MEMORANDUM

TO:	Olivier Ausseil (Aquanet Consulting Ltd) Stuart Watson (Environmental Services, Ruapehu District Council)
FROM:	Marianne Watson
DATE:	4 December 2020
SUBJECT:	Preliminary hydrology of the Mangaparare Stream including issues of water use and availability with regard to consent to abstract for Ohura's public water supply (PWS)

Hi Team

This memo summarises my current understanding of the supply locality and catchment, outlines what hydrological information is available, makes a preliminary desktop assessment of water availability in the Mangaparare Stream using the available information, outlines what would be required to collect some streamflow data and its cost-benefit, and raises some questions that may have an easy answer, or may require some discussion and possibly lead to further investigation.

Supply Locality and Catchment

Ohura's water supply is pumped from a pontoon located in the Mangaparare Stream immediately upstream of a box culvert under Taranui Street (Figure 1). The box culvert is throttled by a significant weir at its inlet that provides a pond for the pontoon (Figures 2 and 3).

Figure 1 (supplied by Aquanet Ltd)

Figure 2 (supplied by Aquanet Ltd)

Figure 3 (supplied by Aquanet Ltd)

The Mangaparare Stream is a small tributary of the Mangaroa Stream. It flows generally west-east and is joined by the smaller Mangatawa Stream approximately 500m downstream of the abstraction point, before entering the Mangaroa just south of Ohura town. The Mangaroa Stream then flows generally south to its confluence with the Ohura River about 5km upstream of the (Ohura) River Rd (SH 43) bridge near Tokirima (Figure 4).

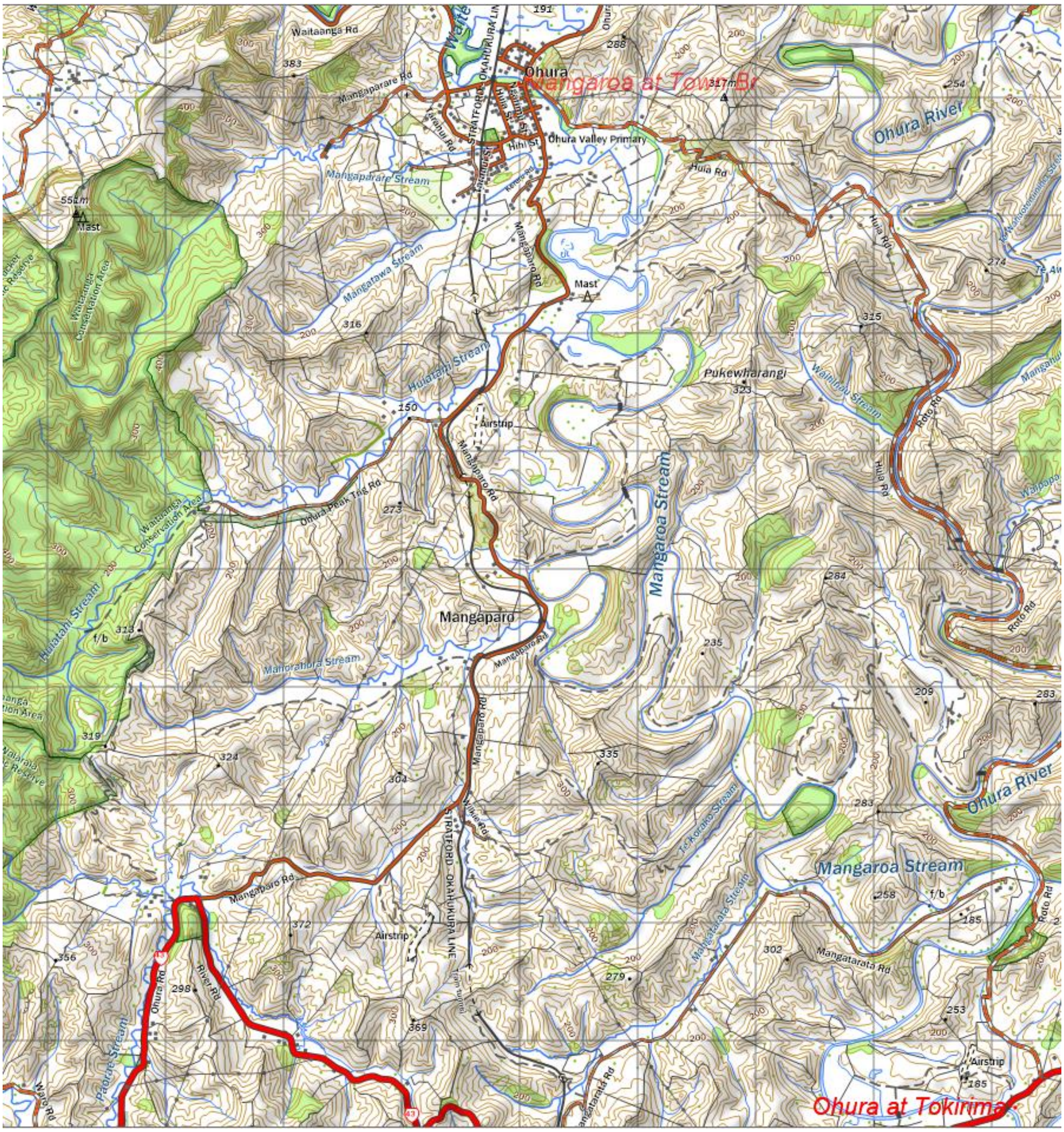

Figure 4 (source Freshmap v20.0)

About 40% of the Mangaparare catchment is in the forested Waitaanga Conservation Area. The remaining catchment is steep pastured hill country and a flat valley floor. Some channel realignment is apparent downstream of Hihi Street, directing the stream around the sportsground (Figure 5).

The Mangaparare catchment is part of the greater Whanganui River catchment and therefore falls within the One Plan Whanganui water allocation planning zone. However, it is near the northern boundary of the Manawatu-Whanganui region and further west than the Ongarue catchment. This area has more in common hydrologically with the southern King Country (Waikato) and northern and inland Taranaki rivers (Figure 6). These rivers are fed largely by north-westerly rain events and drain mudstones that produce runoff with relatively high colour and suspended sediment concentrations but lower than average flow velocities and little in the way of persistent base flows.

Figure 5 (source Google Earth)

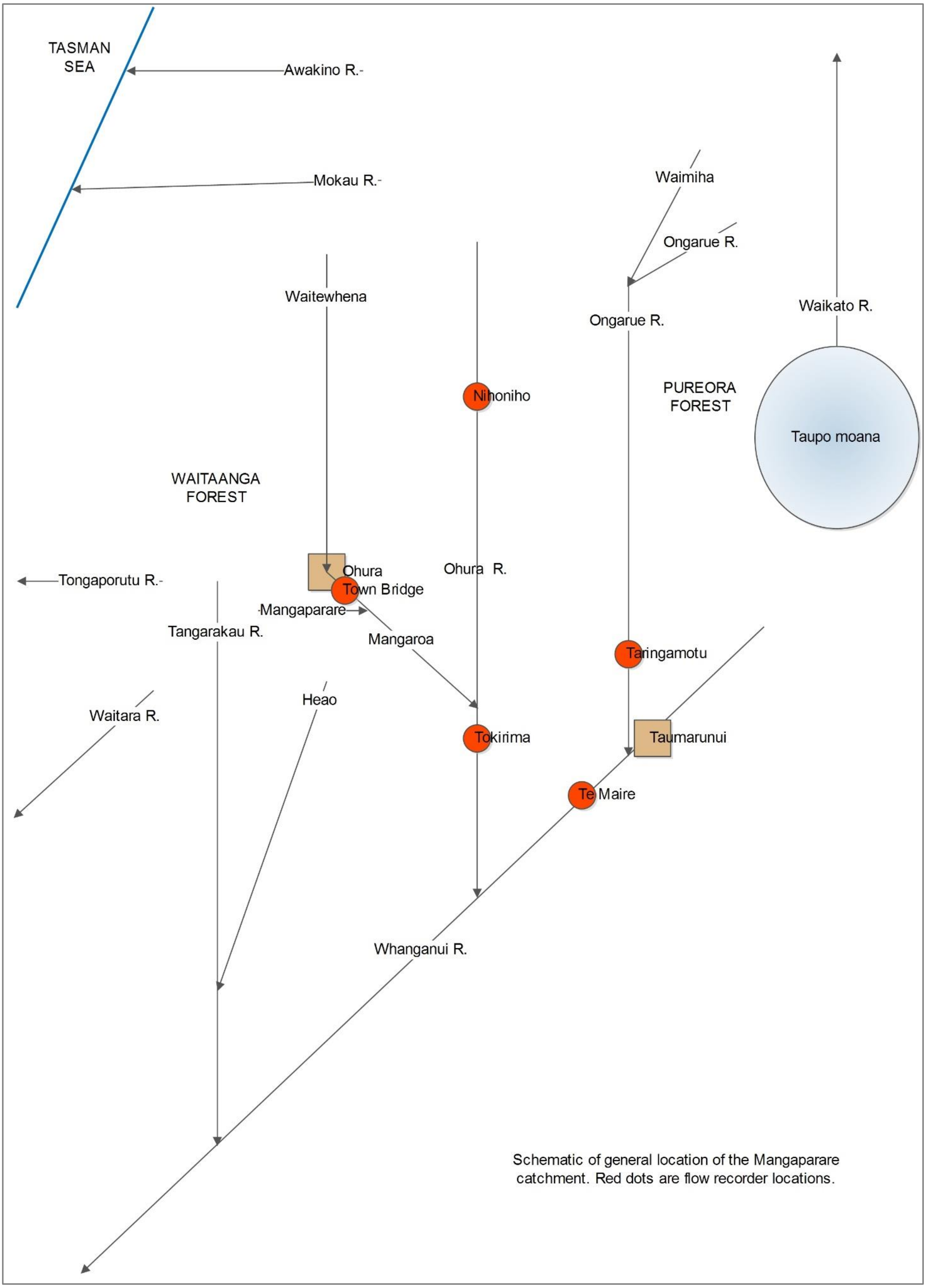

Figure 6

The Mangaroa Stream network and catchment areas as derived from REC v2.4 are shown in Figure 7.

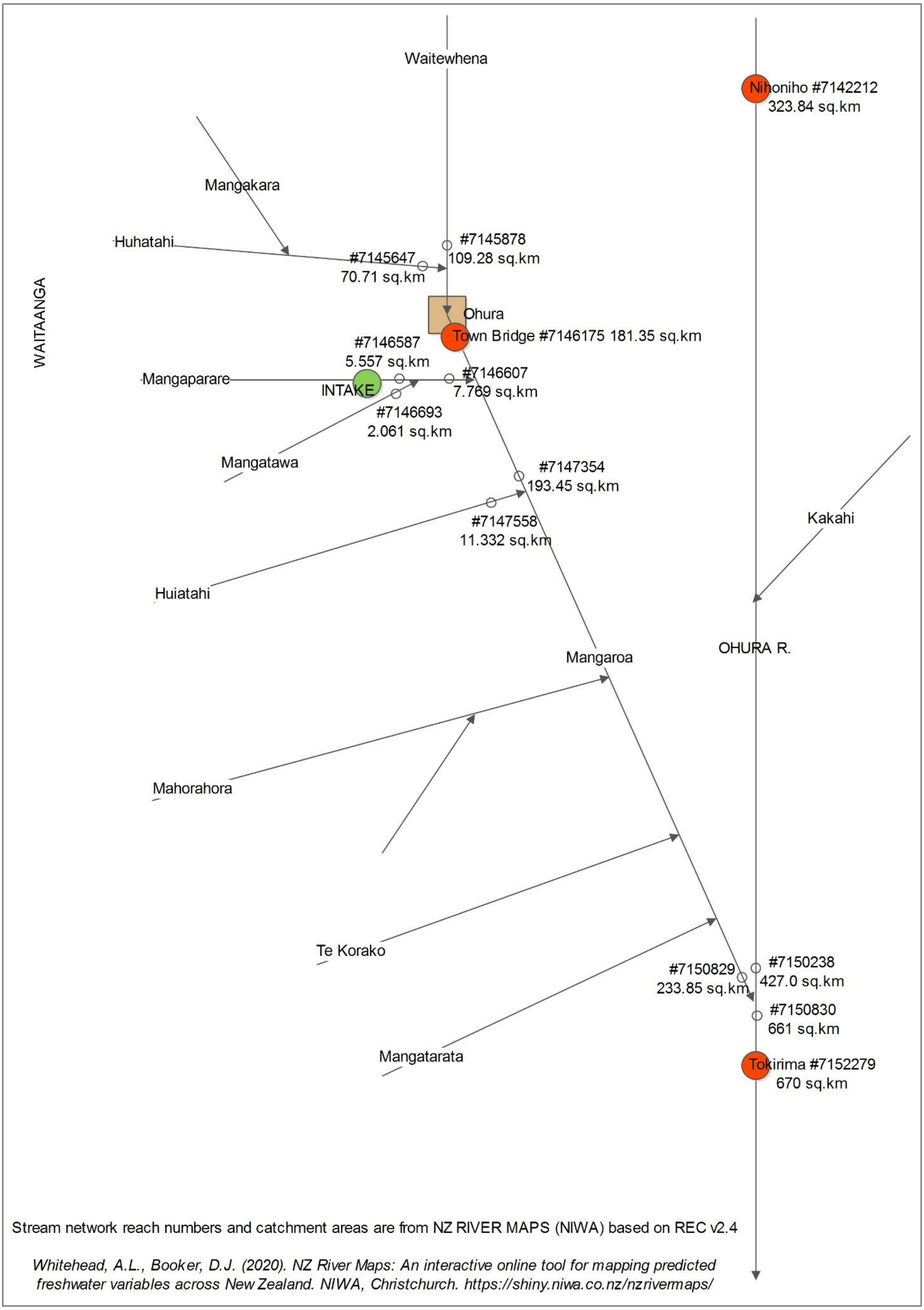
Waitewhena
Nihoniho #7142212
323.84 sq.km
Mangakara
Huhatahi
#7145878
109.28 sq.km
#7145647
70.71 sq.km
WAITAANGA
Ohura
Town Bridge #7146175 181.35 sq.km
#7146587
5.557 sq.km
Mangaparare
INTAKE
#7146607
7.769 sq.km
#7146693
2.061 sq.km
Mangatawa
#7147354
193.45 sq.km
#7147558
11.332 sq.km
Kakahi
Huiatahi
OHURA R.
Mangaroa
Mahorahora
Te Korako
#7150829
233.85 sq.km
#7150238
427.0 sq.km
#7150830
661 sq.km
Mangatarata
Tokirima #7152279
670 sq.km
Stream network reach numbers and catchment areas are from NZ RIVER MAPS (NIWA) based on REC v2.4
Whitehead, A.L., Booker, D.J. (2020). NZ River Maps: An interactive online tool for mapping predicted freshwater variables across New Zealand. NIWA, Christchurch. https://shiny.niwa.co.nz/nzrivermaps/

Figure 7

hydronet environmental monitoring

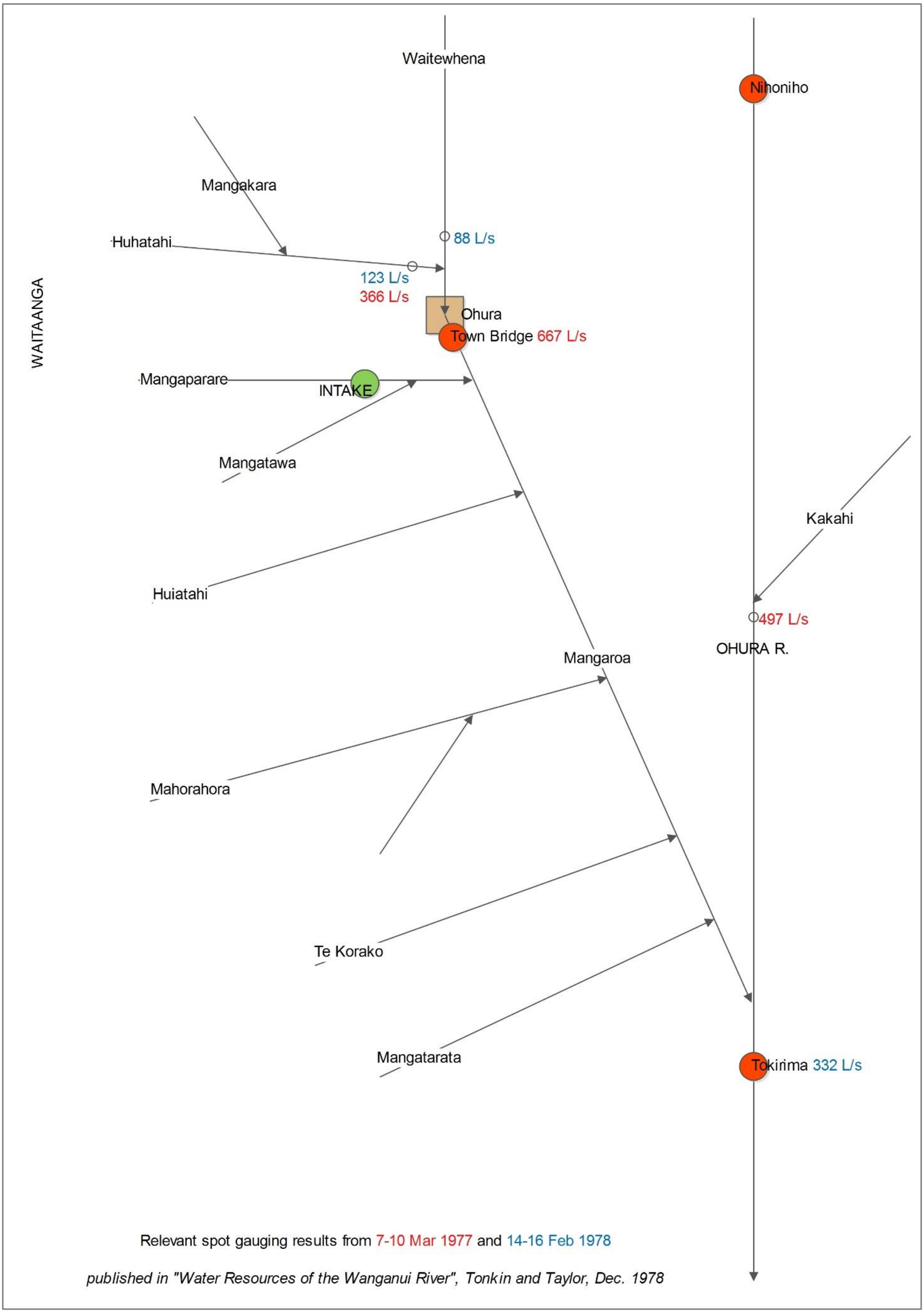

Figure 8

Available Hydrological Information

I have not located any existing actual stream flow data for the Mangaparare Stream.

Horizons is currently operating continuous flow recorders on the Ohura River at Nihoniho and Tokirima (River Rd, SH43 bridge) and on the Mangaroa at the Ohura Town Bridge. Provisional flow information is available on their website in near real time. The Tokirima and Ohura Town Bridge sites were originally installed in the 1960's. Tokirima was operated by the Rangitikei-Wanganui Catchment Board until late 1978 then reopened by Horizons in 2001. Ohura Town Bridge (Mangaroa) was operated by the Ministry of Works until 1971 then reopened more recently by Horizons (thought to be 2014, to be confirmed). Nihoniho was installed by Horizons in 2007. Turbidity is also continuously recorded at Nihoniho and Tokirima.

The flow recording sites have been regularly gauged while the recorders have been in operation to calibrate the relationship required to derive continuous flow records. Spot gaugings also exist for Tokirima and Ohura Town Bridge and the Waitewhena and Huhatahi tributaries of the Mangaroa; obtained as part of the Whanganui catchment water resource study carried out in the late 1970's and reported by Tonkin and Taylor for Rangitikei-Wanganui Catchment Board in December 1978[1]. Relevant results are shown in Figure 8.

Summarised flow statistics for Ohura at Tokirima (site 33313) and Mangaroa at Ohura Town Bridge (site 33341) were compiled by NIWA and published by Horizons in 2007[2]. The Tokirima analysis includes a few years of the recent record and consequently also encompasses a two-decade gap. The Ohura Town Bridge analysis only uses the short record collected in the 1960's. The statistics include flow duration percentiles, mean flow, mean annual flood (MAF), and mean annual low flow (MALF), among others. The mean, range, and quartiles of monthly mean flows are also tabulated. The published statistics for the Mangaroa at Ohura Town Bridge are reproduced below.

Mangaroa at Ohura Town Bridge (1965-70)			
Percentile	Flow (m^3/s)	Percentile	Flow (m^3/s)
0	165.026	90	0.800
10	18.389	91	0.754
20	9.793	92	0.696
25	7.632	93	0.634
30	6.066	94	0.586
40	4.288	95	0.520
50	3.138	96	0.442
60	2.398	97	0.357
70	1.838	98	0.247
75	1.578	99	0.199
80	1.298	100	0.159
mean	7.717		
MALF	0.501		
MAF	126.240		

[1] "Water Resources of the Wanganui River" A report by Tonkin and Taylor for the Rangitikei-Wanganui Catchment Board, December 1978.
[2] "Statistical analysis of river flow data in the Horizons Region" NIWA Client Report CHC2006-154, prepared for Horizons Regional Council, May 2007.

Mangaroa at Ohura Town Bridge Summary Statistics of Monthly Mean Flows (1965-70)												
Flow (m^3/s)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
max.	17.633	22.430	9.324	14.302	21.896	16.068	4.788	9.502	4.531	7.512	14.445	17.757
75%	11.653	13.615	8.630	7.259	17.116	11.547	4.503	7.644	4.460	7.205	12.349	17.470
mean	10.368	11.345	6.760	5.832	11.260	8.460	3.041	4.299	2.465	5.074	9.854	13.744
median	9.339	9.599	7.591	3.591	9.705	7.023	2.667	2.542	1.881	6.596	9.166	16.467
25%	7.749	7.148	4.734	3.372	6.324	5.443	2.015	1.632	0.745	2.199	7.376	8.793
min.	7.315	6.730	3.265	2.790	1.116	2.867	0.982	0.377	0.722	1.837	6.259	8.101

The available Mangaroa gaugings for years 2012-20 are shown associated with their applicable months and the above statistics in Figure 9. Apart from April, the gaugings are reasonably representative of the monthly flow regime. Lowest gauged flow in the last eight years is 287 L/s in March 2015 and it has been gauged on one other occasion at less than published MALF; 418 L/s in January 2020. Note that it would be possible to obtain the recent continuous flow series from Horizons and repeat the NIWA analysis on those recent years and/or the combined record, however the data obtained may require some validation and/or review before use to raise its status above provisional. The gaugings supplied indicate though that the rating is reasonably stable and well defined so this should not involve a great deal of work.

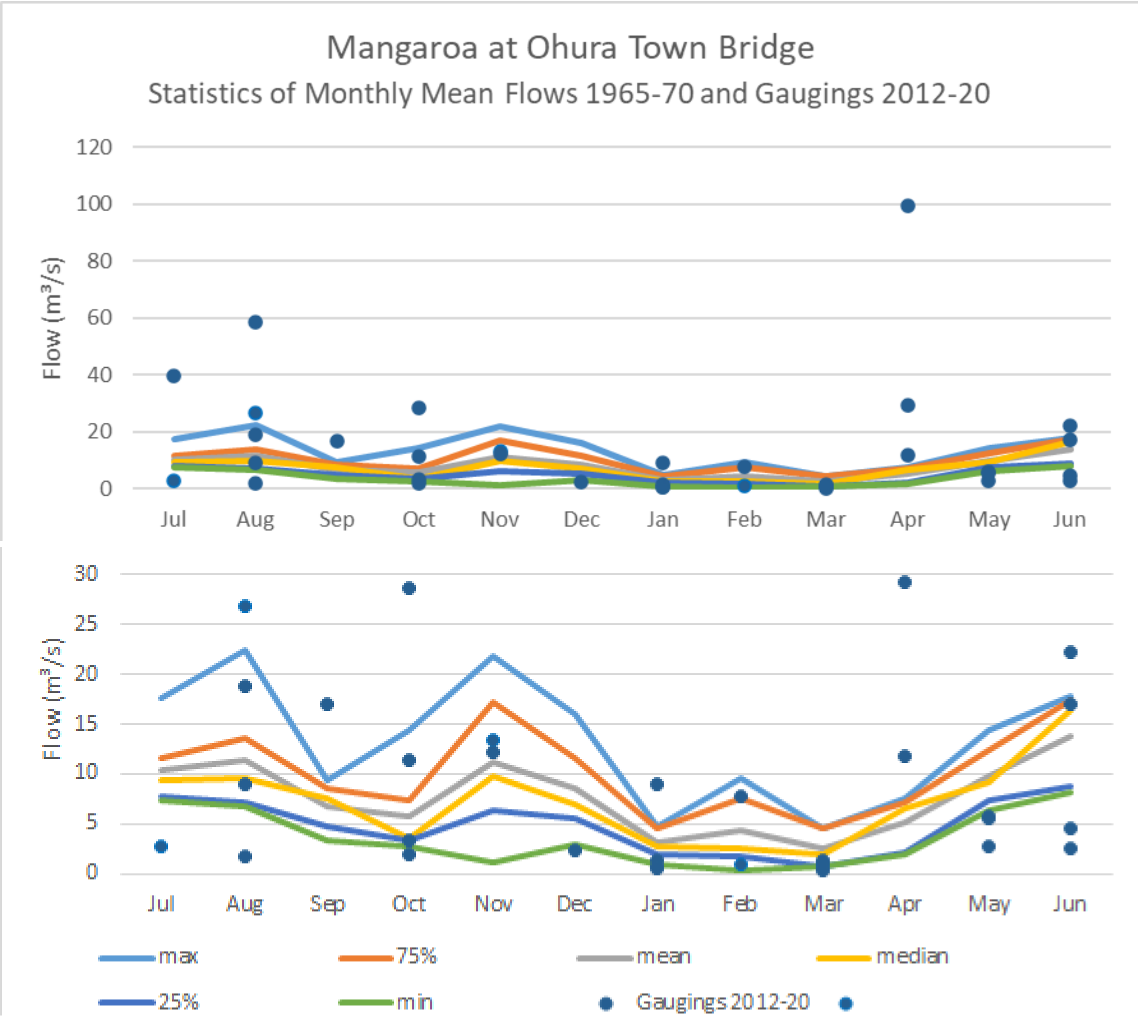

Figure 9

NIWA's NZ River Maps webtool provides estimates of various hydrological, ecological and water quality metrics at reach scale for anywhere in NZ. The tool has been updated to use v2.4 of the River Environment Classification (REC). Drainage areas and various flow statistics are able to be extracted for any location on the stream network as defined by the underlying digital elevation model, but the flow statistics are based on regionalised models and require some circumspect consideration. For the Mangaroa catchment at Ohura Town Bridge the webtool overestimates the lower flows, which is not unexpected given the inland Taranaki mudstones provide relatively little storage to then sustain base flows (Figure 10).

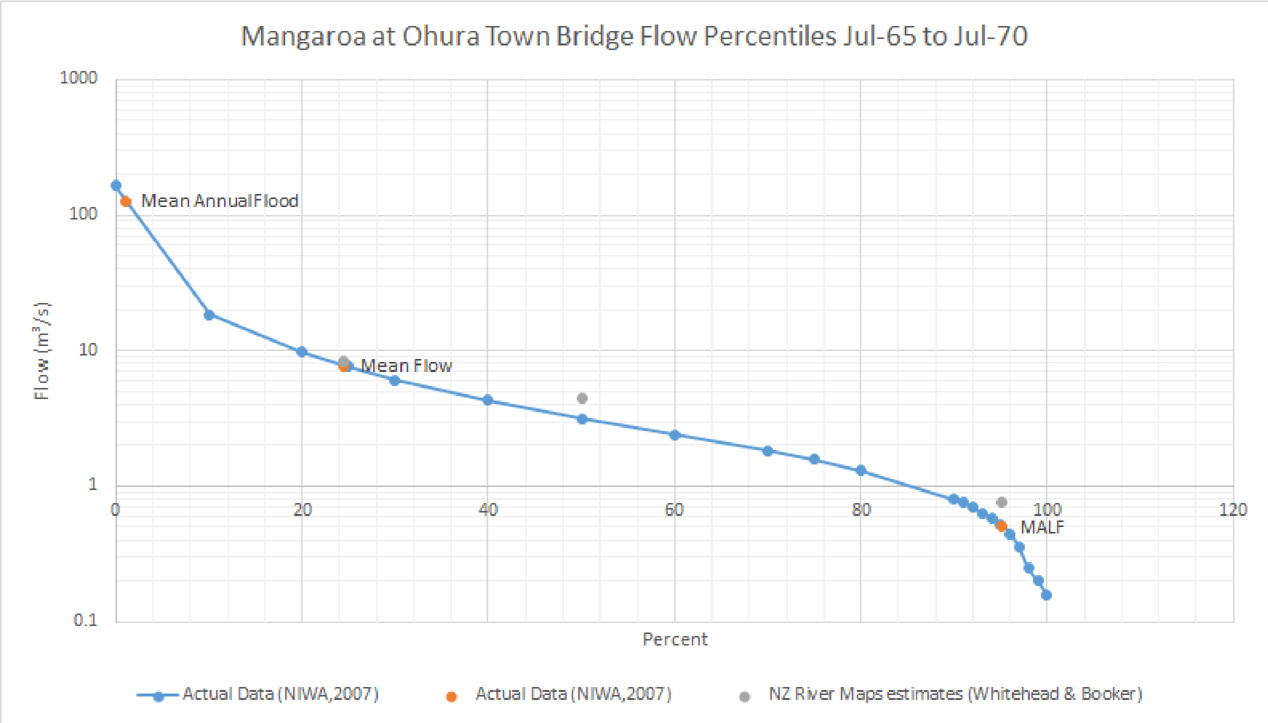

Figure 10

The Mangaroa catchment area above Ohura Town Bridge is 78% of the total Mangaroa catchment area and 27% of the catchment area to the Ohura at Tokirima site (i.e. including the Ohura River). Upper quartile runoff contribution to flow at Tokirima from the Mangaroa above Ohura is in similar proportion to the catchment areas but its low flow contribution increases to about one-third of the total for the lower quartile of runoff, and more than half of the lowest flows recorded at Tokirima. MALF ratio between the two recorder sites is just under one-half. The Mangaroa is therefore an important contributor to low flows in the Ohura River below Tokirima.

Above the Ohura Town Bridge the Huhatahi tributary is 40% of the catchment area and the Waitewhena makes up the remaining 60% but the proportions of extreme low flow contribution to the Mangaroa are the inverse (see Figure 8). At around MALF in the Mangaroa at Ohura Town Bridge the Huhatahi tributary likely contributes about 55% of the flow. The Huhatahi is a much bigger stream than the Mangaparare and extends further west into the thickly forested divide between the Whanganui River catchment and the Taranaki rivers. It is likely to have higher base flows and experience more light rainfall events than the Mangaparare. Given these characteristics and the Mangaparare's location adjacent to and south of the Huhatahi I believe it is reasonable to estimate flows in the Mangaparare using yields derived directly from the Mangaroa at Ohura Town Bridge flow records.

Water Availability (given current information)

The statistics tabulated below are estimates for the Mangaparare Stream at the Ohura PWS intake on Taranui Street derived by multiplying the Mangaroa at Ohura Town Bridge statistics reproduced previously, by the catchment area ratio of 5.557/181.35 obtained via NZ River Maps from REC v2.4 (Figure 7). High flows and therefore the mean flow and monthly mean flows in the wetter months are probably over-estimated given the apparently acceptable severe throttling of the box culvert. Basically I would be surprised if a mean annual flood of near 4 m^3/s would fit through the throttled culvert inlet and therefore, if that were a reasonable estimate of MAF, I would expect the pontoon and road to have sustained some damage due to overflows on average once or twice every two years or so.

FLOW ESTIMATES Mangaparare at Ohura PWS Intake			
Percentile	Flow (L/s)	Percentile	Flow (L/s)
0	5057	90	25
10	563	91	23
20	300	92	21
25	234	93	19
30	186	94	18
40	131	95	16
50	96	96	14
60	73	97	11
70	56	98	8
75	48	99	6
80	40	100	5
mean	236		
MALF	15		
MAF	3868		

ESTIMATES OF MONTHLY MEAN FLOW STATISTICS Mangaparare at Ohura PWS Intake												
Flow (L/s)	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
max.	540	687	286	438	671	492	147	291	139	230	443	544
75%	357	417	264	222	524	354	138	234	137	221	378	535
mean	318	348	207	179	345	259	93	132	76	155	302	421
median	286	294	233	110	297	215	82	78	58	202	281	505
25%	237	219	145	103	194	167	62	50	23	67	226	269
min.	224	206	100	85	34	88	30	12	22	56	192	248

As a sanity check, estimates from the NZ River Maps webtool for the Mangaparare above the Mangatawa confluence (reach #7146587) are mean flow 251 L/s, median flow 136 L/s, and mean annual low flow 25 L/s.

Combining these estimates and the supporting information together I think prudent ‘design’ flows at the intake are mean flow 240 ± 10 L/s, median flow 110 ± 20 L/s, and MALF 20 ± 5 L/s. Critical season in terms of likely low flows is Jan-Apr inclusive, with lowest flows expected in March.

Further Data Collection

With a flow recording station located on the Mangaroa at the Ohura Town Bridge it is possible to check the assumptions made about relative runoff with some spot gaugings in the Mangaparare. For the purposes of consenting a water take under the One Plan these should be targeted to a low flow period i.e. during March. Ideally a minimum of five or six gaugings on separate occasions should be obtained. If Hydronet was to do these it would make sense to make three overnight trips and gauge on each of the two days at site. Likely cost per trip is of the order of $1600 excl. GST including travel, accommodation, and time back in the office processing results. The pump would need to be off for the duration of each gauging and the hour beforehand. Flow in the box culvert may be too shallow for the gauging equipment and the pond above too slow so a suitable location away from the culvert would need to be found and be accessible. Spot gaugings would only serve to either improve confidence in the flow estimates already obtained or provide alternative yield proportions to revise those estimates.

Obtaining a continuous record of flows requires the installation of a sensor and development of relationships that allow flow to be derived from the sensor measurements. Gaugings are required to calibrate the relationships, initially fairly frequently then repeated each time the relationship is suspected to have changed. The presence of the pump, pond and throttled culvert complicate the hydraulics such that the cheaper methods cannot be used in the vicinity of the influence of the pond and pump.

If it is necessary to install the continuous sensor downstream of the pump and weir, the pump rate of take must be calibrated and continuously recorded too, so the abstracted flow rates can be added to the residual stream flows derived from the sensor to obtain stream flow above the intake.

To use a conventional water level sensor, it must be located where the pump and pond will have no influence on the water levels but close enough to represent stream flows at the intake. How far upstream it would need to be to avoid the variable slope and backwater issues would require some reconnaissance. Given the generally flat valley floors in the area it could be some distance upstream and access over private land may then pose a problem.

A conventional water level sensor could be used downstream, but if placed in the box culvert it would need to be capable of 1mm accuracy or a V-notch weir installed in the culvert outlet to obtain satisfactory low flow resolution. Both these options add cost to the estimates provided below. It is also likely that, if placed in the culvert, unstable hydraulic conditions would develop at higher flows that would render the flow data in the affected range unreliable. This may not be a problem if knowledge of mean and flood flows is not needed. As described above the pumped abstraction rate would also need to be known. There may be other suitable sites further downstream but again some reconnaissance is required, and access, power supply, and/or site security may be issues.

Index-velocity techniques would allow data collection and derivation of flows under the variable hydraulic conditions. An up-looking submersible ADV or non-contact down-looking velocity radar could be used in the box culvert near the outlet, although low flow depths in the culvert may be too small for the submersible option. A side-looking ADV would likely be better than a submersible up-looker if installation in the pontoon pond is preferred; an up-looker would be prone to burial by silt and weed. These instruments are typically an order of magnitude more expensive than a simple water level sensor. Gaugings are still required to calibrate the relationships between sensor measurements and stream flow.

If a suitable location for a conventional water level sensor and stage-discharge rating exists, to install and operate the site for the first year would cost in the order of $15,000 excl. GST. If index-velocity instrumentation is needed, the instrument purchase and installation costs alone would be of this order and servicing, maintenance and gauging would add about another $10,000 excl. GST in the first year.

For a community like Ohura I think this sort of money is better spent investing in demand reduction, quality improvements, and supply facilities that can operate at the abstraction rate of the currently consented 15 m^3/hr or less, i.e. ≤ 4 L/s (20% of estimated MALF). If development and/or population growth is anticipated and more than the currently consented daily volumes may be needed over the life of the consent this investment may be better directed at an alternative larger supply, because as with the other District supplies, I expect Horizons would require restrictions on the abstraction focused on essential uses that would reduce the rate of take to no more than 20% of estimated MALF during periods of low flows regardless.

<u>Questions and Knowledge Gaps</u>

The planning framework summary prepared by Deborah Kissick states consent 101866 allows Ruapehu District Council to take water from two sites on the Mangaparare Stream but only shows the Taranui Street pump pontoon. I do not know anything about the other consented location and therefore do not know where it is, whether it would experience significantly different water availability, how the abstraction is distributed between the two locations, nor whether the abstraction summary Deborah provided is for one or both locations.

The 2013 census, and news media articles since, have Ohura's resident population at around 130. The 100 or so bed prison closed in late 2005 with the facility operating since as a bed and breakfast and backpackers' hostel. The current consent is for 360m^3/d at a maximum rate of 15m^3/hr. This is a large amount of water for a permanent population of 130 and a town with no industry and little in the way of commerce. I am not aware of significant numbers of holiday homes and therefore seasonal population variations in Ohura as there is for Owhango, nor large numbers of lifestyle blocks, or reticulated farm supplies, or industrial uses serviced by the Ohura PWS. A reasonable and essential use analysis is needed and may not justify these quantities.

Further, the actual abstraction summary provided by Deborah, and reproduced below for convenience, shows that in three of the last four years the maximum daily take has exceeded the consented volume, the consented maximum flow rate was substantially exceeded in all four years on numerous occasions, and the average daily take has been steadily increasing over the last four years. Average daily take for 2019/20 is reported as 180m^3/d i.e. an average of 1385 L/head/day. Why is actual water consumption apparently so high? Why is it apparently increasing year on year? Can it be reduced? Note I do not as yet have the detailed water use records for this supply nor a reticulation network map so I have no idea of the quality of the abstraction data or the extent of the reticulated supply beyond the town, if any.

According to Deborah's summary, maximum daily take volumes are at least twice the average. Minimum daily take is next to nothing and possibly only non-zero because of metering/recording uncertainty. Together these observations imply the pump is not running every day. The currently consented maximum rate of take of 15m^3/hr means that the abstraction must occur over a full 24 hours to abstract the maximum daily volume without breaching consent. Is the pump capable of running every day? Is it capable of running continuously?

From comments in Deborah's planning framework summary I gather that the abstraction infrastructure may be upgraded or replaced. I believe it would facilitate the consenting process if abstraction rate could be kept to no more than 4 L/s if the Mangaparare is to remain the source of supply for the town.

Abstraction Summary: Source: D Kissick, Traverse Environmental, Nov-2020

Ohura WTP				
Consent Daily Abstraction	360m³			
Consent Maximum Daily (Abstraction) Flow Rate	15m³/hour			
	2016/2017	**2017/2018**	**2018/2019**	**2019/2020**
Minimum daily take (m³)	12	79	71	72
Maximum daily take (m³)	500	335	393	500
Average daily take (m³)	148	169	169	180
Number of exceedances	2	0	1	3
Minimum daily flow rate (m³/hour)	0	14	12	0
Maximum daily flow rate (m³/hour)	26	26	45	45
Average daily flow rate (m³/hour)	15	15	15	14
Number of exceedances	81	12	24	30

Marianne Watson