BEFORE THE KAIPARA DISTRICT COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of a private plan change request by Mangawhai Central Ltd to the Kaipara District Plan ("Plan Change 78")

STATEMENT OF SUPPLEMENTARY EVIDENCE OF JON WILLIAMSON

(WATER SUPPLY)

18 DECEMBER 2020

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INTRODUCTION

1. My full name is Jonathan Lindsay Williamson. I have the qualifications and experience as set out in my evidence in chief dated 6 November 2020.

2. I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note (2014) and I agree to comply with it. In that regard, I confirm that this evidence is written 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

3. In my evidence, I provide a summary of the surface water supply investigations/assessment undertaken and my key conclusions. The majority of this material existed in November at the time I wrote my evidence in chief and was used by me to reach the conclusions set out in that statement.

EXECUTIVE SUMMARY

4. A soil moisture water balance model was used to simulate the daily average historic streamflow regime for a range of catchments within the Mangawhai Central Ltd ("MCL") property and adjacent to it.

5. The analysis was aimed at providing an indication of the volume and frequency of flows above the median flow rate that could be harvested and stored in a reservoir to supply the proposed reticulated area within the MCL development.[1]

6. The following conclusions are drawn from the analyses presented in this evidence:

   (a) A number of surface water catchments of varying sizes surround the proposed MCL development (both within and proximate to the Plan Change 78 ("PC78") site), that could provide a source of water to MCL's development.

   (b) There is an abundance of potentially harvestable high flow volume within these catchments.

   (c) Reservoir storage modelling demonstrates two case study takes within the PC78 site could support a demand of 400 m^3/day with extremely low probability of not meeting the demand. This is sufficient to reliably service the estimated PC78 reticulated area

1 The proposed reticulated area and its estimated demand for potable water are addressed in detail in Mr Dufty's supplementary evidence.

demand of 397 m^3/day (without implementation of any water saving devices or rainwater harvesting) or 303.5 m^3/day (with implementation of water saving devices and supplementary rainwater harvesting as now proposed to be required in the supplementary evidence of Mr Dufty and Mr Tollemache).[2]

(d) Therefore, any of the larger neighbouring catchments (e.g. Tara Creek) would also be expected to support higher water demands if needed in the future as an additional supplementary source

OVERVIEW

7. In 2019 Williamson Water & Land Advisory (WWLA) were commissioned by MCL to assess water supply options for the proposed PC78 residential and commercial development.

8. As part of this assessment, WWLA was tasked with assessing the viability of surface water resources for water supply. The analyses comprised catchment flow and reservoir water balance modelling to quantify potential surface water resources for storage in a reservoir, balanced against daily residential and commercial demands within a proposed PC78 reticulated area.

9. My evidence presents the hydrology analyses undertaken to demonstrate potential available surface water resources to supply the residential and commercial development and is structured in three parts:

   (a) The first part summarises the regulatory framework relevant to surface water takes at/near the PC78 site;

   (b) The second part presents a general high-level assessment of all nearby surface water catchments and their physical characteristics;

   (c) The third part presents a more detailed reservoir storage water balance modelling exercise undertaken for two case study proposed take sites within the PC78 site.

REGULATORY FRAMEWORK

10. The proposed approach to taking surface water for the PC78 reticulated area is by way of high-flow takes (i.e. takes only occur when streamflow is above median), which by virtue of their frequency infers that a reservoir is required to store the water for use during times when

[2] See Mr Dufty's supplementary evidence, which concludes that the estimated demand figures are conservative, including because the 303.5 m^3/day figure does not take into account the contribution of supplementary rainwater harvesting with respect to reducing reticulated water demand.

the river take is not operational (i.e. when flows are below the median). The relevant provision in the Proposed Regional Plan for Northland (pRPN) is Rule C.5.1.10, which provides that when river flow is above the median flow, the taking and use of water from a river that is not a permitted or controlled activity is a restricted discretionary activity.[3] Matters of discretion include:

(a) The timing, rate and volume of the take to avoid or mitigate effects on existing authorised takes and aquatic ecosystem health.

(b) Measures to ensure the reasonable and efficient use of water.

(c) The positive effects of the activity.

11. Applicable rules in the Operative Regional Water and Soil Plan for Northland also still have legal effect.[4] In addition, the National Policy Statement for Freshwater Management 2020 and the Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (Freshwater NES) apply.

SURFACE WATER CATCHMENTS

12. A number of surface water catchments surround the MCL development, as summarised in **Table 1** and **Figure 1**. Each of these catchments, or combination of catchments, represents a potential water supply option for development on the PC 78 site.

Table 1. Summary of surface water catchments central to the MCL development.

Catchment Name	Catchment Area (km^2)
MCL Northern	0.58
MCL Western (Case Study)	0.50
MCL Southern (Case Study)	0.12
Unnamed Stream	1.05
Tara Creek 1	1.83
Tara Creek 2	2.70
Tara Creek at u/s Estuary	17.07

[3] The Appeals Version of the pRPN on the Northland Regional Council website indicates that Rule C.5.1.10 is subject to appeal.

[4] See for example discretionary activity Rule 24.3.3 (proposed takes not covered by any other rules).

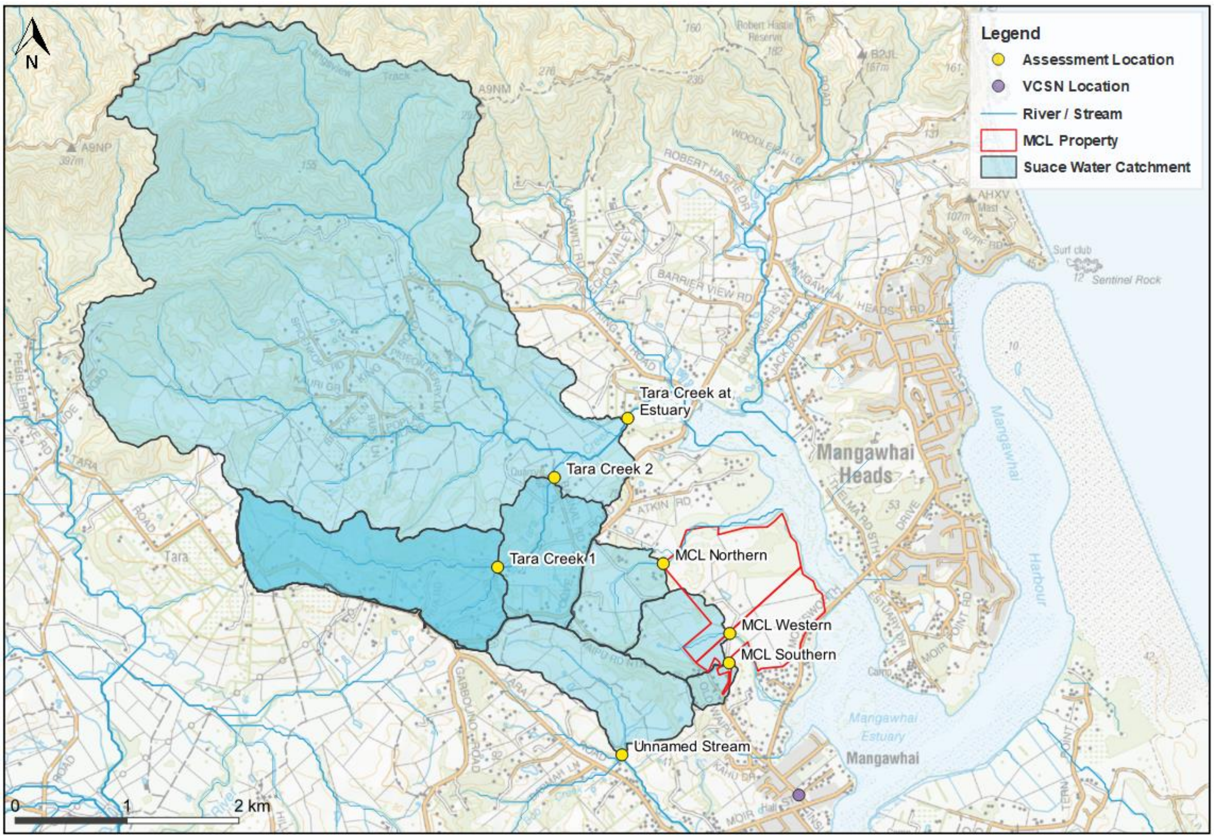


Figure 1. Surface water catchments central to the MCL development.

13. To quantify potential harvestable surface water resources from these catchments, the historic streamflow regimes were simulated using a rainfall-runoff model known as the Soil Moisture Water Balance Model (SMWBM). The SMWBM use inputs of daily rainfall and evaporation, with model parameters set based on the local underlying geology and soils of the catchment of interest. The climate, geology, and soils of the general Mangawhai area are briefly addressed below.

CATCHMENT PHYSICAL CHARACTERISTICS

Climate data

14. Evaporation and rainfall data were obtained from the National Institute of Water and Atmospheric Research (NIWA) virtual climate station network (VCSN) for the period 1972 to 2020. The VCSN data provide estimates of daily rainfall and potential evapotranspiration on a 5 km regular grid, covering all of New Zealand. Estimates of climate parameters are produced for each VCSN point on a daily time-step based on spatial and temporal interpolation of recorded observation data at the nearest reliable meteorological sites.

15. VCSN data were used in the recent Northland Water Storage and Use Project my firm undertook for the Te Tai Tokerau Water Trust. This project was similar to the MCL PC78

reticulated area proposal in that it used catchment models (the SMWBM) to quantify available surface water resources to fill a number of water storage reservoirs. The catchment modelling report was peer reviewed by David Leong of Tonkin & Taylor, who stated the following on the use of VCSN data:

> "*WWLA's… …use of the rainfall and evaporation datasets from NIWA's virtual climate station network (VCSN) is considered appropriate and pragmatic. Compared with rainfall gauges, there are relatively few actual climate stations with evaporation data, therefore the use of VCSN evaporation is an obvious choice. While there are more rainfall stations, we agree with WWLA that the advantage of the VCSN rainfall is that is provides a temporally and spatially continuous dataset, processed in a consistent way…*"

16. Given the relatively small spatial extent of the of the study area of interest, a single VCSN point (**Figure 1**) (EcoConnect ID 21785), located near Mangawhai township, was used to provide an estimate of local rainfall and evaporation.

17. Annual totals of rainfall and evaporation for this location are presented in **Figure 2**. The average annual rainfall, based on the VCSN point, is 1,285 mm, while annual average evaporation is 1,031 mm.

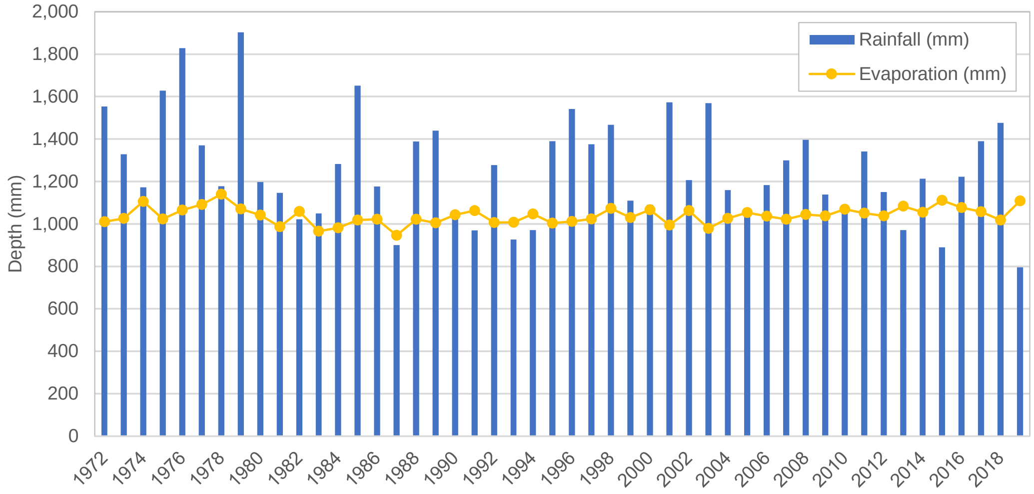


Figure 2. Annual rainfall and evaporation (VCSN ID 21785).

18. A rolling average residual rainfall analysis was undertaken on the VCSN rainfall data to demonstrate historic patterns of rainfall variation (i.e. periods of wetter or dryer than average), and is presented in **Figure 3**. The rolling average residual was calculated as the X years trailing moving average minus the long-term (1972-2019) daily average. A positive residual represents a period of above average rainfall and vice-versa. For example, the period 1976 to 1980 was wetter than usual, while the period 1990 to 1996 was dryer than usual.

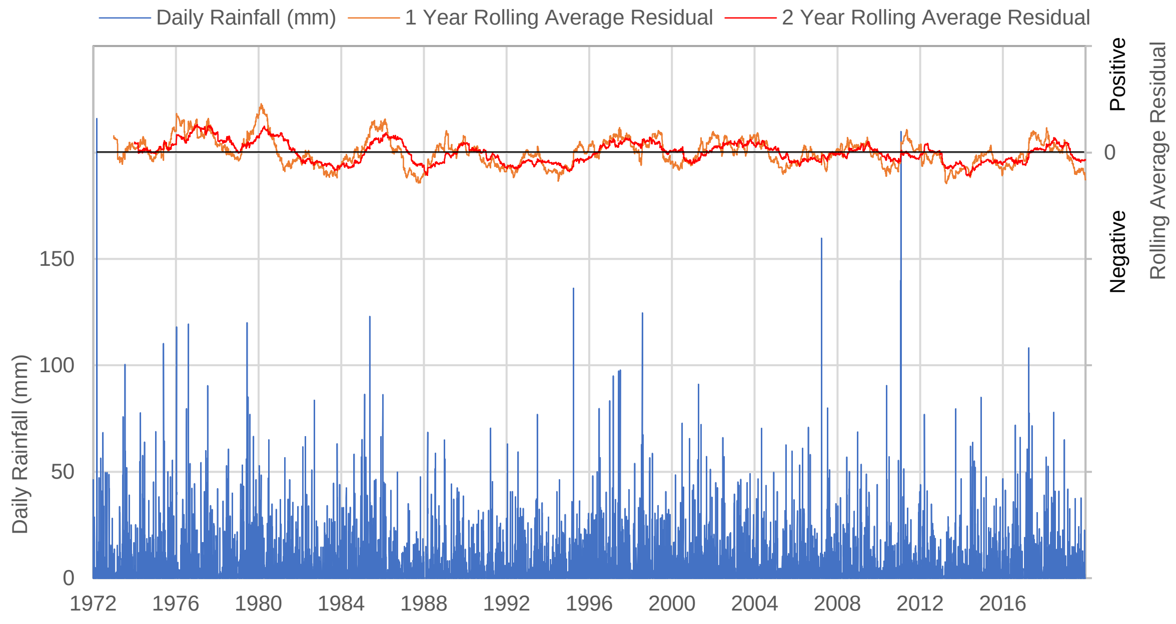


Figure 3. Rolling average residual rainfall analysis.

19. Analyses using future climate predictions were not considered necessary for this area and hence have not been undertaken because:

    a. the latest climate change predictions for Northland for 2090 are fairly neutral with a prediction of 2 to 6 per cent more rainfall in summer, 1 to 17 per cent less rainfall in spring, with autumn and winter rainfall likely to remain fairly neutral; and

    b. there is much uncertainty about climate change predictions given that they depend on predictions of future greenhouse gas emissions that have a high degree of uncertainty, and the models that simulate climate change are still under development and hence changing, which generates further uncertainty in the modelling.

20. Given the above, in my opinion the variability observed in the recent past climate data presents a more certain expectation of what is likely to occur in the near future for this area.

Underlying geology and soil

21. The main geological units underlying the seven surface water catchments are presented in **Figure 4**. The catchments are predominately underlain by the following units as described by GNS QMap:

    (a) Pakiri Formation – An alternating thick-bedded, volcanic-rich, graded sandstone and siltstone.

(b) Northland Allocthon – An alternating thick-bedded, volcanic-rich, graded sandstone and siltstone.

(c) Taurikura Subgroup dacite – Dacite domes and vent-filling breccia, locally altered to halloysitic clay.

(d) Waipapa Group greywacke – Massive to thin bedded, lithic volcaniclastic metasandstone and argillite, with tectonically enclosed basalt, chert and silceous argillite.

22. The predominant soil textures underlying the seven surface water catchments is presented in **Figure 5**. The soils predominately consist of clay loam and silt loam soils, with smaller pockets of fine sandy loam and clay. These soil textures indicate likely relatively low soil infiltration rates across the catchments.

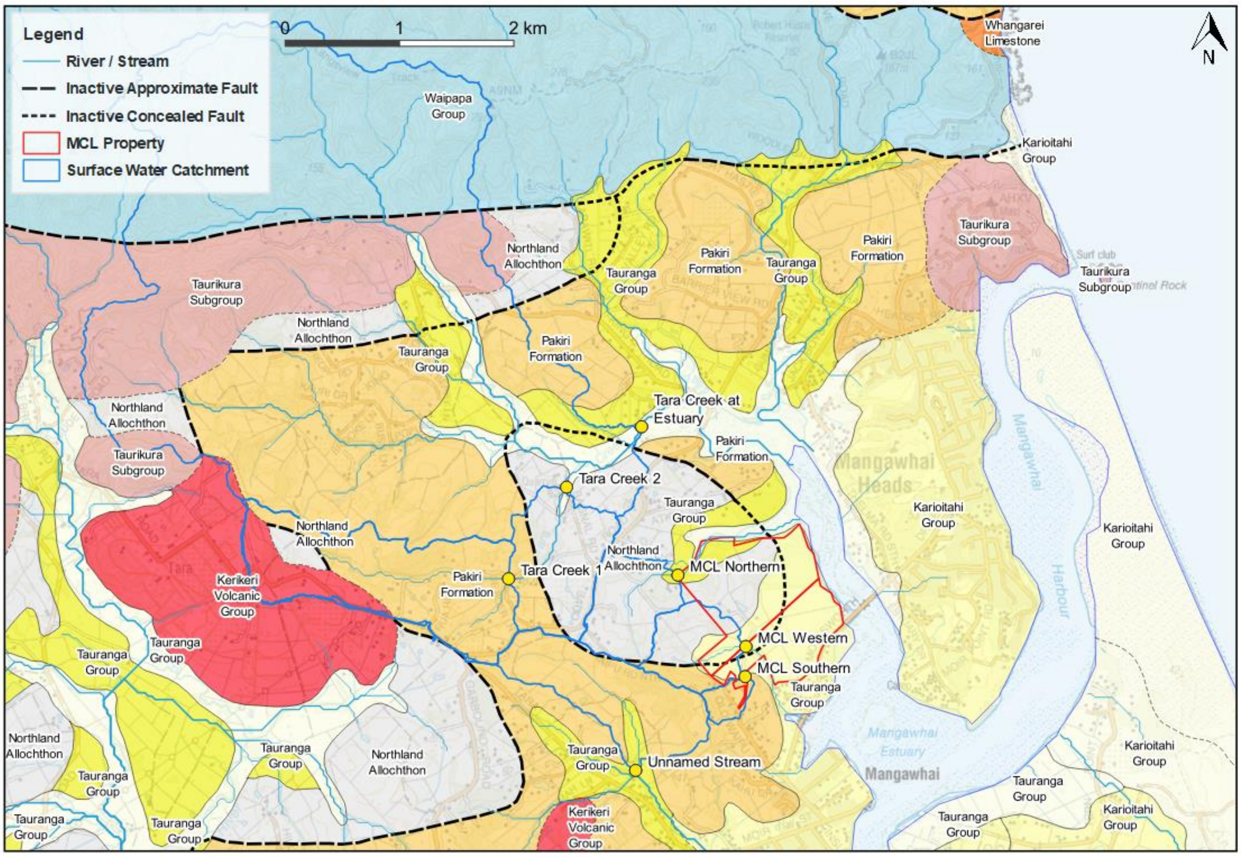


Figure 4. Underlying Geology as per GNS QMap.

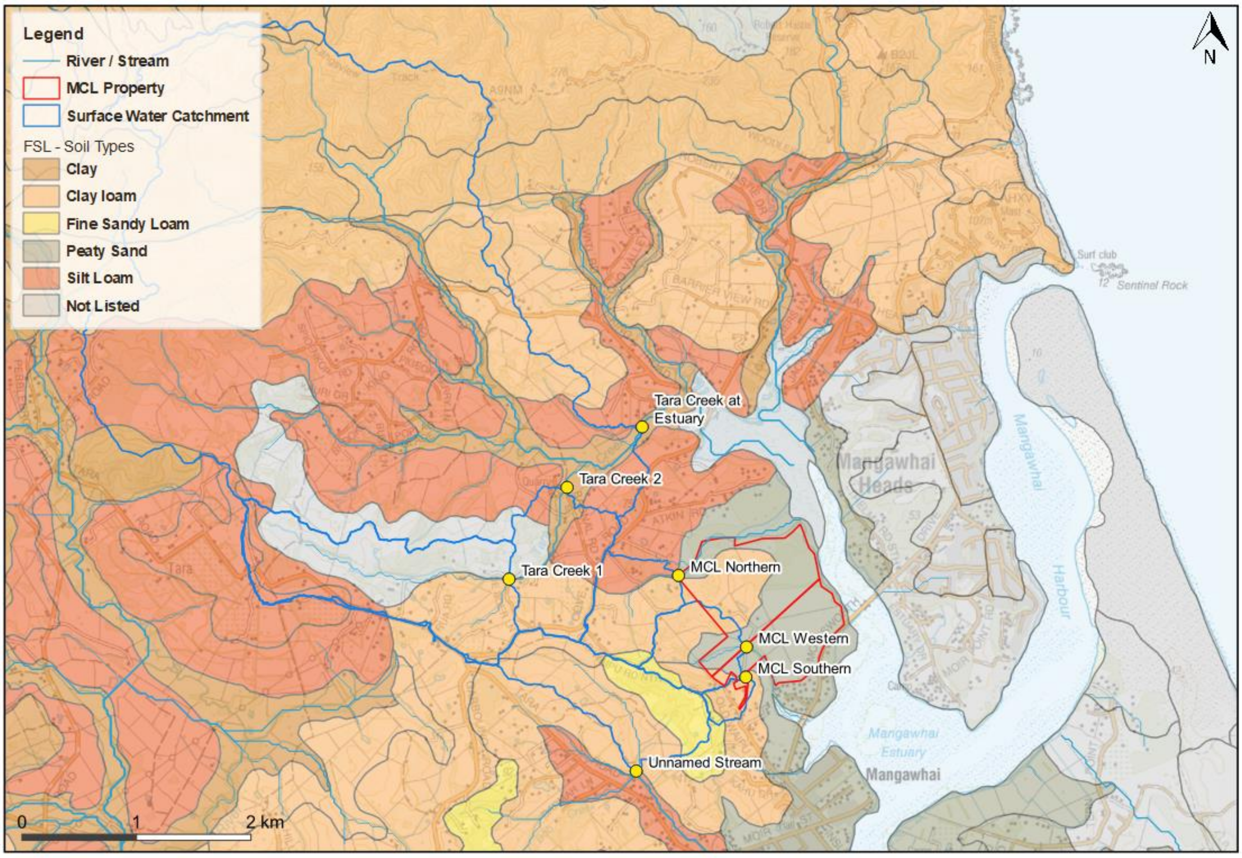


Figure 5. Local soil textures as per Landcare Research Fundamental Soils Layer.

SOIL MOISTURE WATER BALANCE MODEL (SMWBM)

23. In order to quantify local surface water resources, WWLA's SMWBM was used to simulate the daily average historic streamflow regime of the catchments identified in **Figure 1** and **Table 1**, based on the climate data described above.

24. The SMWBM is a semi-deterministic model that is parameterised via relationships to catchment physical characteristics. Model functionality incorporates daily rainfall disaggregation and computation on an hourly timestep during rain events, interception storage, surface runoff, surface ponding, soil infiltration, soil moisture storage, sub-soil drainage, vadose zone flow and groundwater discharges for differing land physical characteristics and use types. For this assessment, the vadose zone flow feature was not required.

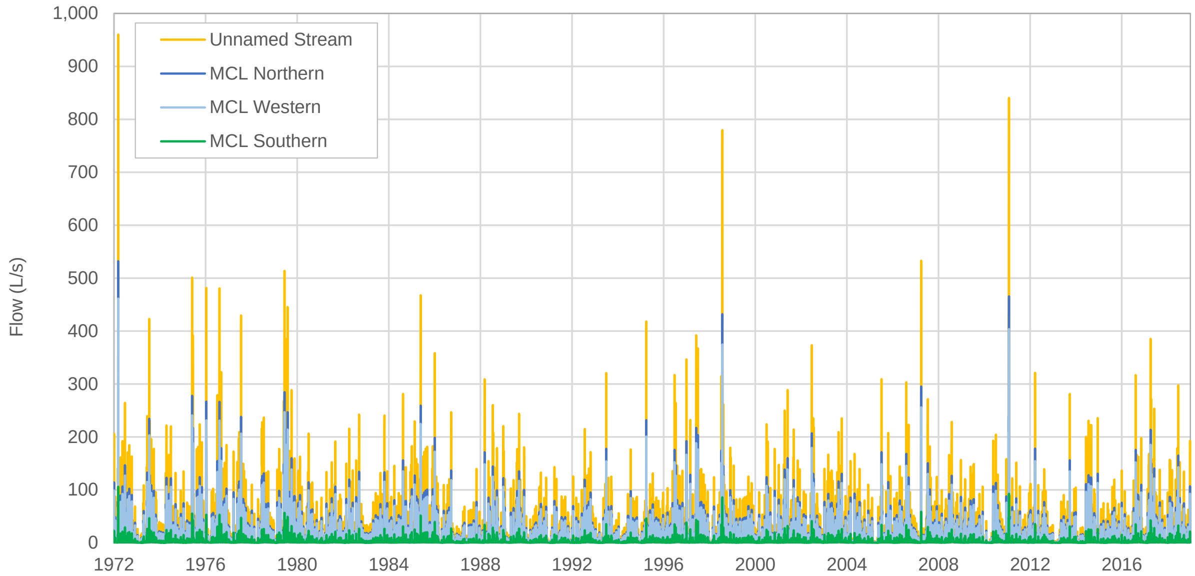
25. As there were no flow monitoring data available on the streams of interest, SMWBM parameters were specified based on the professional judgement and experience of my team and our understanding of the local soil type and underlying geology, as described above.

HISTORICAL STREAMFLOW REGIME

26. The long-term historical streamflow record was simulated for the seven assessment catchments using the SMWBM and VCSN climate data for the period 1972 to 2019. Summary statistics are presented in **Table 2**, and the simulated flow hydrographs are presented in **Figure 6**.

Table 2. Simulated historic streamflow regime – summary flow statistics.

Catchment Name	Area (km^2)	Flow (L/s)				
		Minimum	25%ile	Median	90%ile	Maximum
MCL Northern	0.58	0.4	2.7	4.9	30.4	532.0
MCL Western (Case Study)	0.50	0.4	2.4	4.3	26.4	461.5
MCL Southern (Case Study)	0.12	0.1	0.5	1.0	6.0	105.8
Unnamed Stream	1.05	0.8	5.0	8.8	54.9	960.3
Tara Creek 1	1.83	1.4	8.6	15.3	95.5	1,670.8
Tara Creek 2	2.70	2.0	12.8	22.6	141.2	2,472.2
Tara Creek at u/s Estuary	17.07	12.6	80.5	142.8	891.5	15,603.0



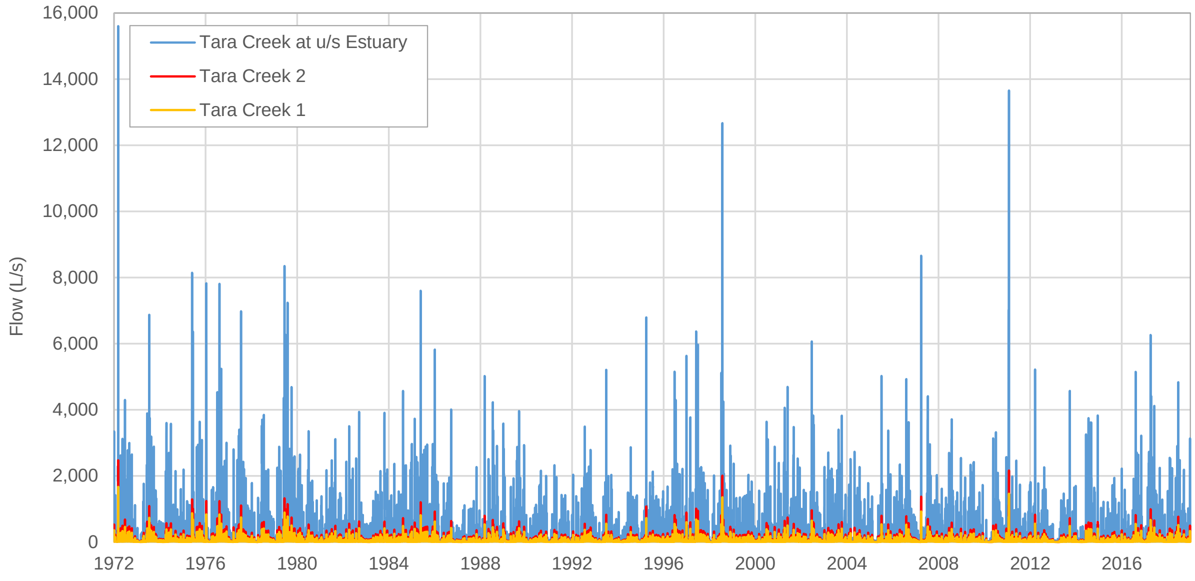


Figure 6. Simulated flow hydrographs.

HARVESTABLE SURFACE WATER AVAILABILITY ANALYSIS

27. As noted in Mr Dufty's evidence, the MCL proposed reticulated area within the PC78 site requires approximately 397 m^3 of water per day (without implementation of any water saving devices or rainwater harvesting) or 303.5 m^3/day (with implementation of water saving devices and supplementary rainwater harvesting as now proposed to be required in the supplementary evidence of Mr Dufty and Mr Tollemache).[5] The reticulated area comprises of 420 residential lots, 200 retirement village lots, and a commercial / retail area.

28. To demonstrate the abundance of high-flow harvestable surface water that could service MCL's reticulated network water requirements, annual volumes of above median flow were calculated for each of the seven catchments. Summary statistics of above median flow annual volumes are presented in **Table 3** (rounded to three significant figures), while **Figure 7** exemplifies how these annual harvestable volumes vary each year for two example/case study catchments and provides a comparison against PC78's annual demand of approximately 110,778 m^3 per annum[6] with water saving devices, or 145,000 m^3 per annum[7] without water saving devices.

5 Mr Dufty's supplementary evidence states that the 303.5 m^3/day demand estimate is conservative because it does not take into account the contribution of supplementary rainwater harvesting with respect to reducing reticulated water demand.

6 MCL's annual demand with water saving devices is calculated from 303.5 m^3/day x 365 days per year.

7 MCL's annual demand of 145,000 m^3 is calculated from 397 m^3/day x 365 days per year.

29. While it is acknowledged it is not physically practical to harvest all flows above median due to the large pump and pipe size requirements for infrequent large flow events, the total harvestable volumes serve to demonstrate:

   a. the abundance of potential harvestable surface water; and

   b. either a combination of small catchments or a single large catchment could meet PC78's entire supply requirements.

Table 3. Simulated historic streamflow regime – harvestable above median volumes.

Catchment Name	Area (km²)	Volume (m³/year)				
		Minimum	25%ile	Median	90%ile	Maximum
MCL Northern	0.58	96,000	193,000	254,000	407,000	551,000
MCL Western (Case Study)	0.50	83,300	168,000	220,000	353,000	478,000
MCL Southern (Case Study)	0.12	19,100	38,400	50,500	80,900	110,000
Unnamed Stream	1.05	173,000	349,000	458,000	734,000	994,000
Tara Creek 1	1.83	302,000	607,000	797,000	1,280,000	1,730,000
Tara Creek 2	2.70	446,000	898,000	1,180,000	1,890,000	2,560,000
Tara Creek at u/s Estuary	17.07	2,820,000	5,670,000	7,440,000	11,900,000	16,200,000

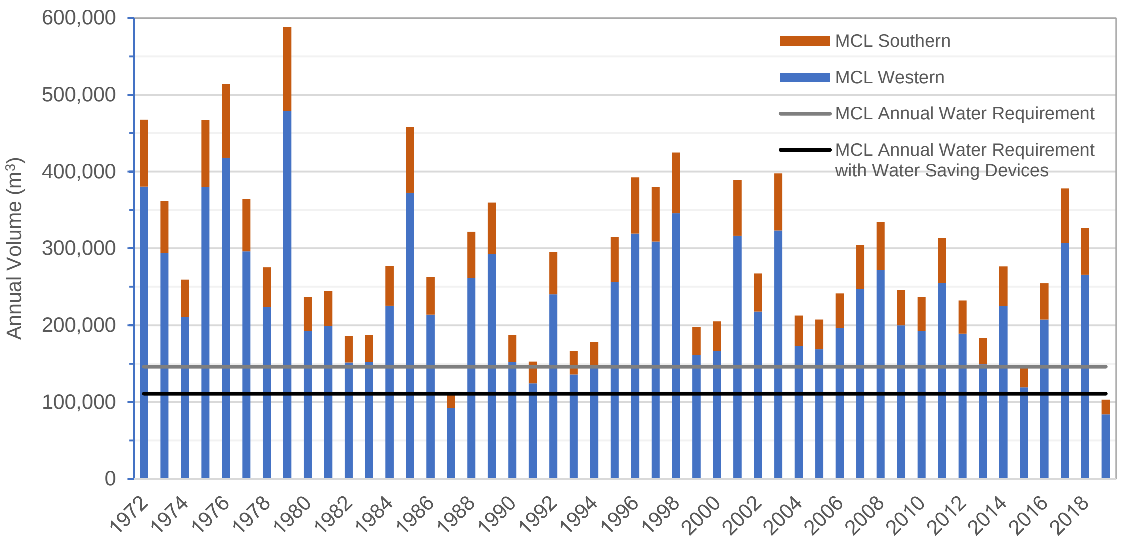


Figure 7. Annual potential total harvestable volumes.

RESERVOIR WATER BALANCE ASSESSMENT

30. To demonstrate the ability for local surface water catchments to provide for the proposed MCL reticulated area development, a case study assessment was undertaken for two water take sites within the PC78 site (MCL Western and MCL Southern).

31. WWLA's Reservoir Storage Model (RSM) was used to determine the reliability of the flow harvested from the two streams with a 100,000 m³ reservoir. 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 model was simulated for the period 1972 through 2019.

32. The following configurations were applied as part of the reservoir storage water balance modelling assessment:

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

(b) A uniform daily demand was assumed to occur for every day of the year;

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

(d) A volume vs. surface area curve was estimated based on the average from a range of reservoirs designed for the ongoing Northland Water Storage and Use Project.

(e) Negligible seepage occurs from the reservoir due to it being synthetically lined with an impervious high density polyethylene (HDPE) liner.

33. Two water takes were configured as inputs into the RSM as outlined in **Table 4**. In order to provide insight into the potential reliability of the reservoir, a range of daily demand water use scenarios were simulated, ranging from 250 m^3/day to 500 m^3/day.

34. An example time series plot showing the simulated change in reservoir storage volume for the 250 and 400 m^3/day scenarios is presented in **Figure 8**. The remaining demand scenarios followed similar temporal patterns, and were omitted from the example figure for clarity.

Table 4. Proposed high-flow takes.

Location	Median Flow (L/s)	Maximum Take Rate (L/s)
MCL Western	4.3	40
MCL Southern	1.0	7.0

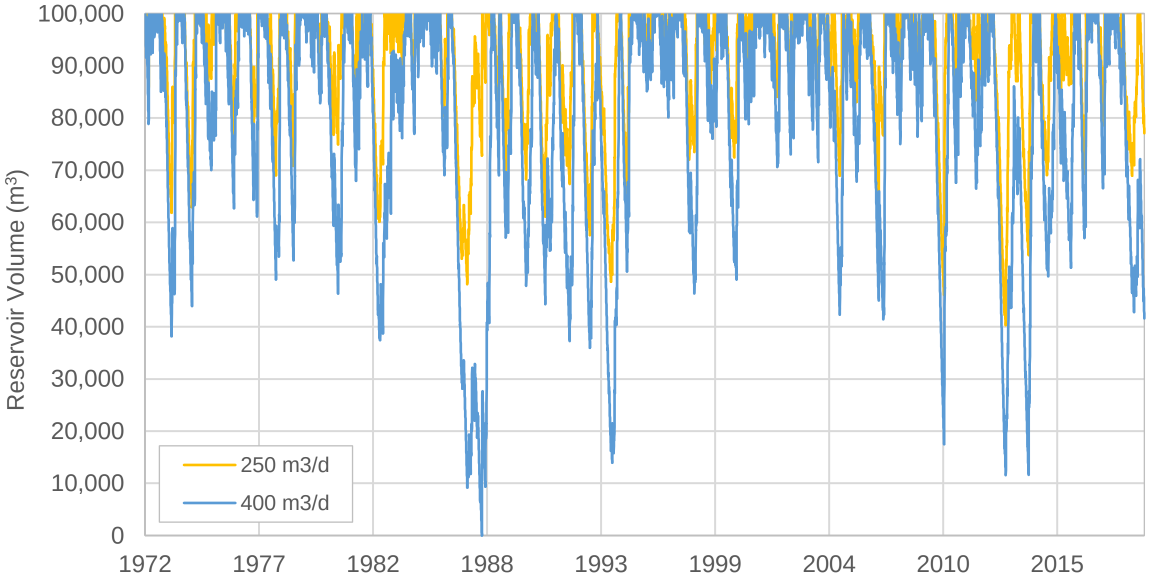


Figure 8. Example reservoir storage volume time series plot for the 250 and 400 m^3/day scenarios.

35. In order to quantify the reliability of the reservoir under a range of daily demand scenarios, the proportion of time the reservoir was simulated as empty during the period 1972 through 2019 was calculated, and presented in **Figure 9.**

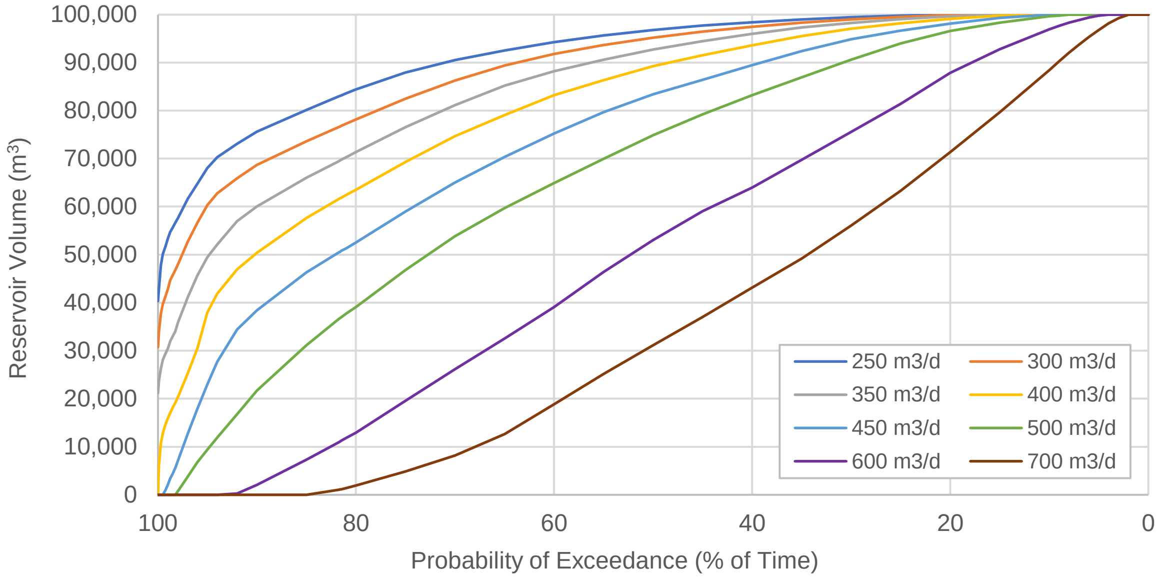


Figure 9. Reservoir volume probability plot for a range of daily water use demands.

36. The percentage of time, and number of days the reservoir was simulated as empty over the duration of the 48-year simulation period is presented in **Table 5** for the full range of daily water use demand scenarios.

Table 5. RSM scenario summary statistics.

Scenario	% Time Empty	No. Days Empty	
		Total	Ave Per Year
250 m^3/day	0	0	0
300 m^3/day	0	0	0
350 m^3/day	0	0	0
400 m^3/day	0	0	0
450 m^3/day	0.5	88	2
500 m^3/day	1.75	307	6
600 m^3/day	6	1,052	22
700 m^3/day	15	2,630	55

37. The example above demonstrates that the two case study water take sites within the PC78 site can reliably support the reticulated area proposed as part of the PC78 development. In summary, the two case study takes could support a demand of 400 m^3/day with extremely low probability of not meeting the demand. This is sufficient to reliably service the estimated PC78 reticulated area demand of 397 m^3/day. In addition, there are additional surface water resources available in the surrounding areas that could also be utilised if additional water was required.

38. The above assessment is conservative in the sense that it does not factor in any contribution that MCL's consented groundwater take (authorising extraction up to 100 m^3 per day) may make in terms of topping up reservoir levels from time to time, as addressed in Mr Dufty's supplementary evidence.

Jon Williamson

18 December 2020