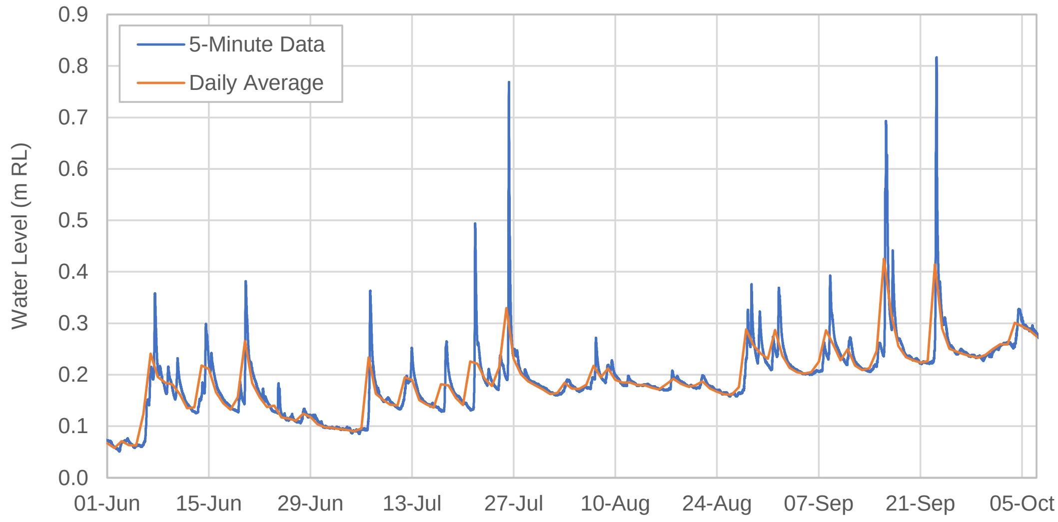

Figure 2. Measured water levels at Take Site 1.

20. Measured water levels at Take Site 2 are presented in **Figure 3**. Similar to Take Site 1, measured levels exhibited a flashy response to rainfall events.

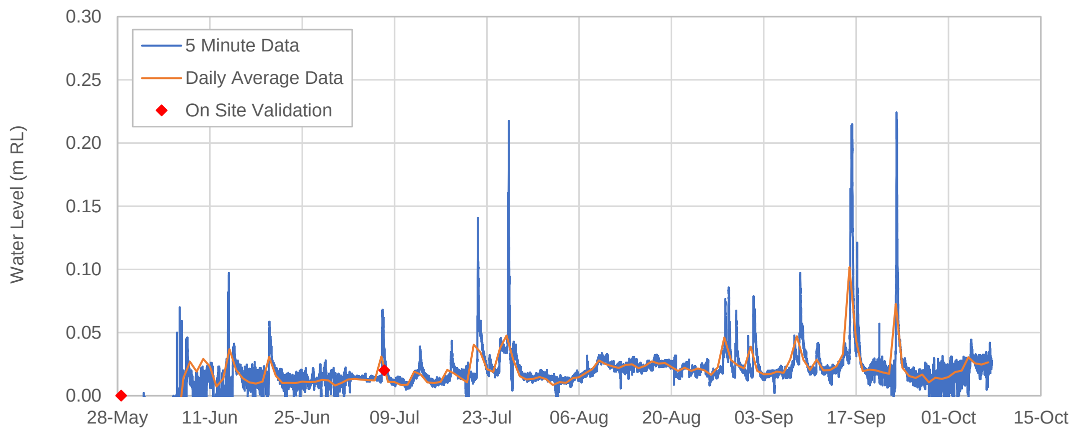

Figure 3. Measured water levels at Take Site 2.

21. A comparison of measured water levels at Take Site 1 and Take Site 2 is presented in **Figure 4**. This illustrates both catchments respond in a similar hydrological manner, with both sites demonstrating a flashy response to rainfall. This is to be expected given the underlying catchment characteristics (soils and geology) are the same, and their close proximity to one another.

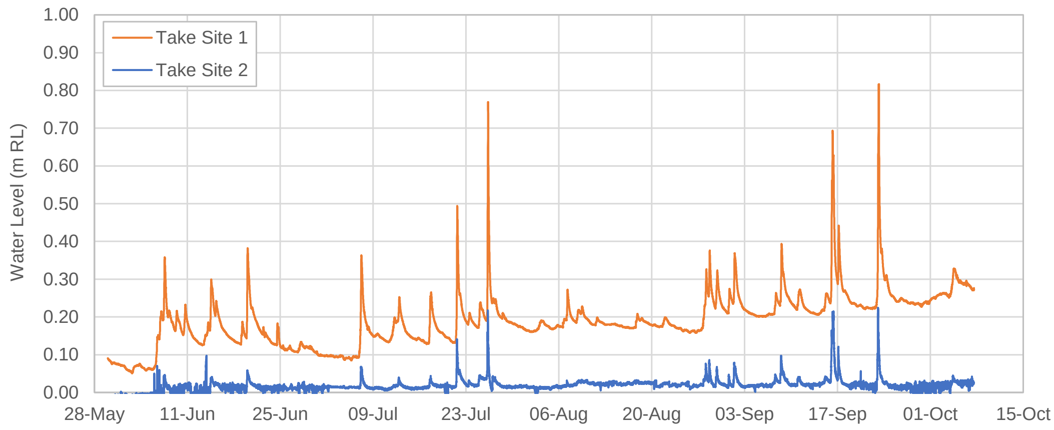

Figure 4. Comparison of measured water levels.

22. My preferred approach to convert measured stream water levels to a corresponding flow rate is through the collection of manual velocity gaugings, and subsequent development of a rating curve. The resulting stream flow dataset is referred to as a rated flow dataset.

23. Due to the dense vegetation at both take sites, this method could not be employed at either site. Therefore, alternative analyses were required in order to determine a representative streamflow monitoring record to enable the verification of the catchment flow models.

24. The Manning's formula[3], is a water engineering industry standard open channel flow approach, used to calculate flow rate based on measured water levels. The Manning's equation is one of the most commonly used methods for calculating flow in open channels.

25. The Manning's equation for open channel flow approach is considered appropriate at Take Site 2 because during the monitoring period the culvert did not flow at full capacity (i.e., it operated as a semi-circular open channel). However, this approach was not considered appropriate at Take site 1 because (as identified in paragraph 17) there is dense vegetation both upstream and downstream of the culvert at Take Site 1, which led to pooling of water[4].

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[3] The Manning formula is an empirical formula estimating the average velocity of a liquid flowing in a conduit that does not completely enclose the liquid, i.e. open channel flow. The equation is also used for calculation of flow variables in case of flow in partially full conduits, as they also possess a free surface like that of open channel flow. All flow in so-called open channels is driven by gravity. It was first presented by the French engineer Philippe Gauckler in 1867, and later re-developed by the Irish engineer Robert Manning in 1890.

[4] No such significant pooling occurred at Take site 2.

26. The culvert at Take Site 2 was surveyed by McKenzie and Co. consultant engineers on 6 July 2021, and the diameter confirmed as 925 mm. The grade (slope) of the culvert was surveyed as -4.69%. A Manning's roughness value considered representative of the concrete culvert's rough condition with offset joint rings (0.02 $s/m^{1/3}$) was selected. To place this roughness value in context, smooth metal surfaces typically have a lower roughness value of 0.01 to 0.015, whilst winding natural channels with weed growth typically range from 0.05 to 0.15. The value applied to the culvert is at the lower end of the overall range, but at the higher end of the range commonly applied to concrete culverts and other devices with similar functionality, reflecting its rough surface.

27. The resulting calculated flow time series for Take Site 2 is presented in **Figure 5**.

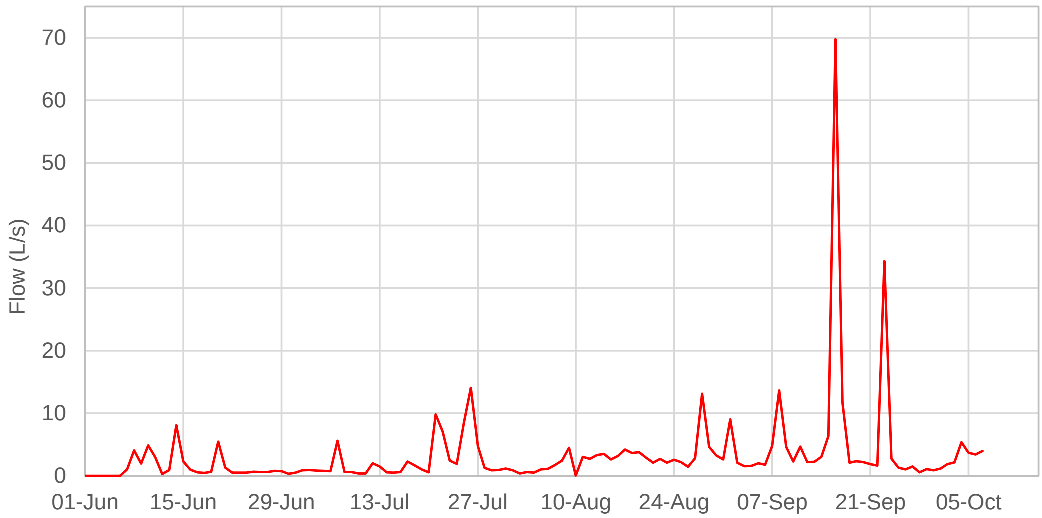


Figure 5. Take Site 2 calculated flow.

28. As discussed in paragraph 25, under pooled conditions, both the velocity flow gauging and Manning's approaches are inappropriate for Take Site 1. Therefore, a paired catchment approach was used for Take Site 1, and this approach is detailed in paragraph 36.

VERIFICATION OF CATCHMENT FLOW MODEL

29. A catchment flow model was developed for Take Site 1 and Take Site 2 to support the resource consent application (paragraph 13) which now authorises the taking of water from these two sites. The

model was developed using WWLA's Soil Moisture Water Balance Model (SMWBM), which is outlined in **Annexure A**.

30. In order to verify the catchment flow model, simulated flow was compared to the calculated streamflow data for Take Site 2.

31. A comparison of simulated and measured flow from Take Site 2 is presented in **Figure 6**. Simulated flow shows good agreement with the timing and general magnitude of measured runoff events, with some events under-simulated and some over-simulated, which is normal for an accurately calibrated model.

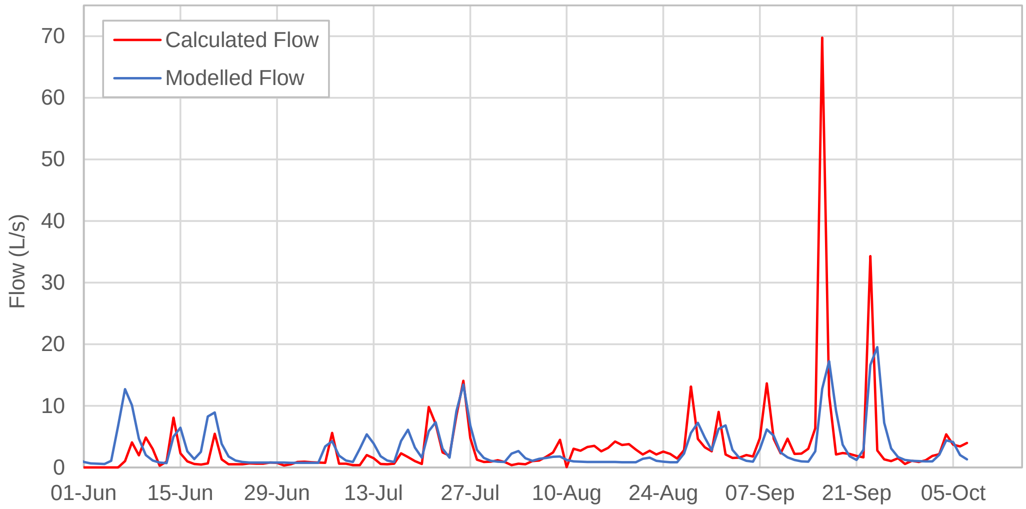


Figure 6. Comparison of simulated flow and flow calculated from the Take Site 2 culver water level measurements.

32. An additional secondary check was undertaken by comparing modelled flow for Take Site 2 against measured streamflow data for the Waihoihoi River at St Marys Road, pro-rated (scaled) by catchment area to Take Site 2.

33. The Waihoihoi River at St Marys Road monitoring site is located approximately 17 kilometres to the north-west, near the Waipu township (**Figure 7**). The monitoring site is operated by Northland Regional Council, and has an upstream catchment area of 25.1 km^2.

34. The Waihoihoi River catchment is underlain by a combination of Waipapa Group greywacke, and Raurangi Formation siltstone in the lower reaches. The catchments of Take Site 1 and Take Site 2 are underlain by Northern Allochthon and Pakiri Formation Sandstone. Given the large difference in catchment size, and underlying

geology, the hydrological response between catchments is expected to differ, and therefore it would not be appropriate to use scaled flows from this gauge as a direct method of calibration. However, scaled flow still provides a useful secondary verification, particularly to demonstrate climatic response (e.g., prolonged periods of low flow / drought which would be of concern from a water supply perspective).

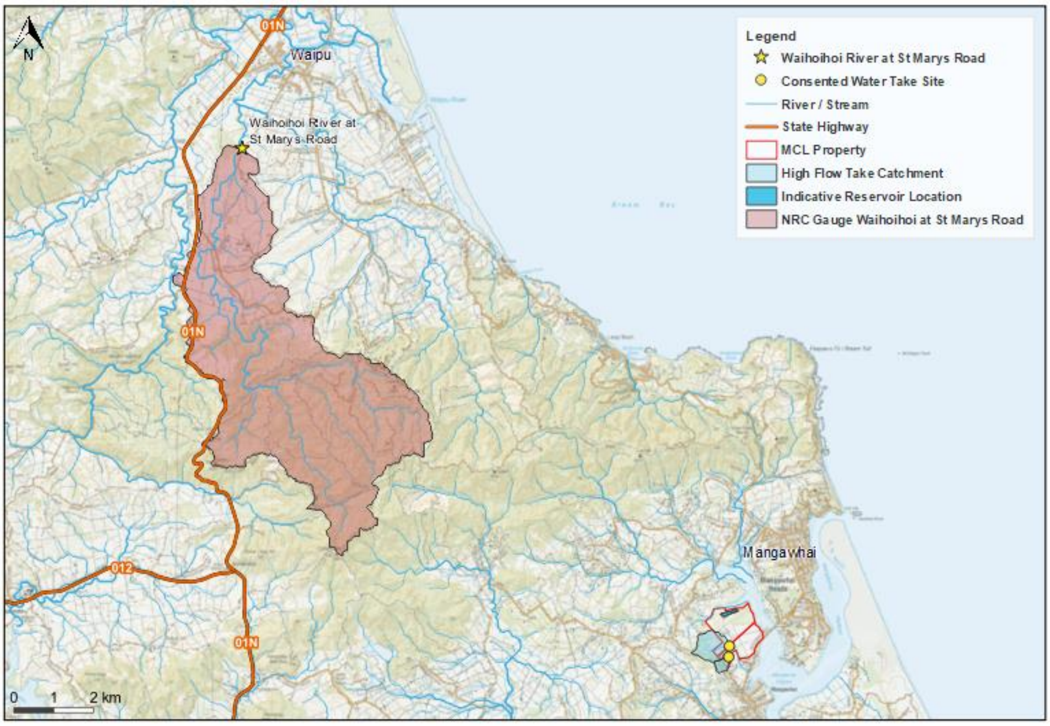


Figure 7. Location of Waihoihoi River at St Marys Road monitoring site in relation to the proposed high-flow take sites.

35. Comparison of modelled and scaled Waihoihoi River flow at St Marys Road for Take Site 2 is presented in Error! Reference source not found. **Figure 8**. This comparison demonstrates reasonable agreement with the timing and general magnitude of modelled flow to scaled flow, noting a perfect match is not expected given the difference in catchment characteristics (paragraph 34). Of particular note, good agreement is observed over the 2019/2020 summer – which was known to be very dry, with low river flows. This provides a secondary form of model verification, specifically with regard to demonstrating the modelled flow, given the climate input data used replicated the drought period of 2019/2020 (i.e., the climatic period of most importance when considering reservoir supply reliability during severe drought).

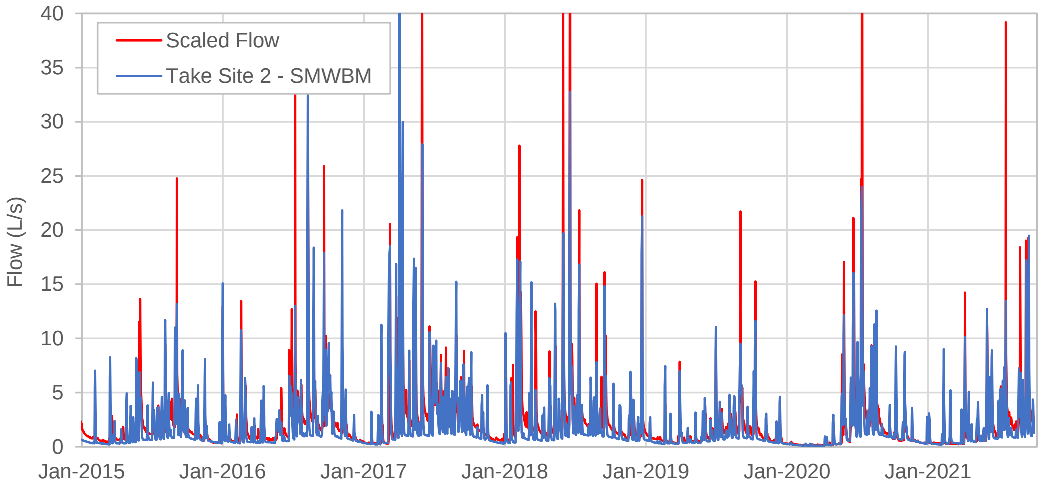


Figure 8. Comparison of modelled flow and pro-rated flow from Waihoihoi River at St Marys Road for Take Site 2.

36. For the derivation of flow for Take Site 1, a paired catchment approach was utilised, which involves transposing calibrated model parameters from a gauged catchment with the same or similar catchment characteristics (i.e., Take Site 2), to an ungauged catchment (Take Site 1). This paired catchment approach is a standard catchment modelling and hydrological analysis technique for simulation of flow in ungauged catchments, and is considered appropriate for application in this project.

37. As noted in paragraph 21, the underlying catchment characteristics are very similar between the two take site catchments and measured water levels from both display similar hydrological response to rainfall (**Figure 4**). This further reinforces the validity of the paired catchment approach.

38. The calibrated catchment flow model was used to simulate the historic streamflow for the two take sites, for the period 1972 through to 2020.

OPERATION OF HIGH-FLOW TAKES IN COMPARISON TO MEASURED WATER LEVELS AND MODELLED FLOWS

39. In order to provide context on the operation of the proposed high-flow takes in comparison to measured water levels, the water level corresponding to median flow (4.3 L/s) and the streamflow at which the maximum take rate for Take Site 1 can occur (44.3 L/s (4.3 + 40

L/s)) were estimated, and plotted as the horizontal black and red lines on **Figure 9**, respectively. Take Site 1 was selected for this example as it is the larger of the two takes. This provides a visual indication of the frequency at which pumping could occur in relation to measured water levels.

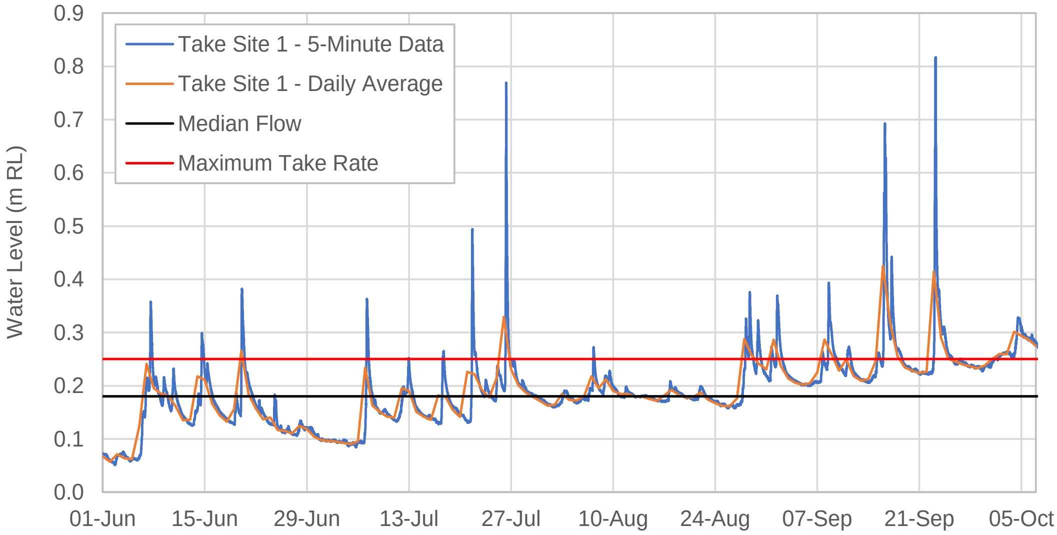


Figure 9. Operation of Take Site 1 in comparison to measured water levels.

40. The same approach was taken using long-term modelled streamflow for Take Site 1, and is presented in **Figure 10**. This provides a similar visual example to the frequency at which the take could operate over the longer term.

41. Given the very similar catchment characteristics for Take Site 2, the frequency at which Take Site 2 would operate would be very similar to Take Site 1.

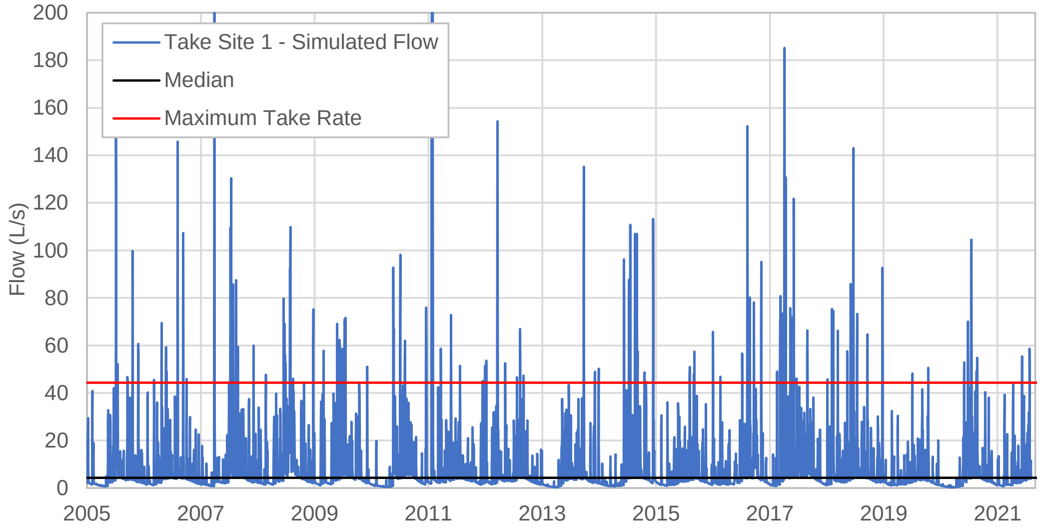


Figure 10. Operation of Take Site 1 in comparison to modelled flow.

RESERVOIR WATER BALANCE ASSESSMENT

42. To demonstrate the reliability of the proposed water storage reservoir, a water balance model was developed. The model was constructed using WWLA's Reservoir Storage Model (RSM). The RSM balances catchment inflows and direct rainfall inputs, with water demand and evaporation losses, to simulate the change in reservoir storage volume on a daily timestep. The RSM was simulated over the period 1972 through 2020.

43. The following criteria and/or assumptions were utilised in the reservoir storage water balance modelling assessment:

    (a) Maximum reservoir storage capacity of 100,000 m^3;

    (b) Direct gains (rainfall) and losses (evaporation) were calculated from the reservoir surface on daily basis;

    (c) A volume vs. surface area curve calculated from the proposed reservoir design (supplied by McKenzie and Co.); and

    (d) No seepage occurs from the reservoir.

44. The catchment flow model was used to simulate the historic streamflow (1972-2020) for the two consented water take sites, and

harvestable flow to the reservoir calculated based on the criteria outlined in **Table 1** for each take site.

45. The reservoir is proposed to supply Subzone 3A (residential) and to supplement Subzone 1 (business) of the proposed Plan Change areas, as described in the evidence of Mr Dufty.

46. Two reservoir water use demand scenarios were determined and provided by Mr Dufty as uniform monthly estimates. Details of these scenarios are included in the evidence of Mr Dufty.

47. The two scenarios are illustrated in **Figure 11**, and summarised as follows:

    (a) **Scenario 1 (S1) –** Water use requirements are supplied from the reservoir, less rain water harvested by individual lots based on 5 m^3 for residential lots, and 3 m^3 for retirement units. Rain harvesting was based on the <u>lowest recorded monthly rainfall</u> across all years; and

    (b) **Scenario 2 (S2) –** Water use requirements are supplied from the reservoir, less rain water harvested by individual lots based on 5 m^3 for residential lots, and 3 m^3 for retirement units. Rain harvesting was based on the <u>mean monthly rainfall</u> across all years.

48. The two scenarios are considered conservative, as neither include the use of water saving devices (e.g., low flow taps and showerheads), that would further reduce water use requirements.

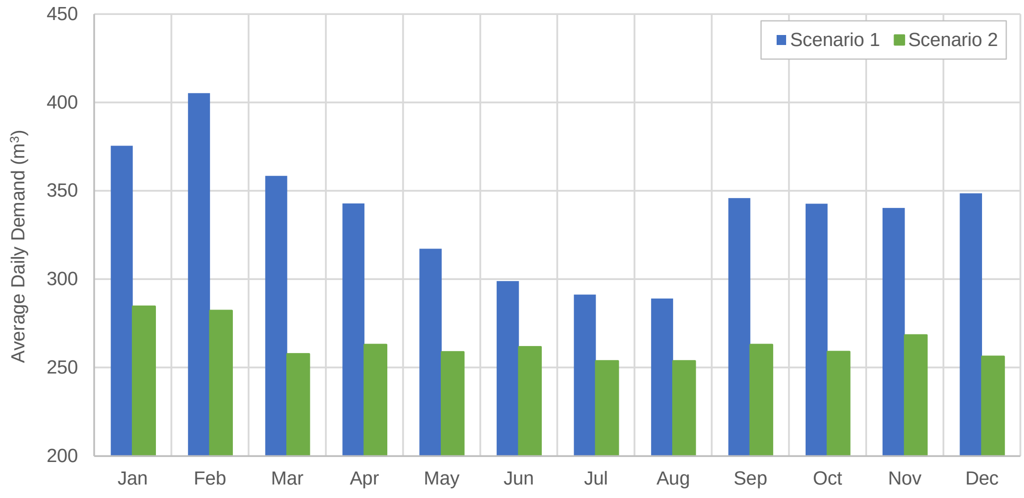


Figure 11. Daily average reservoir demand.

49. The RSM simulated reservoir storage volumes based on historic climate data, simulated historic streamflow and estimated water use demands. A comparison of simulated historic reservoir storage volumes, assuming water use Scenario 1 and water use Scenario 2, is presented in **Figure 12**, and a reservoir volume probability plot presented in **Figure 13**.

50. The simulated reservoir storage volume time series plot and probability plot demonstrate that based on the historic climate record, the reservoir would have provided a 100% reliable water supply under both water use scenarios. In other words, the reservoir never ran dry, and water was always available for supply.

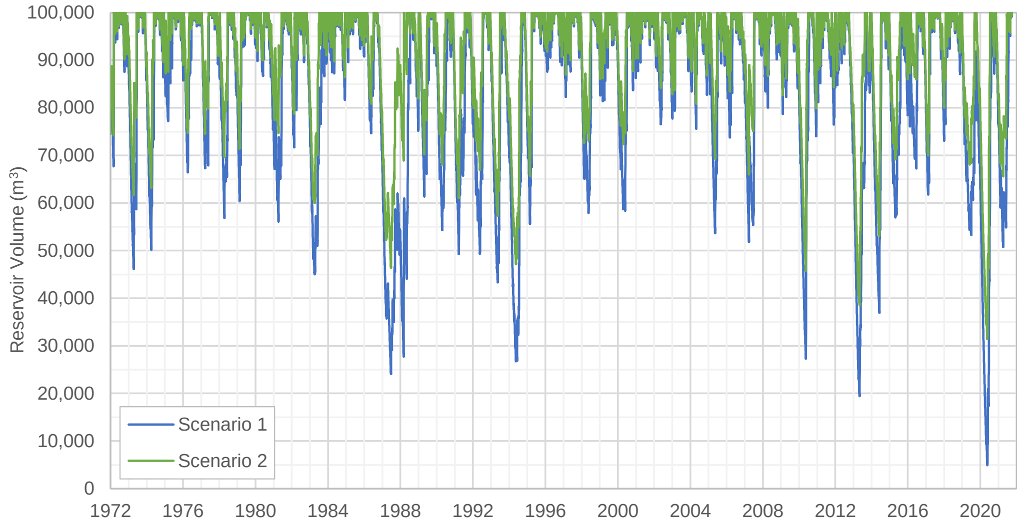


Figure 12. Reservoir storage volume time series plot.

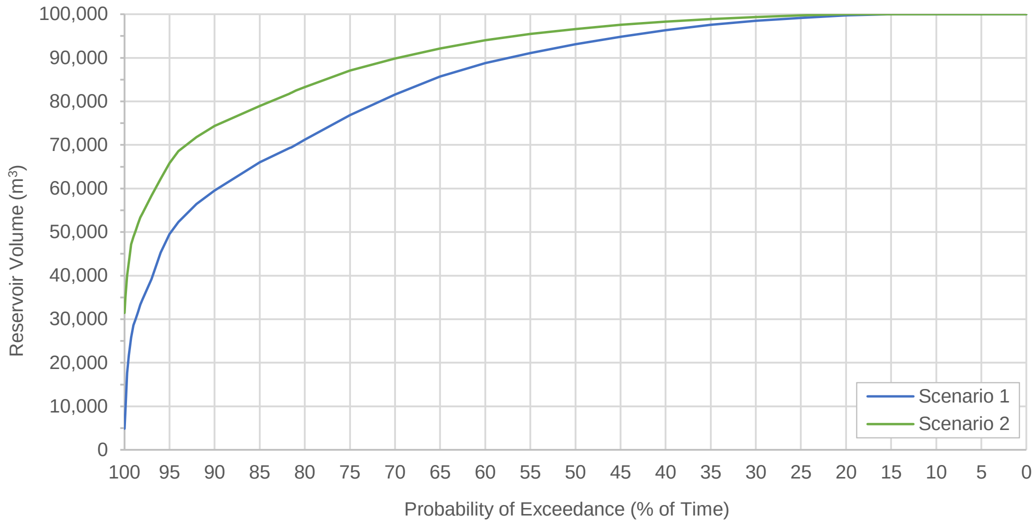


Figure 13. Reservoir volume probability plot.

51. The following key conclusions were drawn from the reservoir storage modelling:

    (a) Under both Scenario 1 and Scenario 2 there was sufficient water available every year (i.e., the reservoir did not become empty at any stage).

    (b) Both scenarios are considered conservative as they do not include water saving devices (e.g., low flow taps and showerheads) for the business subzone, residential or retirement units.

    (c) Based on the historic climate record, the reservoir and reticulated water supply would be considered reliable under both water use demand scenarios.

SUMMARY & CONCLUSIONS

52. A water supply reliability analysis has been undertaken for residential (Subzone 3A) and commercial (Subzone 1) of the proposed Mangawhai Central Development.

53. The analysis relied upon streamflow monitoring data collected in the two streams where resource consents are held to take high-flow waters for storage in the proposed reservoir.

54. Using this data and considering it in context of stream conditions, a rainfall runoff model was developed that enabled the generation of a modelled 48-year long historical flow series for the two streams.

55. A reservoir storage model processed the likely take regime based upon the historical flow series and undertook an assessment of the reservoir's ability to meet demand under two scenarios: one being a very conservative scenario assuming the lowest monthly rainfall on record occurred each month, and the second assuming average rainfall conditions per month.

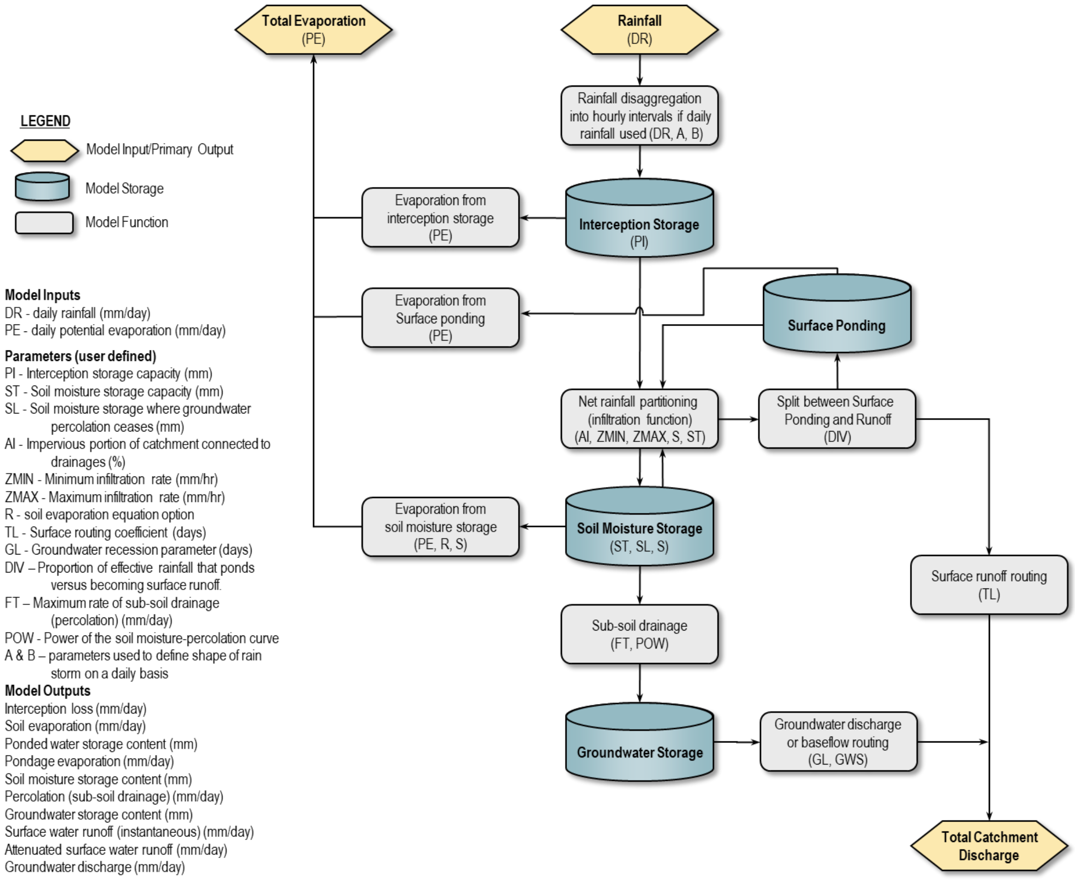
56. Under both scenarios, the proposed reservoir has the ability to meet all of the water demands in subzones 1 and 3A 100% of the time, over the modelled assessment period.

57. Neither of the scenarios implemented water saving devices, hence this analysis provides a high degree of confidence that the reservoir can meet the forecasted demands, and if water saving devices are implemented as planned, the reservoir also has contingency for changing circumstances such as climate aberrations.

Jonathan Lindsay Williamson

17 December 2021

Appendix A: WWLA Soil Moisture Water Balance Model



Parameter	Name	Description
ST (mm)	Maximum soil water content	ST defines the size of the soil moisture store in terms of a depth of water.
SL (mm)	Soil moisture content where drainage ceases.	Soil moisture storage capacity below which sub-soil drainage ceases due to soil moisture retention.
FT (mm/day)	Sub-soil drainage rate from soil moisture storage at full capacity	Together with POW, FT (mm/day) controls the rate of percolation to the underlying aquifer system from the soil moisture storage zone. FT is the maximum rate of percolation through the soil zone.
ZMAX (mm/hr)	Maximum infiltration rate	ZMAX and ZMIN are nominal maximum and minimum infiltration rates in mm/hr used by the model to calculate the actual infiltration rate ZACT. ZMAX and ZMIN regulate the volume of water entering soil moisture storage and the resulting surface runoff. ZACT may be greater than ZMAX at the start of a rainfall event. ZACT is usually nearest to ZMAX when soil moisture is nearing maximum capacity.
ZMIN (mm/hr)	Minimum infiltration rate	
POW (>0)	Power of the soil moisture-percolation equation	POW determines the rate at which sub-soil drainage diminishes as the soil moisture content is decreased. POW therefore has significant effect on the seasonal distribution and reliability of drainage and hence baseflow, as well as the total yield from a catchment.
PI (mm)	Interception storage capacity	PI defines the storage capacity of rainfall that that is intercepted by the overhead canopy or vegetation and does not reach the soil zone.
AI (-)	Impervious portion of catchment	AI represents the proportion of the catchment that is impervious and directly linked to surface water drainage pathways.
R (0,1)	Evaporation – soil moisture relationship	Together with the soil moisture storage parameters ST and SL, R governs the evaporative process within the model. Two different relationships are available. The rate of evapotranspiration is estimated using either a linear (0) or power-curve (1) relationship relating evaporation to the soil moisture status of the soil. As the soil moisture capacity approaches, full, evaporation occurs at a near maximum rate based on the daily pan evaporation rate, and as the soil moisture capacity decreases, evaporation decreases according to the predefined function.
DIV (-)	Fraction of excess rainfall allocated	DIV has values between 0 and 1 and defines the proportion of excess rainfall ponded at the surface due to saturation

Parameter	Name	Description
	directly to pond storage	of the soil zone or rainfall exceeding the soils infiltration capacity to eventually infiltrate the soil, with the remainder (and typically majority) as direct runoff.
TL (days)	Routing coefficient for surface runoff	TL defines the attenuation and time delay of surface water runoff.
GL (days)	Groundwater recession parameter	GL governs the attenuation in groundwater discharge or baseflow from a catchment.
QOBS (m^3/day)	Initial stream volume	QOBS defines the initial volume of water in the stream at the model start period and is used to precondition the soil moisture status.
AA, BB	Coefficients for rainfall disaggregation.	Used to determine the rainfall event duration and pattern.