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10/06/2020

**HYDROMETRIC NETWORK  
– REGIONAL FLOW  
ASSESSMENT MEMO**

## Hydrometric Network – Regional Flow Assessment Memo

This memo has been prepared for Healthy Waters to provide a better understanding and assessment of the historical quality of the hydrometric network and how representative the existing SOE network is in terms of representing the wider regional flow dynamics.

The existing SOE network is not necessarily representative of wider regional flow dynamics;  
To ensure the development and calibration of the FWMT v1 is defensible, greater certainty is needed about the availability, quality and representivity of hydrometric datasets available to AC.

Please do not hesitate to contact us if you have any questions on this document,

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## 1. Introduction

Healthy Waters is currently undertaking the development of a new regional Freshwater Management Tool (FWMT). One of the main data inputs for this model is the regional hydrometric network, which is being utilised to calibrate the flow/discharge component of the FWMT v1.

Presented in the sections below is a summary assessment of the raw hydrological data and sites. This assessment is to better understand and assess the historical quality of the hydrometric network included in the FWMT v1, and how representative the existing network is in terms of representing the wider regional flow dynamics.

To ensure the development and calibration of the FWMT v1 is defensible, greater certainty is needed about the availability and quality and of hydrometric datasets available to AC.

## 2. Data quality summary

The Auckland hydrometric flow network consists of two networks, the State of the Environment (SoE) network and the Healthy Waters flow network. Both networks are managed internally in Council by RIMU. Since the amalgamation to the Auckland Council in 2010 these networks have been managed to the National Environmental Monitoring Standards (NEMS) for level which prescribes how water level and flow monitoring is carried out and to which standard the data is assigned, depending on site location instrumentation, field calibration, this standard also includes how the data is managed and transformed when recorded outside given error bands. <https://www.lawa.org.nz/media/16578/nems-open-channel-flow-measurement-2013-06.pdf>

Councils internal database Hydstra, does not allow the NEMS code to be applied however the codes are “mapped” across to the internal Hydstra codes with Quality Code 10 (QC10) data being the best quality data and QC40 and above being less reliable as per Table 1

Table 1: Hydstra NEMS Quality Codes

NEMS Quality Code	Hydstra Quality Code	Description
<b>600 – Best quality</b>	10 – Best quality	Original record to Q/A standards
<b>500</b>	20	Good quality edited data
<b>400</b>	30	Measured data – unknown quality
<b>300</b>	40	Poor quality suspect data
<b>200 – Poor quality</b>	140 – Poor quality	Undefined – unprocessed
<b>100</b>	Gap	Gap – missing record

The level quality results for 2012-2017 are presented in Table 2. This table highlights that since 2012 the level quality recorded across the network has been at the highest standards (< QC 20) across most of the sites and observations. This is reflective of all the sites being managed by one entity RIMU and to one standard. This can also be seen over time in the quality plots in Appendix 1.

Many of the sites over the 2012-2017 period have greater than 90% reliable data, with 30 site locations have greater than 95% reliable data.

Makarau @ Coles, Oratia @ Parrs Cross and Waitangi@SH5 bridge are exceptions to this, as this data is sourced from other agencies and have not been through the Councils QA processes. This data is sourced from the National Institute of Weather and Atmosphere (NIWA) and will still be collected to a robust standard, however, should be flagged and considered as potentially data of a lesser standard to that sourced from Council.

Table 2: Level Quality Summary 2012-2017

	Data Quality 2012 – 2017							
	Site	10	20	30	40	140	Gap	Reliable data <20
Alexandra @ Rosedale Rd.	7834	60.5	38.92	0	0	0.27	0.22	99.42
Ararimu River @ Old North Rd Bridge	45326	88.6	1.86	0	0	6.58	2.87	90.46
Awaruku stream at Glenvar Road	7516	90.35	5.17	0	0	0	0.82	95.52
Eskdale Stream at Lauderdale Reserve	7706	80.05	14.65	0	5.19	0	0.11	94.7
Hillcrest Stream at Hillcrest Avenue	7609	75.02	2.82	0	0.07	0	22.09	77.84
Hoteo River @ Gubbs	45703	78.5	20.28	0	0	0	1.21	98.78
Kaipara River @ Waimauku	45311	61.68	25.7	0.9	11.38	0	0.33	87.38
Kaipatiki Stream at Kaipatiki road	7719	94.96	5.03	0	0	0	0.01	99.99
Kaukapakapa @ Taylors	45415	70.53	26.58		2.65	0.07	0.17	97.11
Kumeu @ Maddrens Weir	45315	55.29	7.61	0	2.43	0	34.67	62.9
Lucas @ Gills Road	7830	72.88	26.98	0	0	0	0.14	99.86
Mahurangi @ College	6806	97.25	0.51	0.81	1.43	0	0.01	97.76
Mahurangi Argonaut @ College	6863	52.68	46.92	0	0	0	0.4	99.6
Mairangi Bay Stream at Tennis Club	7514	71.43	27.54	0	0.29	0	0.74	98.97
Makarau at Coles	45504	0	0	100	0	0	0	0
Mangawheau Stream @ Weir	8529	87.56	10.47	0	1.8	0	0.17	98.03
Mangemangeroa	8304	68.48	31.44	0	0	0	0.07	99.92
Meola Creek at Motions Road Weir	8106	66.68	33.28	0	0	0	0.04	99.96
Motions Stream @ Western Springs.	8104	47.32	51.33	0	1.25	0	0.09	98.65
Newmarket Stream @ AYR Street crump weir	8176	98.38	1.6	0	0	0	0.02	99.98
Ngakoroa Stream @ Mill Rd	43829	64.31	33.33	0	2.3	0	0.06	97.64
Oakley Creek at Richardson Road	8128	79.44	3.91	13.97	0.77	0	1.91	83.35
Okura Creek @ Awanohi Rd	7502	20.61	3.24	2.72	6.22	0	67.22	23.85
Okura @ Weiti Forest	7505	87.66	6.64	0.49	2.66	0	2.55	94.3
Opanuku @ Vintage Reserve	7912	93.85	6.13	0	0	0	0.02	99.98
Opanuku Stream @ Candia Road Bridge	7904	27.77	64.59	0	5.73	0	1.91	92.36
Oratia @ Parrs Cross Road	7909	0	0	30	0	0	0	0
Oratia @ Millbrook Road	7911	44.22	53.7	0	0	2.05	0.03	97.92
Orewa @ Kowhai Ave	7202	93.39	3.83	0	2.77	0	0.01	97.22
Otara @ Hills Road Bridge	8208	89.72	9.85	0	0	0	0.43	99.57
Oteha River @ Days Bridge	7811	84.82	14.1	0.01	0	0	1.07	98.92
Papakura @ Great South Road Bridge	43803	62.02	34.9	0	2.78	0	0.3	96.92
Puhinui @ Drop Structure	43807	99.14	0.59	0	0	0	0.26	99.73
Rangitopuni River @ Walkers	7805	75.73	21.17	1.52	0	0	1.58	96.9
Swanson Stream @ Woodside Reserve	7907	67.8	26.26	0	5.35	0.42	0.16	94.06
Taiāotea stream at Freyberg Park	7515	83.68	14.88	0	1.42	0	0.02	98.56
Taiorahi Stream at Westbourne ave	7519	84.61	2.14	0.01	4.44	6.95	1.86	86.75
Tamahunga River @ Quintals Falls	6501	84.94	4.86	0.4	9.76	0	0.03	89.8
Tamaki Trib at Bowden Road Crump Weir	8222	95.69	2.06	0	0.04	1.53	0.67	97.75
Vaughn Stream @ Lower Weir	7506	66.25	30.63	0	2.2	0	0.92	96.88
Wairau Creek @ Chartwell Road	7607	76.84	22.97	0	0	0	0.29	99.81

Wairau Creek @ Motorway	7604	63.95	34.6	0	1.43	0	0.02	98.55
Wairoa River @ Tourist Road	8516	96.48	3.52	0	0	0	0	100
Waitangi @ S H Bridge	43602	0	0	30	0	0	0	0
Waiteitei River @ Sandersons	45705	90.44	8.64	0	0	0.91	0.01	99.08
Waiwhiu Stream @ Dome Shadow	45702	54.62	12.44	3.55	0	0	29.39	67.06
West Hoe @ Halls	7206	79.49	12.61	0	4.22	2.66	1.03	92.1
Whangamaire @ Patumahoe Weir	43811	39.28	7.68	0	16.17	0	36.87	46.96
Whau Stream at Blockhouse Bay Road Crump Wier	8006	60.74	33.02	0	6.17	0	0.06	93.76

## 2.1. Calibration site level quality

The level data quality of the calibration sites is presented in Table 3. For the period of calibration, most of the data is good quality with very few gaps and poor-quality records. The data for two sites used for the calibration Oratia @Parrs Cross Road and Waitangi @ SH1 are externally sourced (NIWA) and therefore have no quality codes associated. There is potentially less certainty of the data for these two sites, however, there is insufficient evidence to exclude them from the calibration network within the FWMT Stage 1 (i.e., where regionalised build is occurring in the absence of targeted monitoring and for regional purpose, the inclusion of the two sites is unlikely to distort overall regional configuration).

Table 3: Calibration site level quality

Data Quality 2012 - 2017 (Calibration sites)								
	Site	Quality (%)						
		10	20	30	40	140	Gap	Reliable data <20
Kaukapakapa @ Taylors	45415	70.53	26.58		2.65	0.07	0.17	97.11
Lucas @ Gills Road	7830	72.88	26.98	0	0	0	0.14	99.86
Mangawheau Stream @ Weir	8529	87.56	10.47	0	1.8	0	0.17	98.03
Ngakoroa Stream @ Mill Rd	43829	64.31	33.33	0	2.3	0	0.06	97.64
Oakley Creek at Richardson Road	8128	79.44	3.91	13.97	0.77	0	1.91	83.35
Okura @ Weiti Forest	7505	87.66	6.64	0.49	2.66	0	2.55	94.3
Opanuku Stream @ Candia Road Bridge	7904	27.77	64.59	0	5.73	0	1.91	92.36
Orewa @ Kowhai Ave	7202	93.39	3.83	0	2.77	0	0.01	97.22
Oratia @ Parrs Cross Road	7909	0	0	100	0	0	0	0
Oteha River @ Days Bridge	7811	84.82	14.1	0.01	0	0	1.07	98.92
Papakura @ Great South Road Bridge	43803	62.02	34.9	0	2.78	0	0.3	96.92
Vaughn Stream @ Lower Weir	7506	66.25	30.63	0	2.2	0	0.92	96.88
Wairau Creek @ Motorway	7604	63.95	34.6	0	1.43	0	0.02	98.55
Waitangi @ S H Bridge	43602	0	0	100	0	0	0	0

Additionally, the databases were analysed to determine if the quality of the records were of similar standard outside the 5-year hydrological calibration period. The quality plots for the calibration period and the entire records are attached in appendix 1 and 2 respectively. From these plots the data can be considered as good quality > QC 20 for the majority of the sites since 2006 with good quality data available from some sites since the early 2000 and earlier.

The quality of the level records has been very consistent since the year 2000 across all level sites which is approximately coincides when new monitoring technologies were introduced across the network. New technologies such as loggers with cellular modems and accurate digital level instrumentation, has resulted in consistent better-quality level data being record across the network. As quality assurance processes and technology improves, the overall quality of the data and the network improves.

### 3. Flow quality

Currently, quality codes are only mapped to the raw level data not to the derived “rated” flow data. The quality of flow data derived from a rating curve, is associated with both the physical nature of the site and the construction and development of a flow rating. The quality of a rating is a function of many things including;

- Physical site location and characteristic
  - Upstream control
  - Downstream control
  - Soft/hard bottomed stream
  - Weed and vegetation growth
- Rating development
  - Number of gaugings
  - Gauging quality
  - Range of gaugings
  - Rating curve extrapolation
  - Professional judgement

Depending on the above factors and their effect on the quality of the site rating, some of the flow records may have a lower quality. This is most usually associated with high level flood flows which have the greatest uncertainty and where there are limited gauging points on which the rating can be verified. Equally, poor flow rating quality can occur not simply from insufficient gauging but from the lack of continuous (unimpeded) flow.

The lack of high stage gauging points (observed level and velocity) on a rating is common in the development of flow ratings and is not a unique issue to Council databases. Although the greatest care and professional judgement is taken to extrapolate rating curves to cover the full extent of recorded levels, uncertainty exists where the rating is extrapolated above the level of the observed/measured flow.

#### 3.1. Physical site attributes.

Several physical site characteristics determine the quality of the stage-to-flow record. The Auckland council flow sites were designed to measure long term regional trends; therefore, the initial physical site selection was investigated thoroughly to reasonably ensure that the location could provide good flow records for the entire record. Unfortunately, it is not always possible to optimally locate sites to ensure good quality of stage-to-flow relationships; changes in adjacent land use, infrastructure and site channel geometry can occur over time which affect such relationships.

Tide or flow constrained sites – these are sites which can be tidally affected or have flow constraints upstream or downstream that effect the flow record (e.g., culverts or structure which restrict flow upstream or downstream of gauge site). Clearly, interfering with flow alters the stage-to-flow relationship, creating inaccurate flow estimates in non-free flowing conditions.

The hydrological network site history’s and processing comments were reviewed to identify comments that could indicate that flow records that have been influenced by tidal or downstream constraints. The processing and historical comments for tidally influenced sites indicate that periods of tidal influence have been present during periods of high storm surge tides or king tide events on several sites.

The identification of sites with downstream constraints were able to be identified from a combination historical comments in the site databases and professional judgment based on 13 years of knowledge and operation of the Auckland Council Hydrometric network.

Table 4 lists the sites that are affected by tidal or downstream constraints.



Table 4: Tidal or Flow constrained sites\*

	Site	Tidal or Flow constrained
Hillcrest Stream at Hillcrest Avenue	7609	Yes
Kumeu @ Maddrens Weir	45315	Yes
Newmarket Stream @ AYR Street crump weir	8176	Yes
Okura Creek @ Awanohi Rd	7502	Yes
<b>Okura @ Weiti Forest</b>	<b>7505</b>	<b>Yes</b>
<b>Papakura @ Great South Road Bridge</b>	<b>43803</b>	<b>Yes</b>
Taiāotea stream at Freyberg Park	7515	Yes
Taiorahi Stream at Westbourne Ave	7519	Yes
<b>Vaughn Stream @ Lower Weir</b>	<b>7506</b>	<b>Yes</b>
Whau Stream at Blockhouse Bay Road Crump Weir	8006	Yes

\*Calibration sites in bold

Another factor that can impact stage-to-flow relationships is the effect of aquatic macrophyte (weed) growth. This can cause elevated levels to be recorded in the stream without increased flow. If the weed-affected recorded level is applied to a free-flowing rating curve, the derived flow will be inaccurate (i.e., higher than the actual flow).

Spring and summer weed growth can be an issue in Auckland streams which can affect the flow at some sites. Instances of sites affected by weed growth was not always reflected in the review of the sites historical comments, therefore professional judgment was exercised where operational site knowledge and processing comments could be used to identify sites potentially effected by weed growth.

Table 5 lists the sites that can be affected by weed growth. Four calibration sites appear likely to be affected by spring and summer weed growth, artificially inflating flows and more so during seasonal macrophyte growth period (e.g., spring to summer flows).

Table 5: Weed affected sites\*

	Site	Weed issues
Ararimu River @ Old North Rd Bridge	45326	Yes
Kaipara River @ Waimauku	45311	Yes
<b>Kaukapakapa @ Taylors</b>	<b>45415</b>	<b>Yes</b>
Kumeu @ Maddrens Weir	45315	Yes
Mangawheau Stream @ Weir	8529	Yes
Meola Creek at Motions Road Weir	8106	Yes
<b>Papakura @ Great South Road Bridge</b>	<b>43803</b>	<b>Yes</b>
Puhinui @ Drop Structure	43807	Yes
Rangitopuni River @ Walkers	7805	Yes
<b>Vaughn Stream @ Lower Weir</b>	<b>7506</b>	<b>Yes</b>
Wairau Creek @ Chartwell Road	7607	Yes
<b>Waitangi @ S H Bridge</b>	<b>43602</b>	<b>Yes</b>
Whangamaire @ Patumahoe Weir	43811	Yes

\*Calibration sites in bold

### 3.2. Gauging and rating quality.

The quality of a rating curve and the confidence in the derived flow is a function of the gauging (calibration measurements) that have been undertaken and used to develop the rating. For accurate rating, gauging should endeavour to cover as much of the level range as possible to ensure that the rating is not extrapolated beyond observed information (e.g., the range of meaningful flow conditions at a site governing outcomes – whether flooding or water quality related). In most cases gauging will be weighted to the lower part (lesser level and flow) of the rating as this is where flows occur most frequently (i.e., are more easily observed). High stage gauging is challenging as such flows are infrequent by nature and challenging to accurately measure both velocity and level for. Generally, a rating improves in quality (coverage and reproducibility) with increasing number of observed measurements.

The natural stream channel ‘bank full’ (the top of the banks formed in a natural cross section) or ‘channel-forming flow’ is approximately at the 1 to 2 year ARI rainfall event, so events up to and including these events have the most impact on stream erosion and in-stream habitat, in part due to the frequency of occurrence.

Erosion in natural streams is driven by channel-forming flows, which are often defined as flow up to and including bank full flow (Auckland Council TR2013/035). These flows are typically in the 1 – 2-year ARI flow range and are where the flows reach the top of the banks. It is important to accurately discern the flows up to a 2-year flow as these are the flows responsible for both the channel forming flows, and the transfer of sediment and other contaminants of concern

Table 5 presents the days greater than a 2-year flow observed at hydrometric stations in the Auckland region. If the flow rating has been adequately constructed it is reasonably expected that a 2-year event should have been recorded at least once within the 5-year calibration period. Inversely, 2-year events should occur infrequently in a 5-year period, meaning any frequent such event indicate inaccuracy in the rating (e.g., where sites have experienced >4 2-year events over 5-year period). This test is only indicative, as several sites might well have experienced unusual flow events but alongside other tests, helps to prioritise calibration to sites of higher quality records (including representative datasets).

Table 6: Days recorded greater than a 2-year flow\*

	Site	> 2-year flow
Alexandra @ Rosedale Rd.	7834	2
Ararimu River @ Old North Rd Bridge	45326	3
Eskdale Stream at Lauderdale Reserve	7706	2
Hoteo River @ Gubbs	45703	3
Kaukapakapa @ Taylors	45415	2
Mairangi Bay Stream at Tennis Club	7514	4
Mangawheau Stream @ Weir	8529	2
Meola Creek at Motions Road Weir	8106	4
Motions Stream @ Western Springs.	8104	3
Newmarket Stream @ AYR Street crump weir	8176	4
<b>Oakley Creek at Richardson Road</b>	<b>8128</b>	<b>5</b>
<b>Okura @ Weiti Forest</b>	<b>7505</b>	<b>3</b>
Taiaotea stream at Freyberg Park	7515	4
Taiorahi Stream at Westbourne ave	7519	3
Tamahunga River @ Quintals Falls	6501	2
Wairau Creek @ Chartwell Road	7607	5
<b>Wairau Creek @ Motorway</b>	<b>7604</b>	<b>3</b>
Whau Stream at Blockhouse Bay Road Crump Weir	8006	2

\*Calibration sites in bold

The further a flow rating is extrapolated beyond measured gauging, the greater the uncertainty in any inferred flow. To assess for such uncertainty and recognising the importance of the 2-year flows as a key determinant of channel shaping (erosive), the maximum measured flow was compared against the 2-year flow (annual return interval). Max observed flow was expressed as a percentage of the 2-year flow in Table 6, to identify those sites where the maximum measured (gauged) flow is  $\geq 75\%$  of the 2-year flow (e.g., sites where maximum observed flow is close to or greater than channel shaping events to ensure confidence in those latter events being gauged).

Table 7: Maximum gauged flow as a percentage of the 2-year flow

	Site	Maximum Gauged flow as % 2 year flow
Alexandra @ Rosedale Rd.	7834	7.1
Ararimu River @ Old North Rd Bridge	45326	78.9
Awaruku stream at Glenvar Road	7516	2.2
Eskdale Stream at Lauderdale Reserve	7706	7.5
Hillcrest Stream at Hillcrest Avenue	7609	9.6
Hoteo River @ Gubbs	45703	163.1
Kaipara River @ Waimauku	45311	375.5
Kaipatiki Stream at Kaipatiki road	7719	11.6
Kaukapakapa @ Taylors	45415	72.6
Kumeu @ Maddrens Weir	45315	103.9
Lucas @ Gills Road	7830	27.9
Mahurangi @ College	6806	73.0
Mahurangi Argonaut @ College	6863	34.8
Mairangi Bay Stream at Tennis Club	7514	17.3
Makarau at Coles	45504	
Mangawheau Stream @ Weir	8529	20.9
Mangemangeroa	8304	36.4
Meola Creek at Motions Road Weir	8106	38.5
Motions Stream @ Western Springs.	8104	12.2
Newmarket Stream @ AYR Street crump weir	8176	0.8
Ngakoroa Stream @ Mill Rd	43829	34.0
Oakley Creek at Richardson Road	8128	63.2
Okura @ Weiti Forest	7505	82.6
Okura Creek @ Awanohi Rd	7502	33.8
Opanuku @ Vintage Reserve	7912	109.0
Opanuku Stream @ Candia Road Bridge	7904	67.9
Oratia @ Millbrook Road	7911	52.8
Oratia @ Parrs Cross Road	7909	0.0
Orewa @ Kowhai Ave	7202	40.9
Otara @ Hills Road Bridge	8208	95.7
Oteha River @ Days Bridge	7811	48.5
Papakura @ Great South Road Bridge	43803	176.3
Puhinui @ Drop Structure	43807	80.7

Rangitopuni River @ Walkers	7805	174.1
Swanson Stream @ Woodside Reserve	7907	67.5
Taiaotea stream at Freyberg Park	7515	11.9
Taiorahi Stream at Westbourne ave	7519	21.1
Tamahunga River @ Quintals Falls	6501	74.8
Tamaki Trib at Bowden Road Crump Weir	8222	19.7
Vaughn Stream @ Lower Weir	7506	78.6
Wairau Creek @ Chartwell Road	7607	72.2
Wairau Creek @ Motorway	7604	131.5
Wairoa River @ Tourist Road	8516	280.9
Waitangi @ S H Bridge	43602	39.4
Waiteitei River @ Sandersons	45705	92.6
Waiwhiu Stream @ Dome Shadow	45702	0.0
West Hoe @ Halls	7206	44.6
Whangamaire @ Patumahoe Weir	43811	29.1
Whau Stream at Blockhouse Bay Road Crump Wier	8006	5.3

Table 7 indicates that 14 hydrometric stations (of 48) have an observed (gauged) flow three quarters or more of the 2-year ARI. So, there are arguably few sites with high stage or flood gauging in the Auckland Council hydrometric monitoring network. This is not uncommon for many flow networks given the challenges of gauging extreme flow events, but given the relative frequency of such 2-year ARI events (as a relative measure in Table 5), does imply that a large component of flow records are based on extrapolation of flow rating relationships beyond their calibrated performance. Hence, overall high flow events are likely to not necessarily be reported accurately by observational datasets (i.e., affecting later inspection and explanation of hydrological performance in the FWMT).

## 4. Calibration Sites

The calibration flow sites were assessed across five measures of accuracy in level-to-flow (gauging) relationship. These are summarised in the Table 8 below.

Table 8: Calibration site summary

	Site	Quality (%) Reliable data <20	Tidal or Flow constrained	Weed issues	> 2-year flow	Maximum Gauged flow as % 2-year flow
Kaukapakapa @ Taylors	45415	97.11	No	Yes	2.00	72.61
Lucas @ Gills Road	7830	99.86	No	No	0.00	27.91
Mangawheau Stream @ Weir	8529	98.03	No	Yes	2.00	20.92
Ngakoroa Stream @ Mill Rd	43829	97.64	No	No	1.00	34.01
Oakley Creek at Richardson Road	8128	83.35	No	No	5.00	63.16
Okura @ Weiti Forest	7505	94.3	Yes	No	3.00	82.59
Opanuku Stream @ Candia Road Bridge	7904	92.36	No	No	0.00	67.94
Oratia @ Parrs Cross Road	7909	0				0.00
Orewa @ Kowhai Ave	7202	97.22	No	No	0.00	40.89
Oteha River @ Days Bridge	7811	98.92	No	No	1.00	48.53
Papakura @ Great South Road Bridge	43803	96.92	Yes	Yes	0.00	176.32
Vaughn Stream @ Lower Weir	7506	96.88	Yes	Yes	1.00	78.59
Wairau Creek @ Motorway	7604	98.55	No	No	3.00	131.46
Waitangi @ S H Bridge	43602	0	No	Yes	0.00	39.35

With the purpose of identifying gauged flow sites whose records appear more robust from those of greater uncertainty and inaccuracy, most calibration sites meet at least 3 of 5 conditions and several 4 of 5 conditions (e.g., 10 and 6 of 14, respectively). The two externally sourced (NIWA) data sets from Oratia @ Parrs Cross Road and Waitangi @ S H Bridge have some uncertainty when compared to Auckland Council's quality assurance programme but are likely "fit for calibration purpose" (e.g., collected under NIWA audited approaches).

Three of the 14 calibration sites appear tidally or flow-constrained (e.g., expected to suffer marked inaccuracy in estimating flow from level). Lower Vaughan and Okura @ Weiti Forrest are tidally influenced sites, compromising the resulting flow records. Papakura @ Great South Rd bridge is constrained at high flows by the bridge culverts.

Alternative sites should be considered for calibration to those identified as being tidally or flow constrained sites, however, given the limited number of sites and associated representative HRU land units, the use of these sites may be required for lack of an alternative option.

Five sites are affected by seasonal weed growth impacting the flows during the macrophyte growing seasons of spring and summer. Due to the seasonal nature of weed growth and the varying effects on flow records from one growth period to the next, it is difficult to ascertain that any individual site should be excluded from the calibration group – the data from these sites is therefore recommended to be treated cautiously particularly during seasonal growth periods (e.g., spring to summer).

Table 9: Validation site summary

	Site	Quality (%) Reliable data <20	Tidal or Flow constrained	Weed issues	> 2 year flow	Maximum Gauged flow as % 2 year flow
Alexandra @ Rosedale Rd.	7834	99.42	No	No	2.00	7.08
Ararimu River @ Old North Rd Bridge	45326	90.46	No	Yes	3.00	78.92
Awaruku stream at Glenvar Road	7516	95.52	No	No	1.00	2.20
Eskdale Stream at Lauderdale Reserve	7706	94.7	No	No	2.00	7.49
Hillcrest Stream at Hillcrest Avenue	7609	77.84	Yes	No	0.00	9.65
Hoteo River @ Gubbs	45703	98.78	No	No	3.00	163.10
Kaipara River @ Waimauku	45311	87.38	No	Yes	1.00	375.50
Kaipatiki Stream at Kaipatiki road	7719	99.99	No	No	1.00	11.61
Kumeu @ Maddrens Weir	45315	62.9	Yes	Yes	0.00	103.87
Mahurangi @ College	6806	97.76	No	No	1.00	73.01
Mahurangi Argonaut @ College	6863	99.6	No	No	1.00	34.80
Mairangi Bay Stream at Tennis Club	7514	98.97	No	No	4.00	17.27
Makarau at Coles	45504	0	No	No	0.00	
Mangemangeroa	8304	99.92	No	No	1.00	36.41
Meola Creek at Motions Road Weir	8106	99.96	No	Yes	4.00	38.52
Motions Stream @ Western Springs.	8104	98.65	No	No	3.00	12.22
Newmarket Stream @ AYR Street crump weir	8176	99.98	Yes	No	4.00	0.78
Okura Creek @ Awanohi Rd	7502	23.85	Yes	No	0.00	33.82
Opanuku @ Vintage Reserve	7912	99.98	No	No	0.00	109.02
Oratia @ Millbrook Road	7911	97.92	No	No	1.00	52.79
Otara @ Hills Road Bridge	8208	99.57	No	No	1.00	95.71
Puhinui @ Drop Structure	43807	99.73	No	Yes	0.00	80.73
Rangitopuni River @ Walkers	7805	96.9	No	Yes	1.00	174.10
Swanson Stream @ Woodside Reserve	7907	94.06	No	No	0.00	67.50
Taiaotea stream at Freyberg Park	7515	98.56	Yes	No	4.00	11.90
Taiorahi Stream at Westbourne ave	7519	86.75	Yes	No	3.00	21.13
Tamahunga River @ Quintals Falls	6501	89.8	No	No	2.00	74.78
Tamaki Trib at Bowden Road Crump Weir	8222	97.75	No	No	0.00	19.66
Wairau Creek @ Chartwell Road	7607	99.81	No	Yes	5.00	72.22
Wairoa River @ Tourist Road	8516	100	No	No	0.00	280.87
Waiteitei River @ Sandersons	45705	99.08	No	Yes	0.00	92.61
Waiwhiu Stream @ Dome Shadow	45702	67.06	No	No	0.00	0.00
West Hoe @ Halls	7206	92.1	No	No	1.00	44.61
Whangamaire @ Patumahoe Weir	43811	46.96	No	Yes	1.00	29.10
Whau Stream at Blockhouse Bay Road Crump Wier	8006	93.76	Yes	No	2.00	5.34

## 5. Conclusions

Following an assessment of the Council hydrometric level and flow database for the purpose of informing selection and inspection of flow-simulation performance within the FWMT, 12 of 14 sites are recommended for use in flow calibration. The two calibration sites, Lower Vaughan and Okura Forest, that have both flow constraints from tidal influences and issues with macrophyte growth in spring and summer flow conditions, should be carefully considered prior to their use in the calibration process. It is recommended to review and cleanse the raw data for suspect periods.

As the Council network matures and more measurements of flow are undertaken, the quality of the flow information will improve over time as will the level of confidence in the derived flows. Hence, ongoing review of the performance of the network for flow-simulation is recommended, identifying where to target additional flow-sites to cover wider gradients of hydrology, accurately.

It has been identified through this review that some sites should be considered prior to their use in the development and validation of hydrological models. While these sites are not considered “bad” sites they should be at a lower standard than others in the network and otherwise omitted unless necessary.

### Sites to be considered for exclusion:

1. Okura Creek @ Awanohi Rd 7502 – this site has had many historical rating and flow issues which has led to this site being closed
2. Kumeu @ Maddrens Weir 45315 – this site has also been closed due to multiple onsite issues affecting the flow record including low stage weed issues and high stage rating issues
3. Hillcrest Stream at Hillcrest Avenue 7609 – this site is now closed and has a flow record that was influenced and constrained by a downstream culvert
4. Whangamaire @ Patumahoe Weir 43811 – this is a closed site which had ongoing issues with weed and sediment, and keeping a valid rating

Additionally, the following sites should be used with caution as they may, at certain times, have a compromised flow record (e.g., due to the physical nature of the site constraining flow, having upstream or downstream impediments to flow and/or tidal influences on flow). These sites should be used with caution and may influence the model calibration and validation results.

### Sites that should be used with caution (**bold sites are calibration sites**):

1. **Papakura @ Great South Road Bridge 43803 – weed growth impacted site and constrained downstream by 2 box culverts**
2. Taiaotea stream at Freyberg Park 7515 – Flow constrained with a culvert immediately downstream
3. Taiorahi Stream at Westbourne ave 7519 – Tidally influenced site
4. **Vaughn Stream @ Lower Weir 7506 - historically tidally affected and impacted by weed vegetation growth – this site has new weir structure above the tidal influence -(late 2017)**
5. **Waitangi @ S H Bridge 43602 – this site is seasonally impacted by weed during spring and summer growing seasons – this site is external to council**
6. Newmarket Stream @ AYR Street crump weir 8176 – tidally influenced
7. Oratia @ Parrs Cross Road 7909 - this site is managed externally to council

## 6. References

Auckland Council, (2013), Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements, Prepared by Auckland Council. Auckland Council technical report, TR2013/035



## 7. Site summaries

### 7.1. 7834 Rosedale Rd

Commence: 14/12/1979

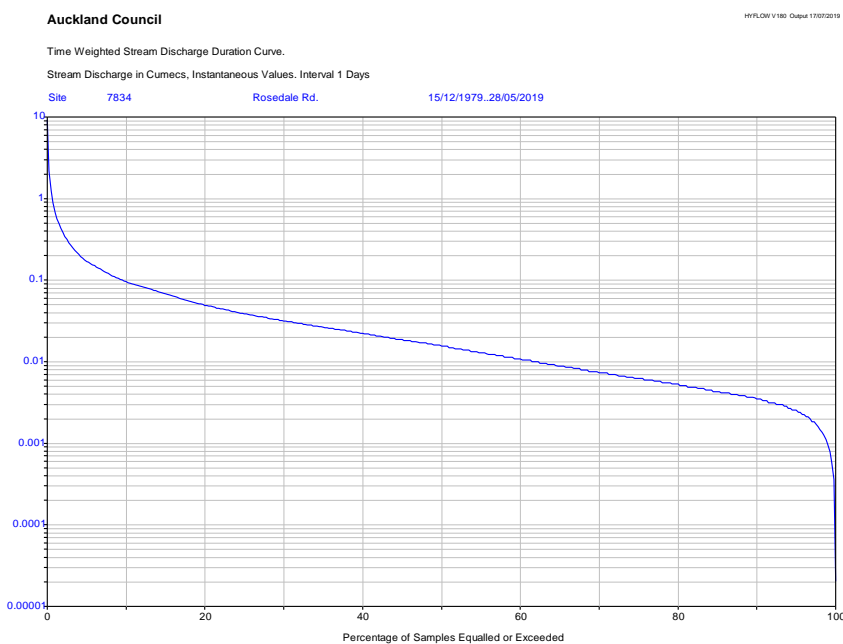
Cease:

Easting: 1752377.800 Northing: 5932435.200

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 14.547

Comment: Site taken over from North Shore City Council by Auckland Council, continuous water level, flow and temperature, Data used by Civil Defence, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



## 7.2. 45326 Ararimu

Commence: 14/12/1983

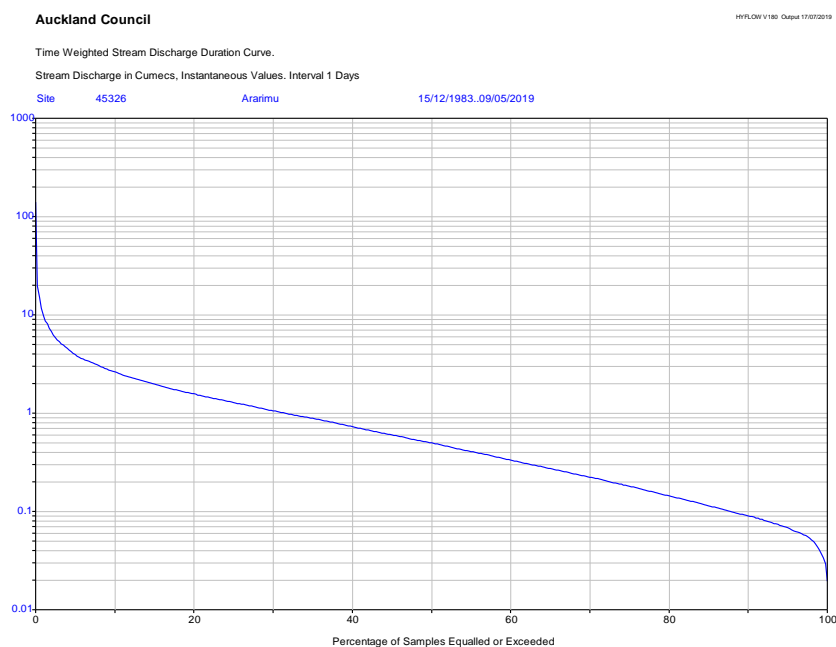
Cease:

Easting: 1734999.000 Northing: 5932630.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 11.919

Comment: Site was originally a watercare site taken over by Auckland regional council, Long term record for statistical analysis also dissolved oxygen and temperature site. NPSFM may require the site, initial modelling results through which will be May next year (2018), this will look at various land use types, geology and flow regimes and should identify where we might have gaps in terms of being able to model the region efficiently in terms of water quality. This NPSFM assessment will determine if site is required long term for AC.NZVD datum applied at last annual survey 30/01/2019



### 7.4. 7516 Awaruku at Glenvar

Commence: 14/05/2004

Cease:

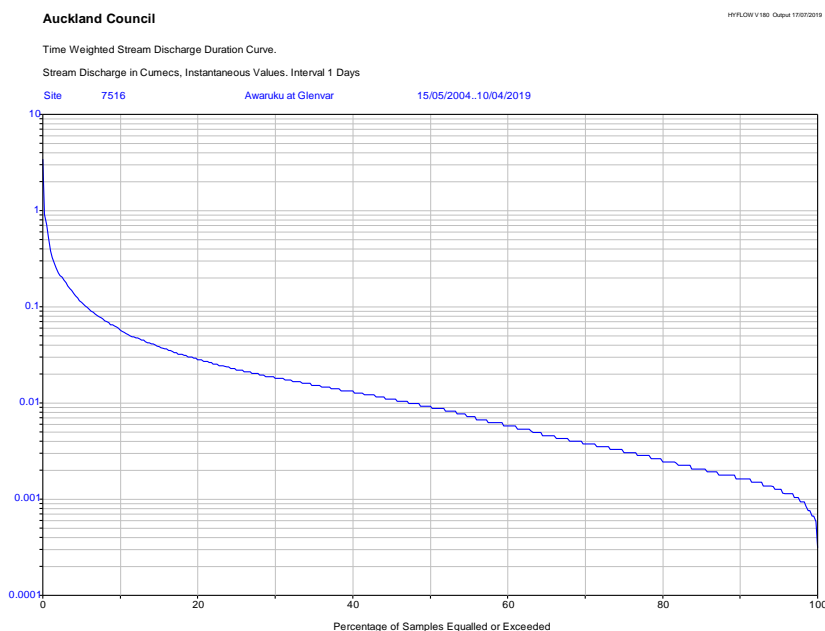
Easting: 1755673.800 Northing: 5937597.200

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 6.999

Comment: Site originally installed for North Shore city Council taken over after Auckland Council amalgamation 2011, continuous water level flow and temperature. Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning ,Data also input to long bay structure plan, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

### 7.5.



### 7.6. 7706 Eskdale Stream

Commence: 8/05/2005

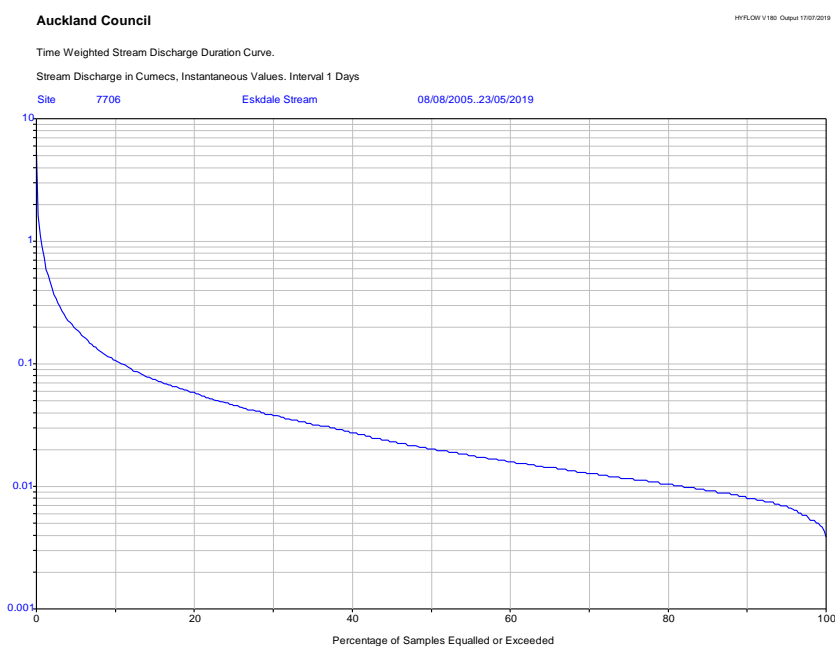
Cease:

Easting: 1752366.500 Northing: 5926879.600

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 3.847

Comment: Site taken over from North Shore City Council by ARC, continuous water level, flow and temperature, Data used by Civil Defence, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



## 7.7. 7609 Hilcrest Stream

Commence: 10/12/2001

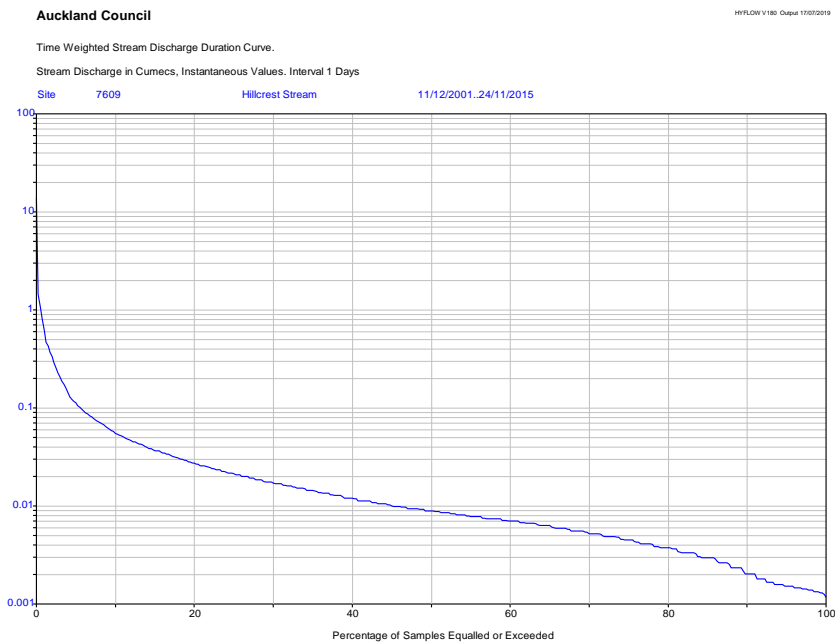
Cease: 10/04/2013

Easting: 1755518.700 Northing: 5926578.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 53.193

Comment: Site taken over from North Shore City Council by ARC, continuous water level, flow and temperature, Data used by Civil Defence, Stormwater Modelling, Future Development Planning. Site closed due to the culvert immediately downstream being widened. This site only recorded the maximum level associated with the crest of the road and was directly influenced by the culvert constriction.



### 7.8. 45703 Hoteo River

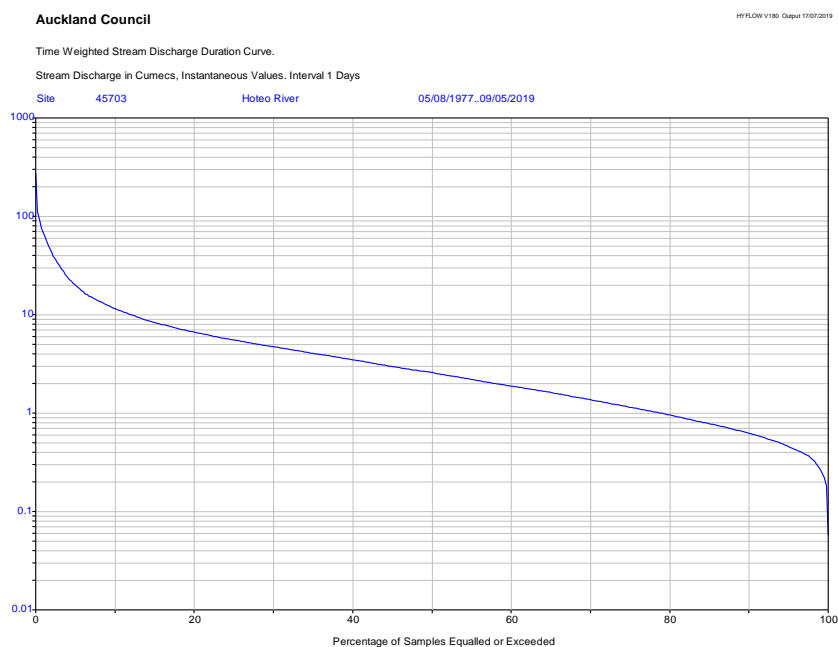
Commence: 10/06/1977

Cease:

Easting: 1735424.000 Northing: 5972357.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Comment: Site established as primary river flow monitoring site on largest river in Auckland, Continuous level, flow, temperature, dissolved oxygen, turbidity, sediment, Streams water quality site, Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Data linked to Kaiapra harbour monitoring and sediment studies, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.9. 45311 Kaipara River

Commence: 6/10/1978

Cease:

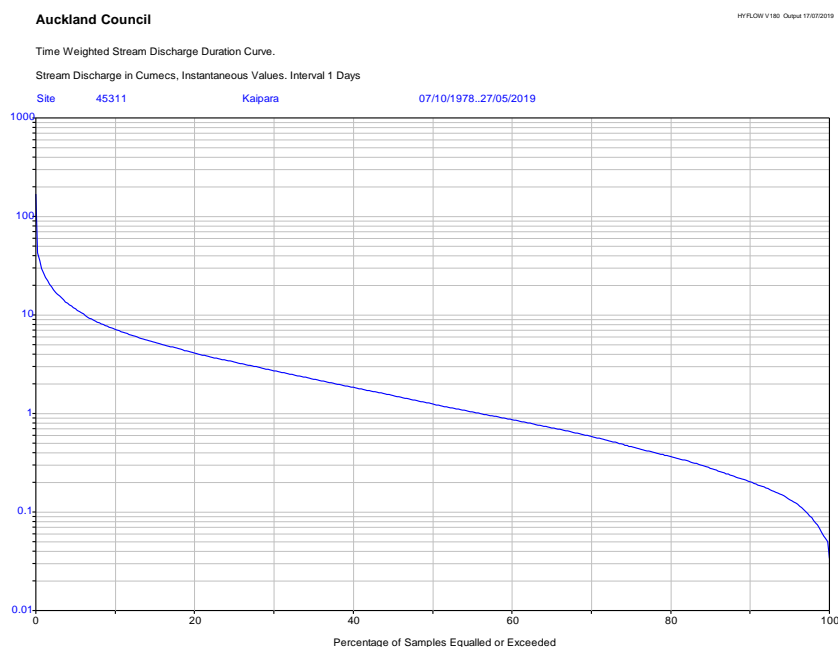
Easting: 1733345.000 Northing: 5930348.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 3.721

Comment: Site established at long term baseline site to measure continuous level, flow, temperature, dissolved oxygen and sediment monitoring. Site is major southern input into the Kaipara harbour. Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to

freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.10. 7719 Kaipatiki Stream

Commence: 8/12/2006

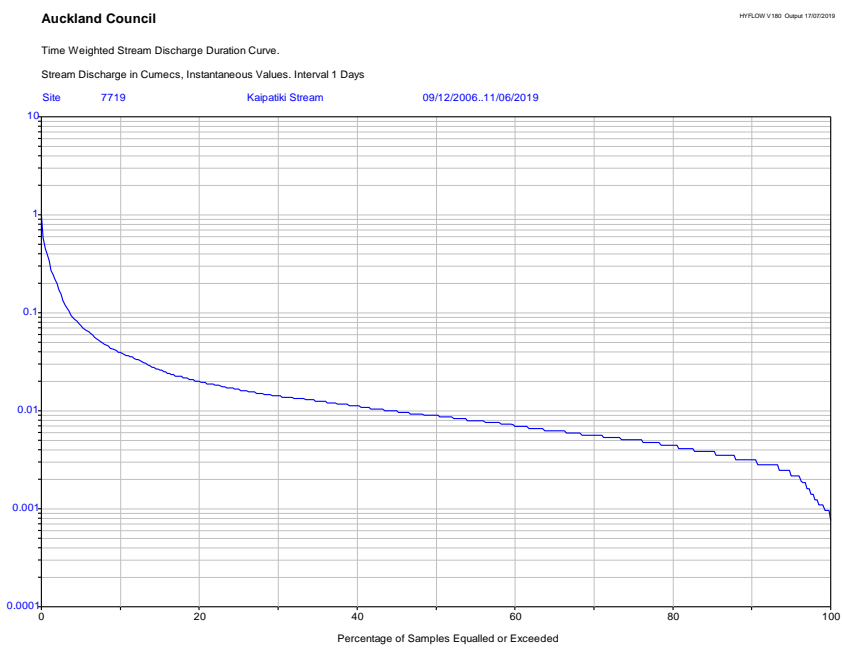
Cease:

Easting: 1752666.000 Northing: 5927947.700

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 14.809

Comment: Site taken over from North Shore City Council by Auckland Council, continuous water level, flow and temperature, Data used by Civil Defence , Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,





### 7.11. 45415 Kaukapakapa @ Taylors

Commence: 4/07/1994

Cease:

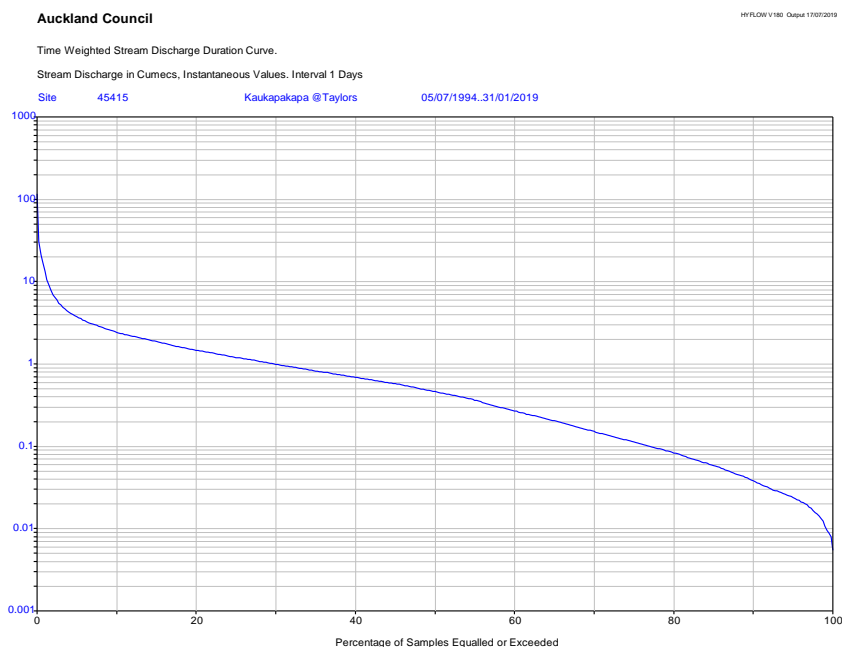
Easting: 1735809.000 Northing: 5945031.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 3.098

Comment: Site established as part of flood warning and long term stream flow 4/07/1994, continuous level flow temperature and dissolved oxygen, Stream water quality site, Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan.Auckland Plan chapter 7,8,

The Kaukapakapa @ Taylors level site performed well over the 5-year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.12. 45315 Kumeu at Maddrens

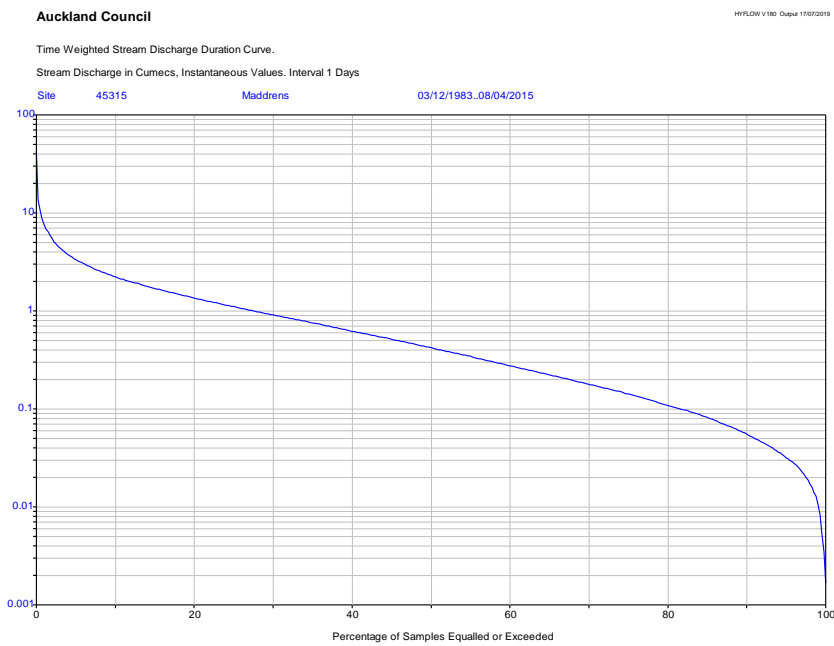
Commence: 2/12/1983

Cease: 8/04/2015

Easting: 1739254.000 Northing: 5929059.000

Elevation: 18.436

Comment: Weir constructed 19-4-1990. Fish passage added 20/04/05



### 7.13. Lucas @ Gills Road

Commence: 11/10/2006

Cease:

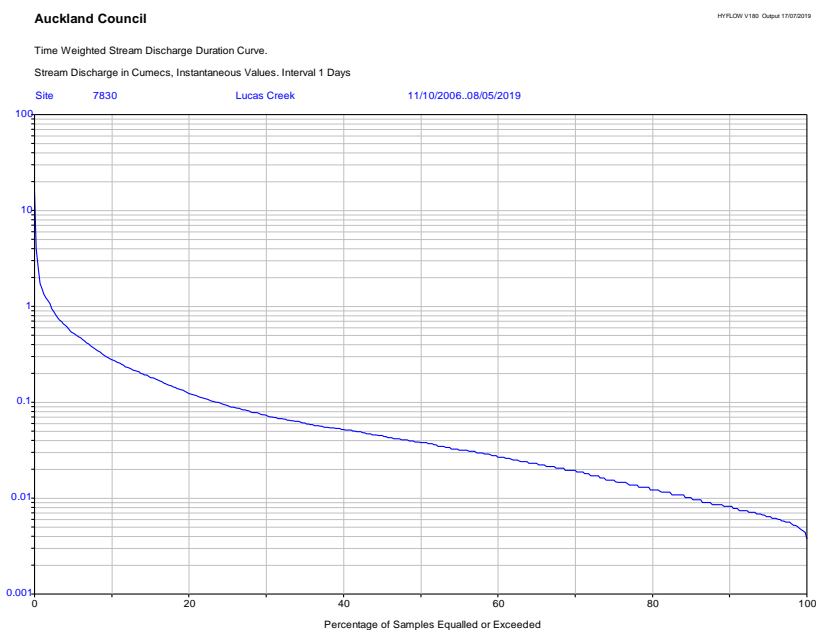
Easting: 1751467.700 Northing: 5934509.700

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Comment: Flow record for current site begins 11/10/2006. Site taken over on 20/08/2011 by AC. Previous SG and gauging site was located downstream of current site. 05aug08 - changed coords to NZTM.

Date of initial site establishment. Site original installed by NIWA then North Shore city council then taken over by Auckland Council, continuous water level, flow and temperature, Streams water

The Lucas @ Gills Rd level site has performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.14. 6806 Mahurangi @ College

Commence: 11/06/1982

Cease: 5/12/2018

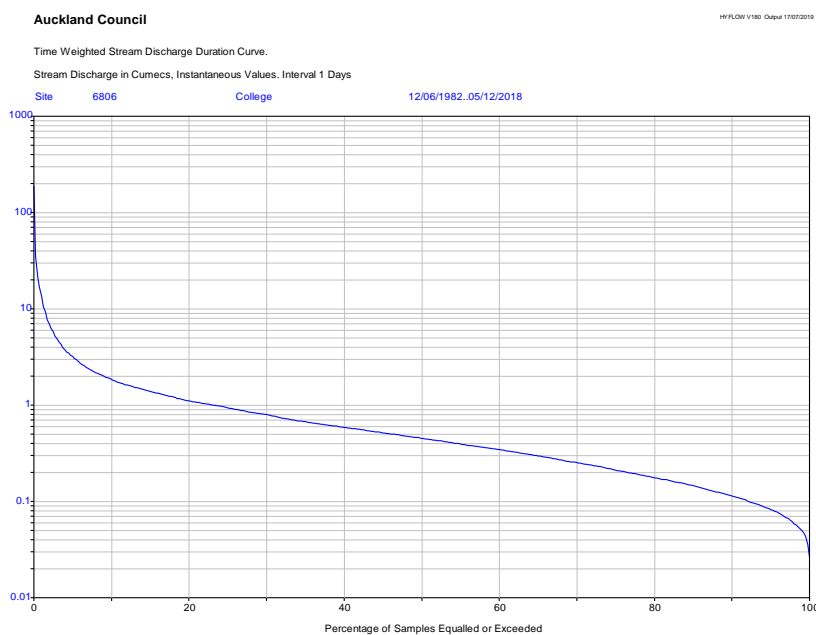
Easting: 1748387.000 Northing: 5969849.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 8.903

Comment: Major site monitoring Mahurangi river draining north east coast Auckland, long term baseline record, and continuous DO and temp Watercare, Downstream water quality site, (Warkworth town water supply is subject to minimum flow conditions set on the stream), Data used for, Civil Defence for

flood warning, Environmental Monitoring , Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8, data also critical to the Mahurangi action harbour plan and linked to the marine sedimentation program.



### 7.15. 6863 Mahurangi @ Argonaut

Commence: 21/04/2009

Cease:

Easting: 1748589.000 Northing: 5970087.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Comment: Experimental site using Sontek Argonaut site was originally back up test site for flow and level will be primary sit from upstream weir from 2019. data from start was provisional as never set up to record QC600 NEMS data. Major site monitoring Mahurangi river draining north east coast

Auckland, long term baseline record, and continous DO and temp, Streams water quality site

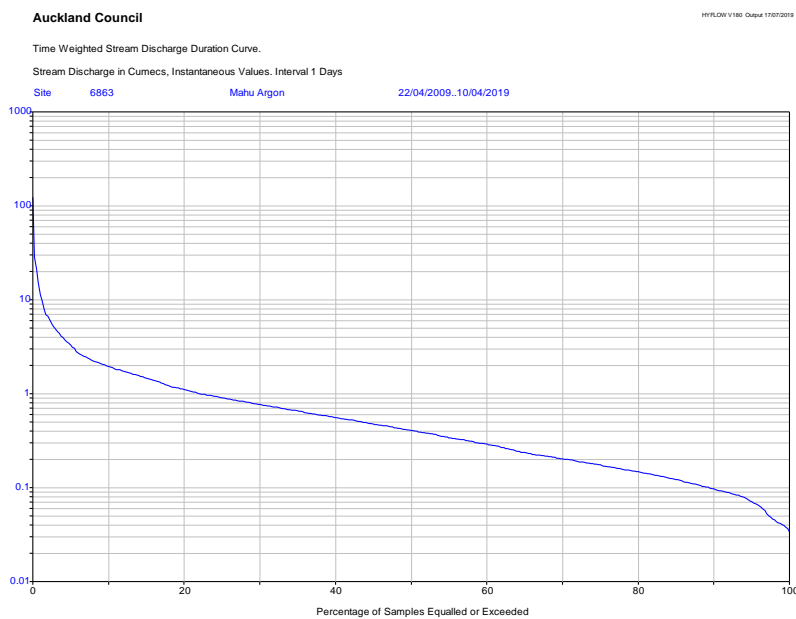
Watercare(Warkworth town water supply is subject to minimum flow conditions set on thestream), Data

used by Healthy Waters, NIWA, Civil Defence for flood warning, Environmental Monitoring ,

Stormwater Modelling, Future Development Planning, National policy statement of freshwater

management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan.

Auckland Plan chapter 7,8,



### 7.16. 7514 Mairangi Bay Stream

Commence: 9/08/2003

Cease:

Easting: 1756355.800 Northing: 5932535.500

Grid Datum: NZTM New Zealand Transverse Mercator 2000

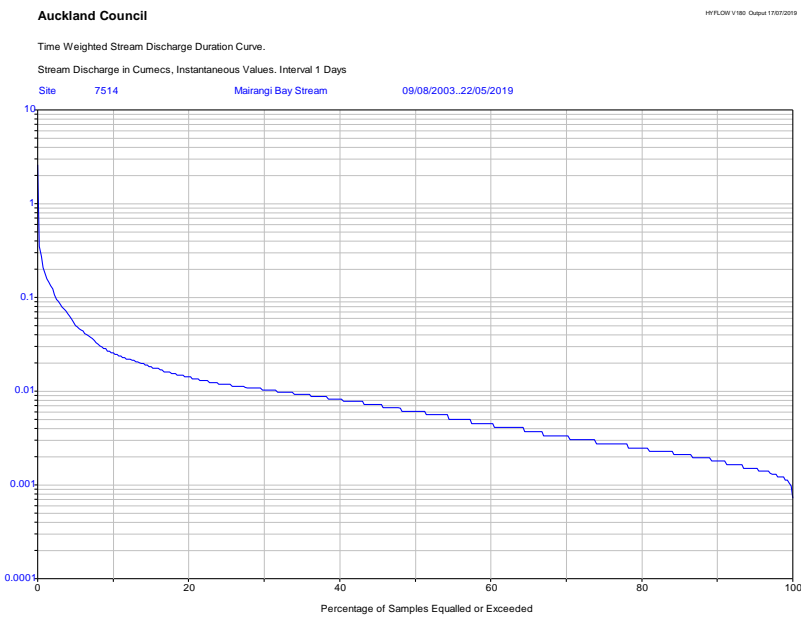
Latitude: -36.740040000 36°44'24.1"S

Longitude: 174.751030000 174°45'03.7"E

Lat/Long Datum: NZMG49 NZ Geodetic Datum 1949

Elevation: 4.760

Comment: Site originally installed for North Shore city Council taken over after Auckland Council amalgamation, continuous water level flow and temperature. Data used by Stormwater modelling, Future planning, Civil Defence, Data also input to long bay structure plan, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.17. 45504 Makarau

Commence: 31/03/1989

Cease:

Easting: 1735399.000 Northing: 5953251.000

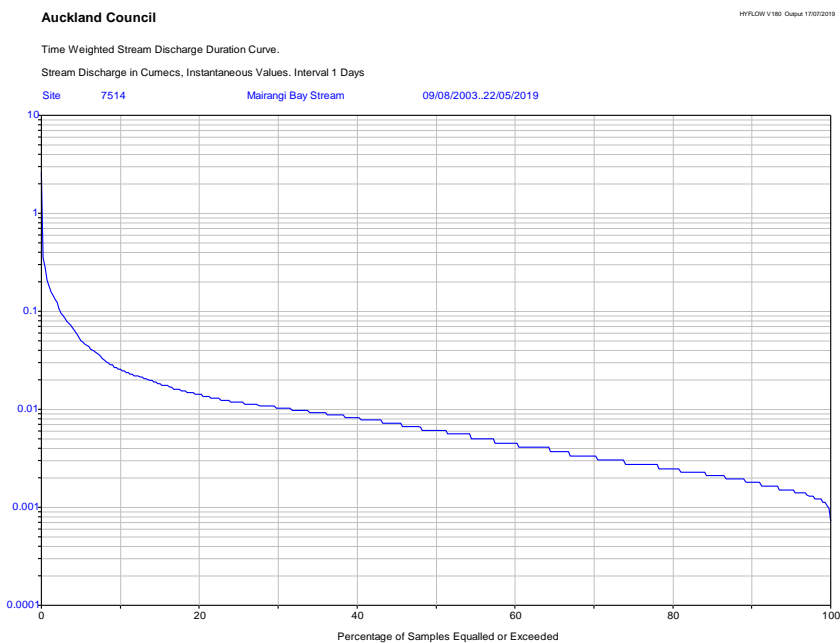
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Latitude: -36.556574970 36°33'23.7"S

Longitude: 174.512959300 174°30'46.7"E

Lat/Long Datum: WGS84 World Geodetic System 1984

Comment:



### 7.18. 8529 Mangawheau Stream @ Weir

Commence: 15/06/1988

Easting: 1783781.000 Northing: 5891411.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 100.000

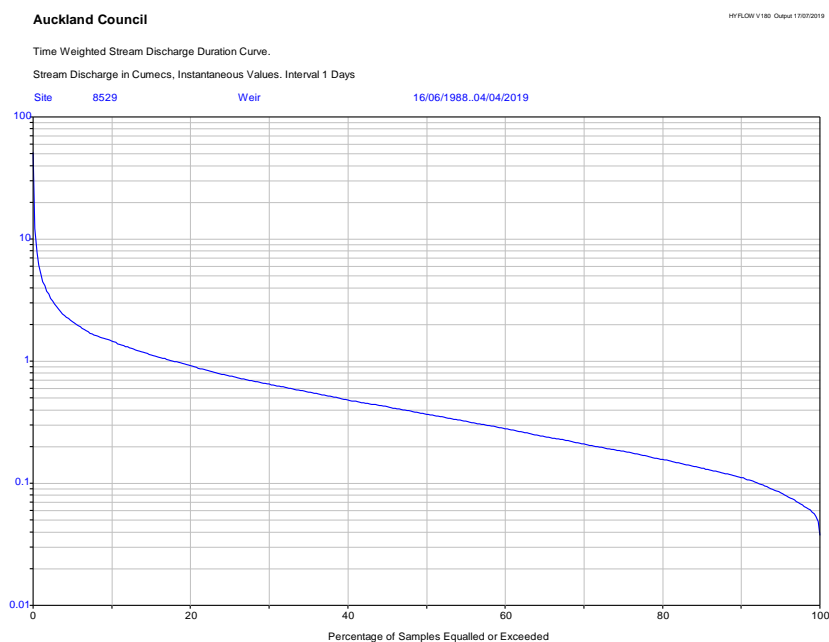
Comment: Site established 15/06/1988, continuous level and flow record, site was originally installed as part of Hunau ranges water resources study for another water supply dam in the catchment, ARC took over the site after dam was scraped, There are no stm takes in catchment. But the stream augmentation conditions of quarry groundwater take(dewatering) consents for both Winstone and

Stevenson quarries are linked to flow at that site. Both quarries pay about \$10,000 /year in annual

Fee FPD charges to council ( that is tagged to groundwater, not stream flow monitoring programmes).

Data used by Civil Defence early warning for Wairoa, Environmental Monitoring, Stormwater Modelling

The Mangawheau Stream @ Weir site has performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.





### 7.19. 8304 Mangemangeroa

Commence: 14/07/2000

Cease:

Easting: 1772261.000 Northing: 5910514.000

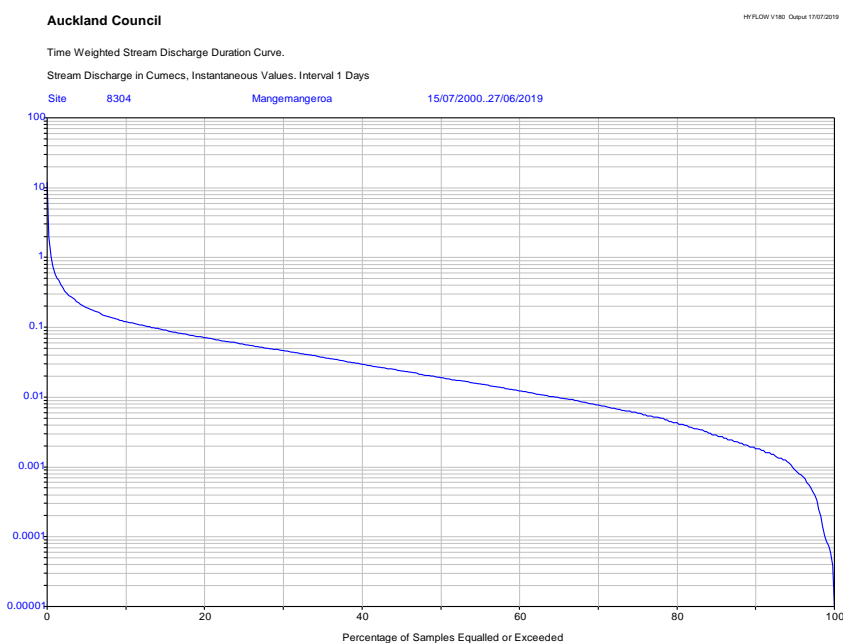
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 95.724

Comment: Site established by NIWA as a collaboration project with Auckland Regional Council, this was a catchment estuary study into sediment and turbidity, Site is now a primary sediment monitoring site, Data used by Environmental Monitoring, Stormwater Modelling, National policy statement of

freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative

unitary plan. Auckland Plan chapter 7,8,



## 7.20. 8106 Meola Stream @ Weir

Commence: 3/04/1998

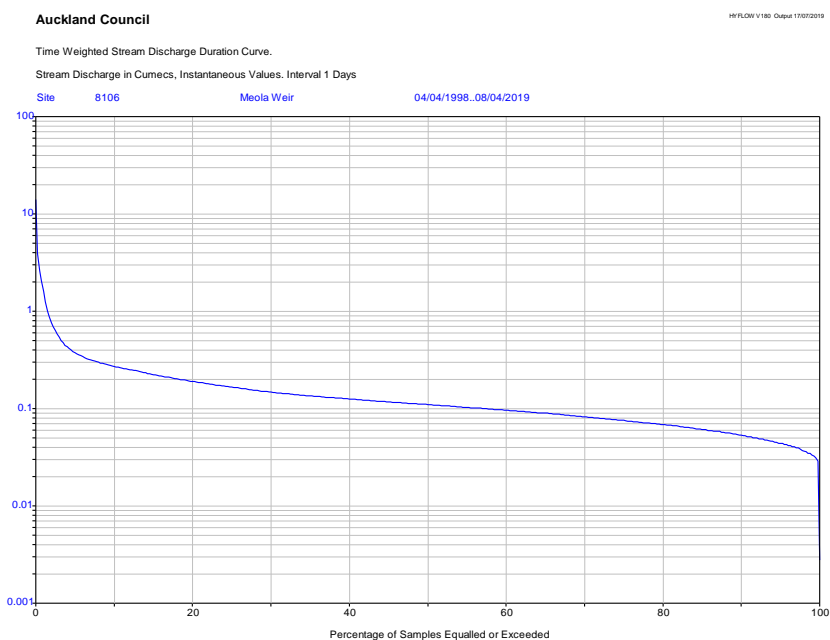
Cease:

Easting: 1753197.000 Northing: 5918529.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 4.187

Comment: Station replaces site 8111 Meola @ Great North Road which was situated upstream of the Gt North Road Bridge culverts. Site established as upgrade to original site located on Gt North road, long term monitoring, continuous level and flow. Site is significant for waitemata model development and future Ecoli sampling work, Data used for Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.21. 8104 Motions @ Western Springs

Commence: 27/03/1990

Cease:

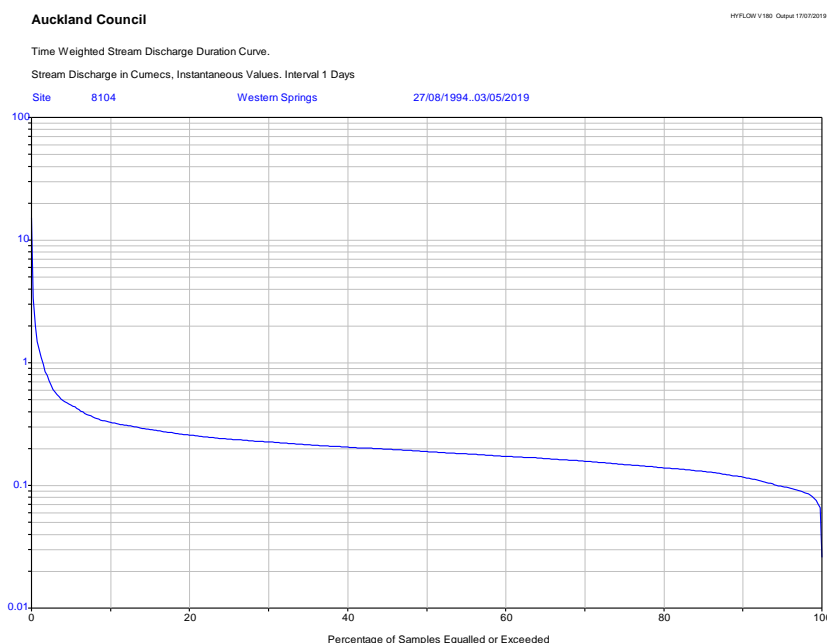
Easting: 1753745.000 Northing: 5918720.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 7.339

Comment: Site established as measurement for western spring lake long term monitoring, continuous level and flow. Site is significant for waitemata model development and future Ecoli sampling work, Data used for Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater

quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



## 7.22. 8176 Newmarket Stream

Commence: 9/05/2006

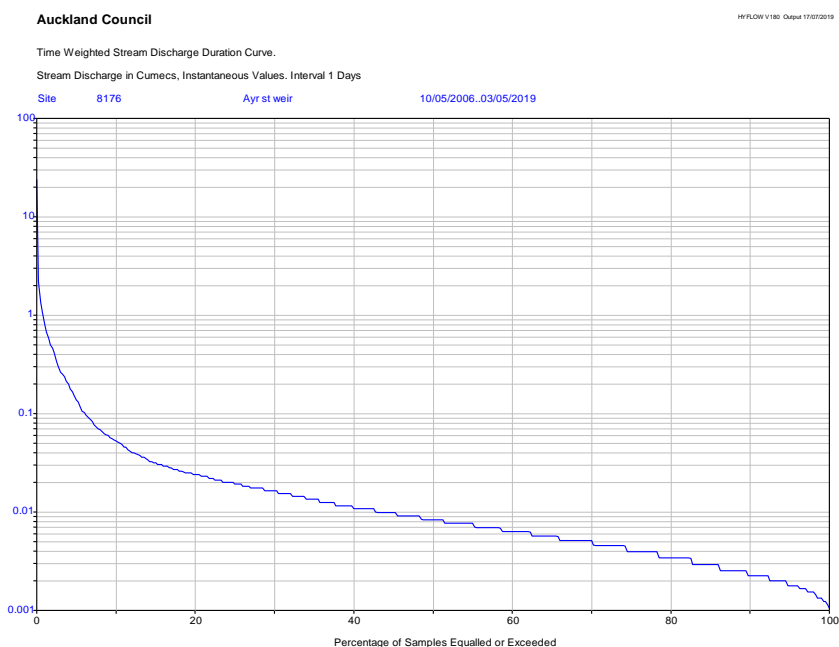
Cease:

Easting: 1759168.200 Northing: 5918606.300

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 1.404

Comment: Known as the Ayr street weir. Site originally established by Auckland City Council taken over after Auckland Council amalgamation, Continuous water level flow and temperature. Civil Defence and Emergency Management Planning, Stormwater network modelling, Future development planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.23. 43829 Ngakoroa Stream @ Mill Rd

Commence: 28/03/1980

Cease:

Easting: 1775153.000 Northing: 5881619.000

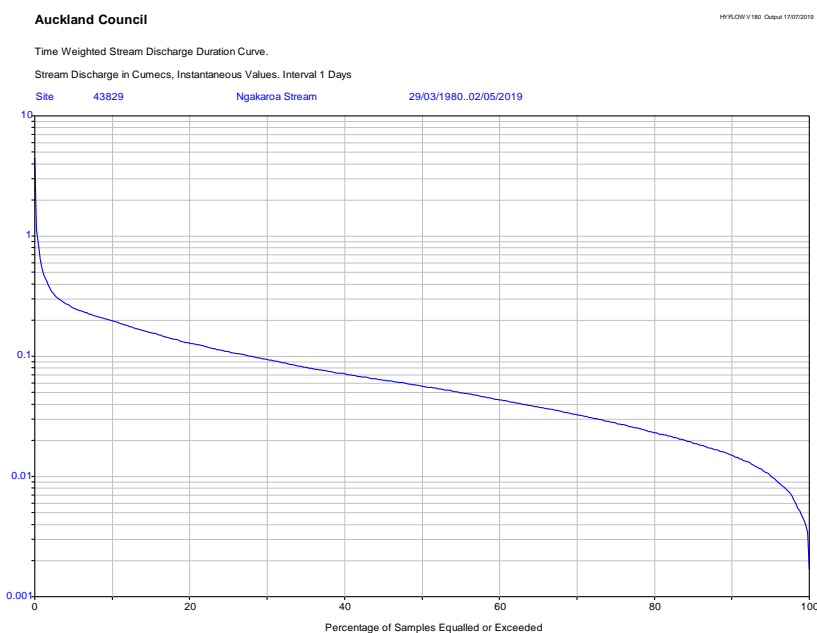
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 141.268

Comment: Site established for continuous long term flow record, continuous dissolved oxygen and temperature, stream water quality site, data used for Civil Defence, Environmental Monitoring, Stormwater Modelling, consents monitoring, National policy statement of freshwater management. Data is

indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Ngakoroa Stream @ Mill Rd level site has performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.24. 8126 Oakley Creek at Richardson Road

Commence: 29/05/2002

Cease: 28/11/2016

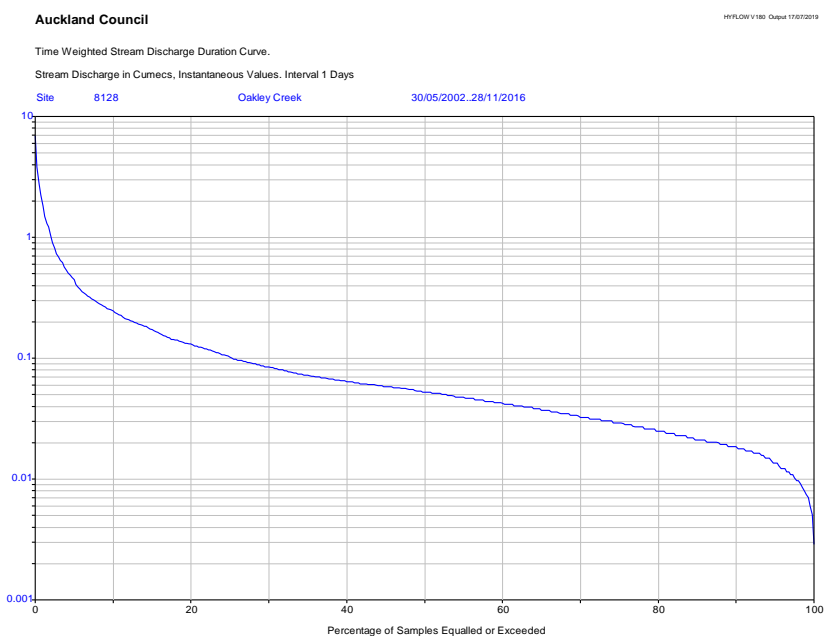
Easting: 1753075.900 Northing: 5914994.400

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 42.790

Comment: Stormwater site. Closed for remediation work.

The Oakley Creek at Richardson Road level site performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived. Of note is that the site was removed during the end of the calibration period and is due to be replaced after a 2-year gap.



### 7.25. 7502 Okura Creek

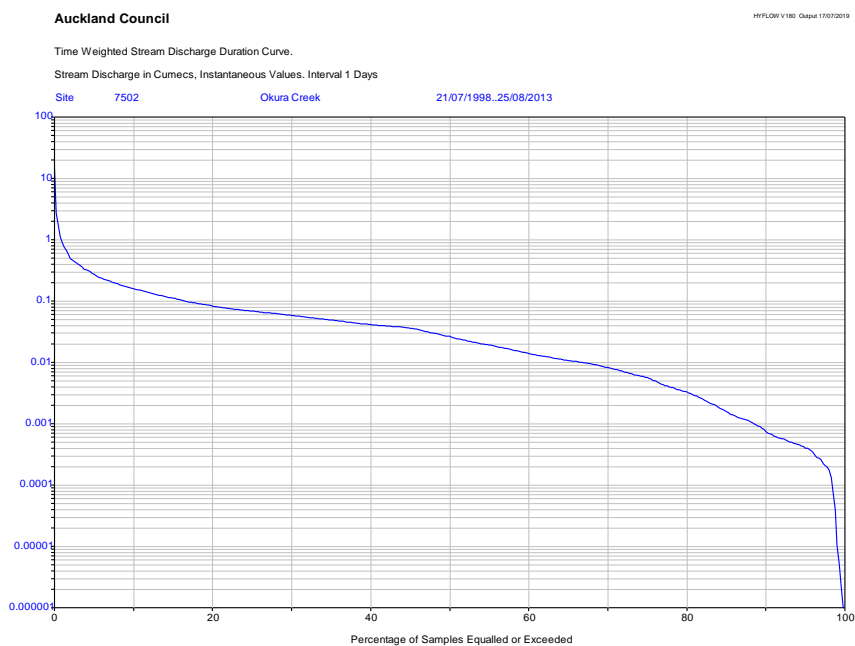
Commence: 6/07/1998

Cease: 01/03/2013

Easting: 1751391.000 Northing: 5938700.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Comment: Okura Study. 05aug08 - changed coords to NZTM



### 7.26. Okura @ Weiti Forest

Commence: 23/07/1998

Cease: 6/12/2016

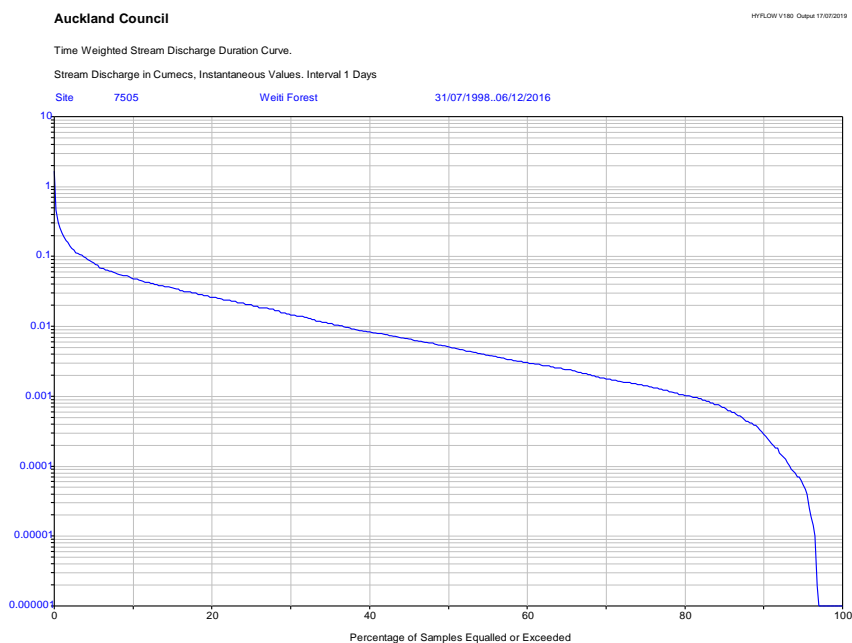
Easting: 1751872.000 Northing: 5940969.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 2.000

Comment: Site reinstated 11/07 Site decommissioned on @ 08:51 06/12/2016. Look in hydstra docs for documentation around the removal the site. gauge left oniste for future reference. CAn still be accessed by boat but no more access via landowners.

The Okura @ Weiti Forest level site performed well over the 5-year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.





### 7.27. 7912 Opanuku @ Vintage Reserve

Commence: 23/06/1999

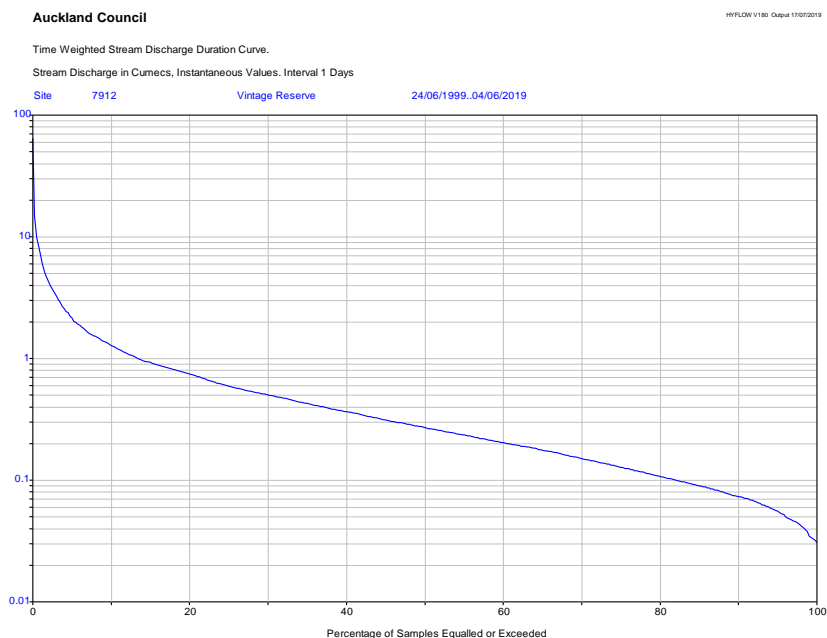
Cease:

Easting: 1744587.000 Northing: 5917203.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 20.000

Comment: Site established for flood warning in the Opanuku valley catchment part of a series of sites in the catchment as part of the flood warning, continuous level, flow and temperature Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, Stormwater Operations Support, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.28. 7904 Opanuku Stream @ Candia Road Bridge

Commence: 8/08/2006

Cease:

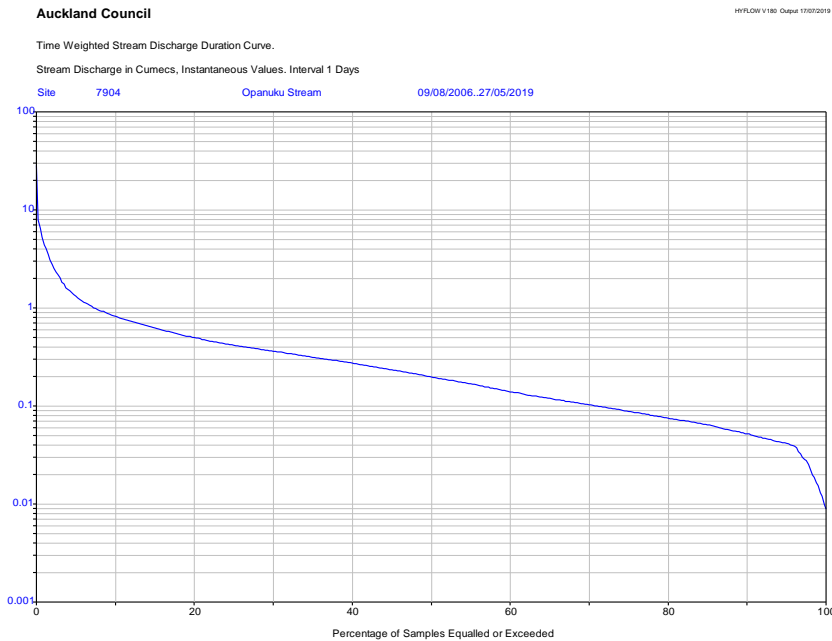
Easting: 1742162.000 Northing: 5915566.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Comment: Site was a gauging only site to support the ARC water quality SOE program. As of Sept 2006 site upgraded to Automatic flow site for the purposes of supporting Waitare City Council in Flood warning. 05aug08 - changed coords to NZTM Site originally run by Waitakere city council as early

flood warning for Opanuku catchment, Site upgraded by ARC continuous water level, flow, dissolved oxygen, temperature, sediment, Streams water quality site, Data used by Health waters - Henderson Sediment Programme. Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, Stormwater Operations Support, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Opanuku Stream @ Candia Road Bridge level site performed well over the 5-year calibration period in terms of the quality of the level data. This site has a stable bedrock control which provides a solid rating calculation.



### 7.29. 7911 Oratia @ Millbrook Rd

Commence: 22/06/1999

Cease:

Easting: 1745527.000 Northing: 5916175.000

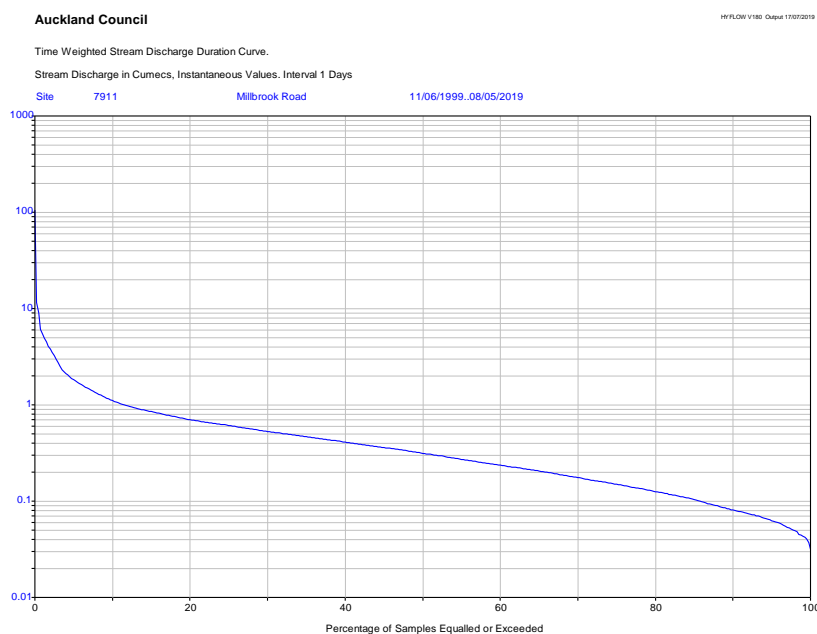
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 4.197

Comment: Site established as part of long term monitoring program and for localised flood warning for the Oratia catchment. Continuous water level, flow and temperature, Data used for Civil Defence, Environmental monitoring, Stormwater Modelling, Future Development Planning, National policy

statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E

operative unitary plan. Auckland Plan chapter 7,8,



### 7.30. 7202 Orewa @ Kowhai Ave

Commence: 20/06/1980

Cease:

Easting: 1748293.810 Northing: 5948506.750

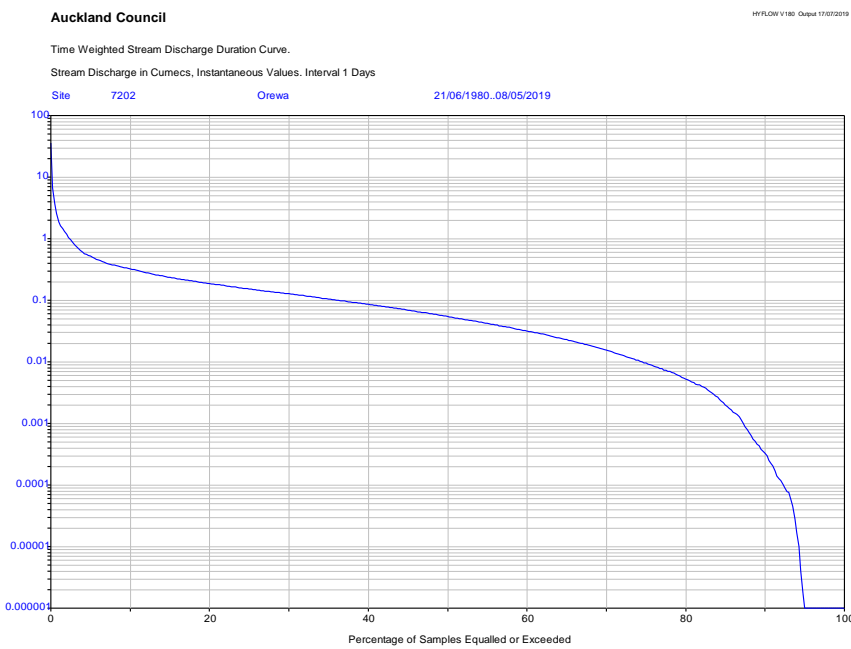
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 2.522

Comment: Site established as long term baseline flow catchment with continuous sediment record. This site is used for Civil Defence emergency management, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Long term trends analysis local reports cards, flood analysis reports, and indirectly freshwater quantity Chapter

B,D,E operative unitary plan. Auckland Plan chapter 7,8. Site is also unique due to geological formation causing flow to cease in period of drought

The Orewa @ Kowhai Ave level site performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.31. Oratia @ Parrs Cross Road

### 7.32. 8206 Otara @ Hills Rd Bridge

Commence: 28/04/1992

Cease:

Easting: 1767628.000 Northing: 5908076.000

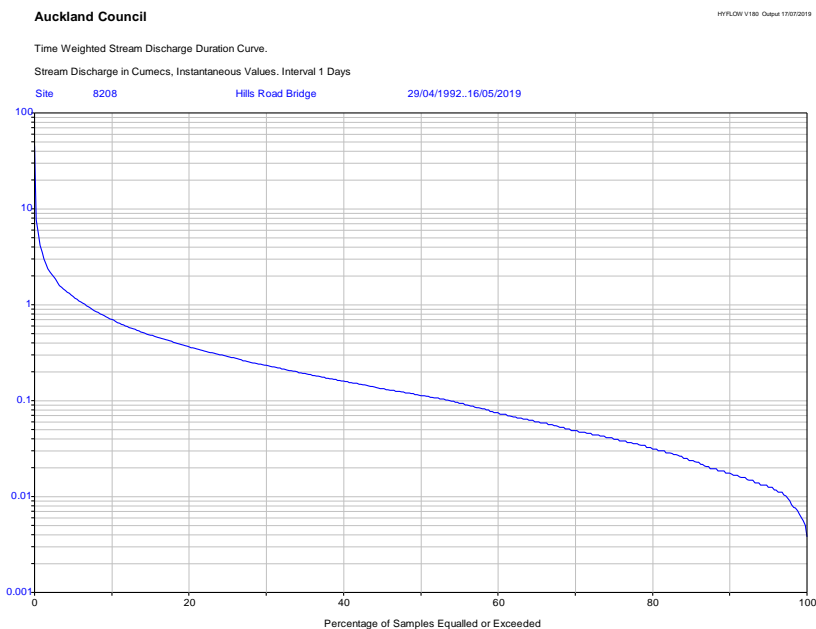
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 1.876

Comment: Site originally by NIWA was on tributary upstream Hills road site installed and taken over by ARC , Site linked to two nearby water quality sites, Data used for Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of

freshwater management. Long term trends reports cards, flood analysis reports, Data is indirectly

linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.33. Oteha River @ Days Bridge

Commence: 13/12/1979

Cease:

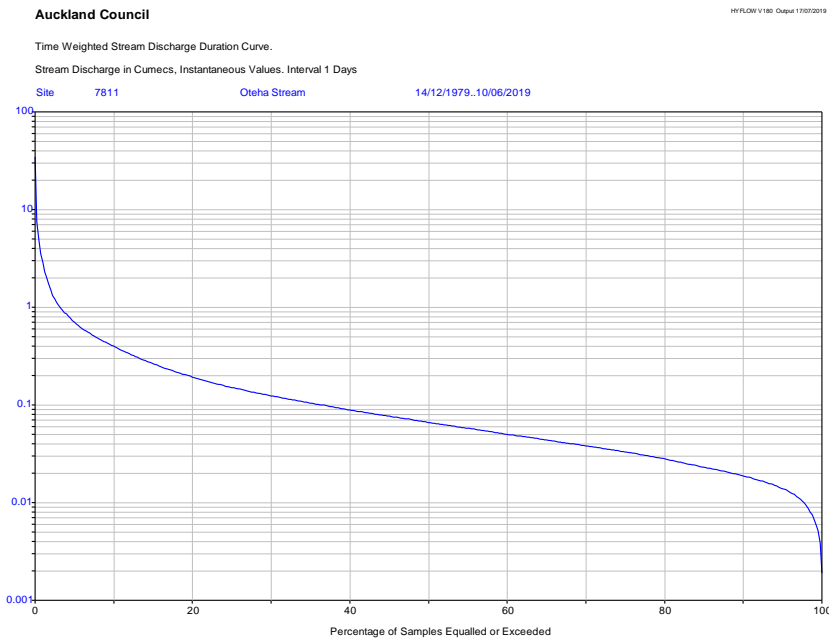
Easting: 1751328.000 Northing: 5933522.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 2.480

Comment: 05aug08 - changed coords to NZTM 17jun 2013-Oteha catchment over the length of flow record has continued to become more urbanised. This is reflected in the Double Mass Plot with neighbouring flow sites. Rangitopuni 7805 is best used for longer term trends although seasonal variation is apparent. Lucas 7830 is the closest site located 1km away and the double mass plot shows a very good relationship however the record is only available from 2007. NIWA data from 1978 to 01/04/1982. Auckland Council data from 01/04/1982, Continuous Level, Flow and Water temperature, Streams water quality site. Site monitors the long term hydrological change as catchment has changed from rural to urban. Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning and consents, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Oteha River @ Days Bridge level site performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.34. Papakura @ Great South Road Bridge

Commence: 16/06/1969

Cease:

Easting: 1769579.000 Northing: 5899729.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 3.862

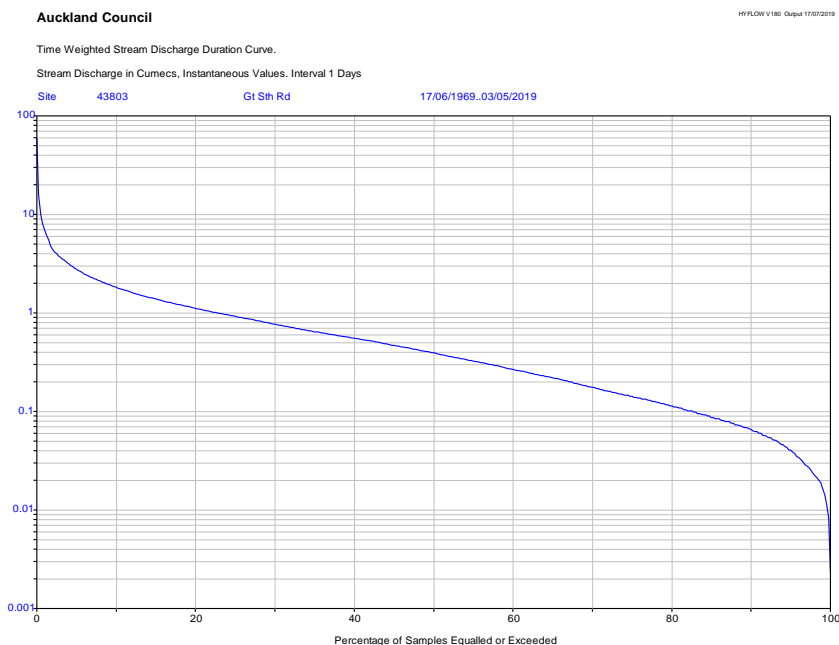
Comment: Site originally established by ministry of works as a baseline regional stream level and flow monitoring site, significant long term record with stable control which is well rated. Site has continuous temperature monitoring, upstream water quality site on Porchester road, Data used by

Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning,

National policy statement of freshwater management. Data is indirectly linked to freshwater

quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Papakura @ Great South Road Bridge site performed well over the 5-year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.35. 43807 Puhinui Stream

Commence: 6/12/1978

Cease:

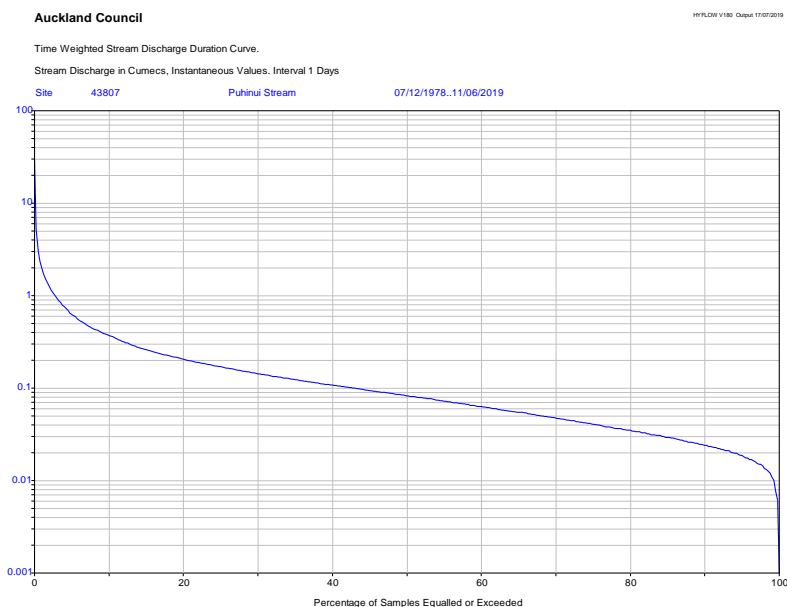
Easting: 1766420.000 Northing: 5904316.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 14.612

Comment: Site originally maintained by NIWA from 1978-1987 then ARC take over. Long term baseline monitoring location in South Auckland continuous level, flow, dissolved oxygen and temperature, streams water quality site. Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, consent monitoring, National policy statement of freshwater management. Data

is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,





### 7.36. 7805 Rangitopuni Stream

Commence: 16/05/1975

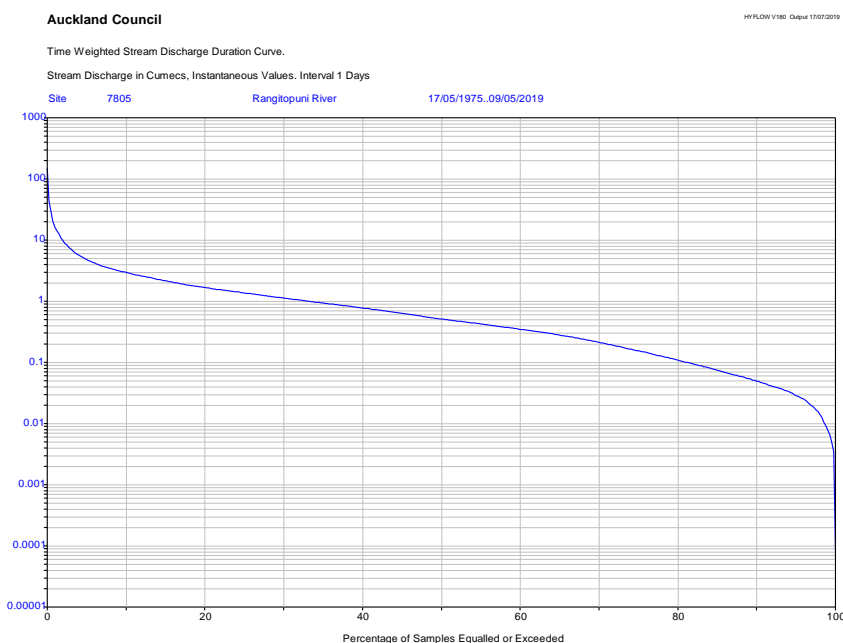
Cease:

Easting: 1744587.000 Northing: 5933077.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 6.023

Comment: Long term Continuous water level and flow data from 16/05/1975, continuous dissolved oxygen and temperature, Streams water quality downstream, major inflow in Waitemata harbour, data linked to consent holders, data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.37. 7907 Swanson @ Woodside

Commence: 3/02/1994

Cease:

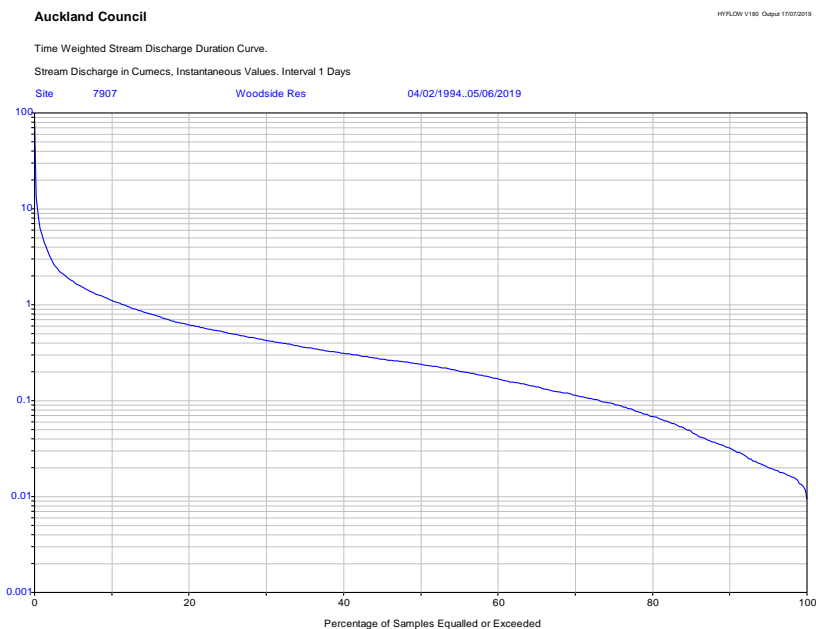
Easting: 1743783.000 Northing: 5919897.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 40.000

Comment: Site established 3/02/1994 for flood warning and long term continuous level and flow, sediment sampling from 2016, Continuous temperature and streams water quality, Data used for HW - Henderson Sediment Programme, Civil Defence, Environmental Monitoring, Stormwater Modelling, Future

Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.38. 7515 Taiaotea Stream

Commence: 9/08/2003

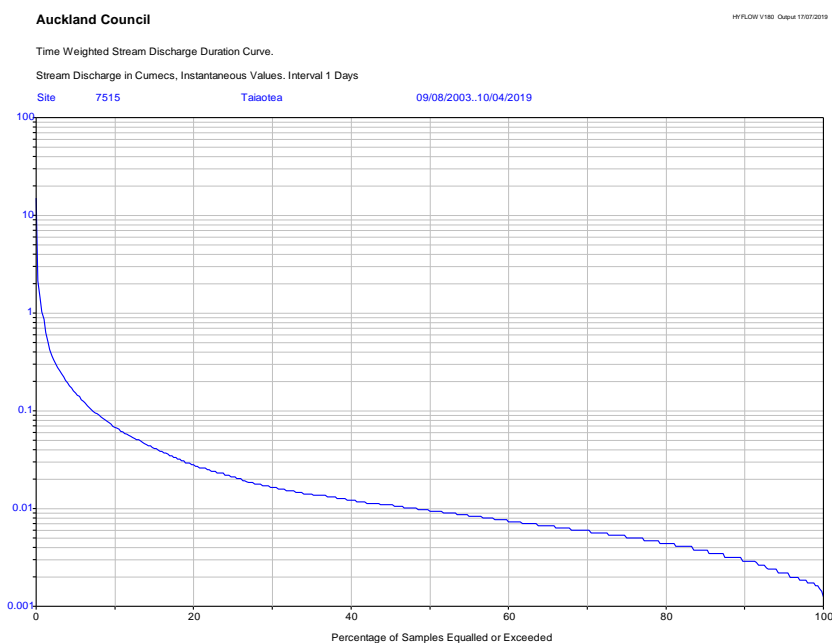
Cease:

Easting: 1755362.000 Northing: 5935169.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 1.503

Comment: SITE ESTABLISHED IN SEPT 2001 UNDER NORTSHORE CITY COUNCIL. TAKEN OVER BY AUCKLAND COUNCIL IN AUG 2011. Site originally installed for North Shore city Council taken over after Auckland Council amalgamation, continuous water level flow and temperature. Data used by Stormwater modelling, Future planning, Civil Defence, Data also input to long bay structure plan, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.39. 7519 Taiorahi Stream

Commence: 27/03/2006

Cease:

Easting: 1756374.400 Northing: 5933484.600

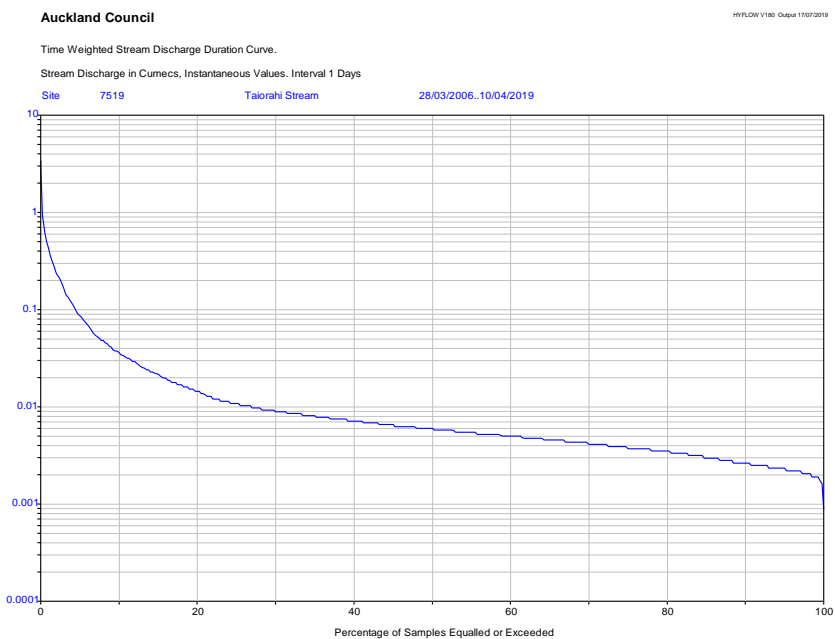
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 1.270

Comment: Site established 27/03/2006. Currently run by AC. Takeover date 21/08/2011.

Taiorahi site location is affected by high tides with the affect varying depending on wind direction and the water level at the site. Peaks in the data caused by high tides have been commented and coded differently since 21/8/12. High tide effects can also be seen to a lesser degree in the water temperature record. These effects have not been coded or commented.

Site taken over from North Shore City Council by ARC, continuous water level, flow and temperature, Data used by Civil Defence , Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.40. 6501 Tamahunga @ Quintals Falls

Commence: 23/02/1978

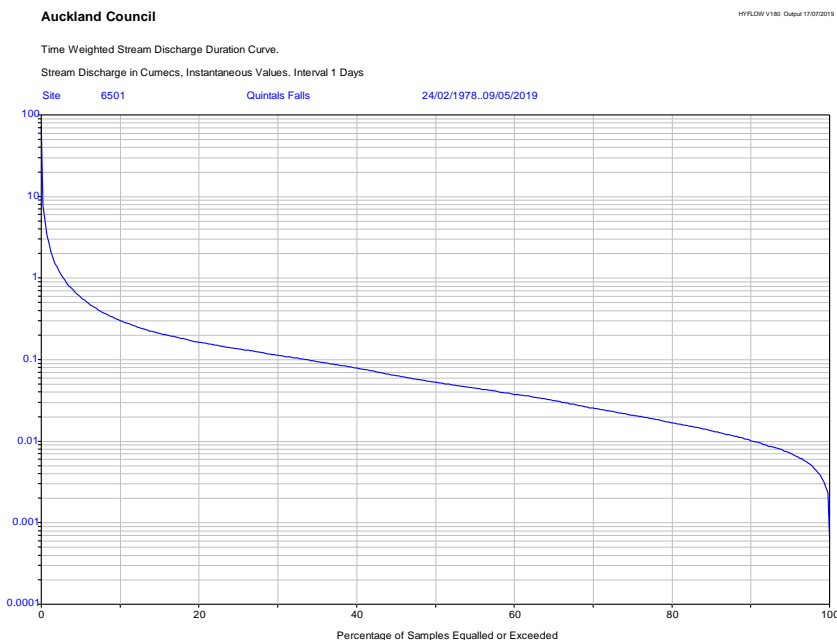
Cease:

Easting: 1755631.000 Northing: 5978391.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 5.301

Comment: Site flow linked to Matakana WQ site is the only flow site for the north east and only site entering Whagatea harbour, long term record for statistical measurements with stable control. NPSFM may require the site, has temporary temperature sensor deployed for initial modelling results through which will be May next year (2018), this will look at various land use types, geology and flow regimes and should identify where we might have gaps in terms of being able to model the region efficiently in terms of water quality. This NPSFM assessment will determine if site is required long term for AC.



### 7.41. 8222 Tamaki Trib

Commence: 14/04/2006

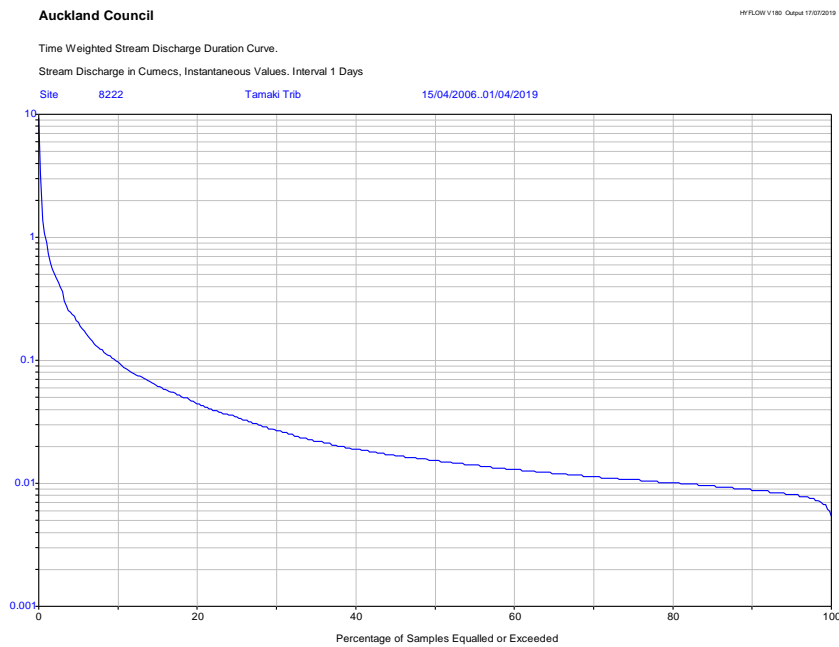
Cease:

Easting: 1764879.500 Northing: 5912818.100

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 1.992

Comment: Site originally established by Auckland City Council taken over after Auckland Council amalgamation, Continuous water level flow and temperature. Data used by Stormwater Modelling, Future Development Planning National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.42. 7506 Vaughn Stream @ Lower Weir

Commence: 1/09/1998

Cease:

Easting: 1755422.000 Northing: 5938731.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

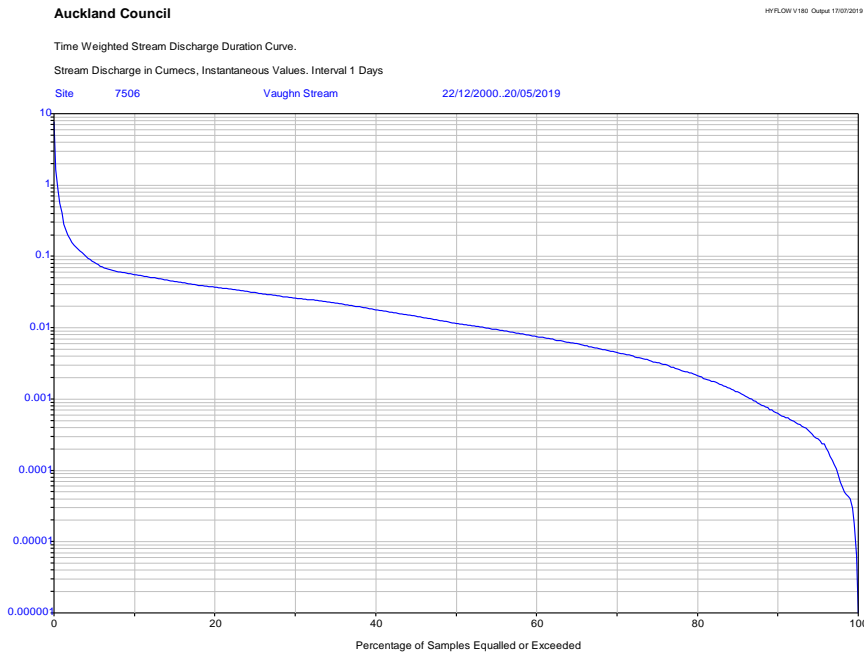
Elevation: 1.700

Comment: Site Commissioned to monitor water level and sediment runoff in the Vaughn catchment as part of Okura study. 05aug08 - changed coords to NZTM Site established for continuous level and flow is required as part of the long bay structure plan, sediment monitoring for long bay/Okura marine environment, Stream water quality site, Historical turbidity, EC, pH. Data used by Civil Defence, Environmental Monitoring, Stormwater Modelling, Future Development Planning. Site monitors catchment changes over time and low impact stormwater design, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8, New weir installed March 2018. Site data from 26/03/2018.

The Vaughn Stream @ Lower Weir site performed well over the 5-year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.

This site historically has been tidally influenced which can affect the flow record. The stage record has been edited to remove the tidal influence however this effect won't be reflected in the derived flow record due to the tide potentially influencing the flows at this site.

The site ratings were analysed to determine how representative the rated flows were of the gauged flows. The following plots are the differences between the rated and measured flows plotted against time and stage, with the cumulative difference plotted to determine any trends or bias that may be present within the rating and resultant flow record



### 7.43. 7607 Chartwell Stream

Commence: 14/04/1980

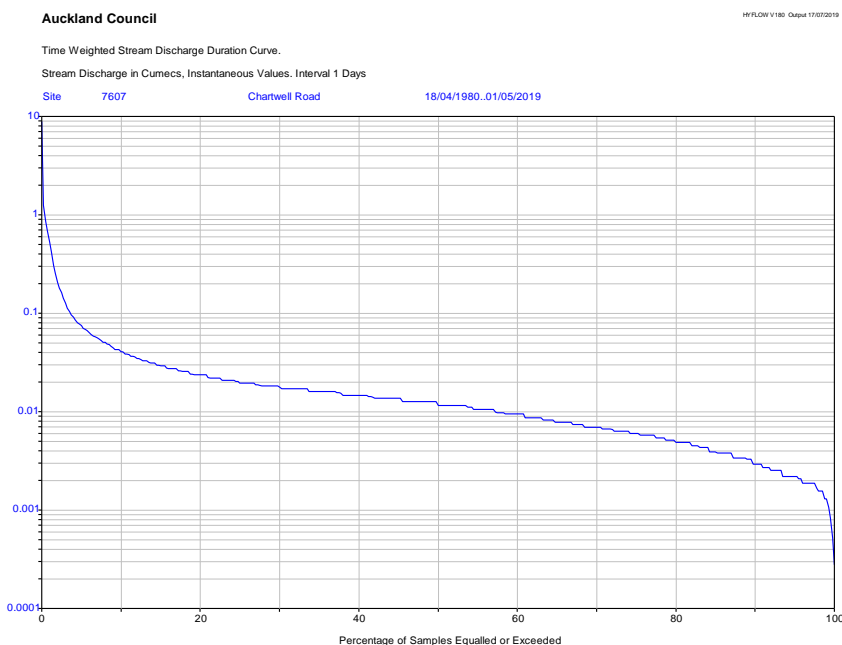
Cease:

Easting: 1754730.000 Northing: 5927651.800

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 18.786

Comment: Site originally installed by NIWA for North shore city council as part of Wairau catchment flood modelling, site taken over by consultants prior to Auckland Council. Data used Civil Defence, Stormwater Modelling, Future Development Planning, Site has significant record for flooding or Wairua catchment. Continuous stream flow and temperature, Data for National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,





### 7.44. Wairau Creek @ Motorway

Commence: 17/03/1978

Cease:

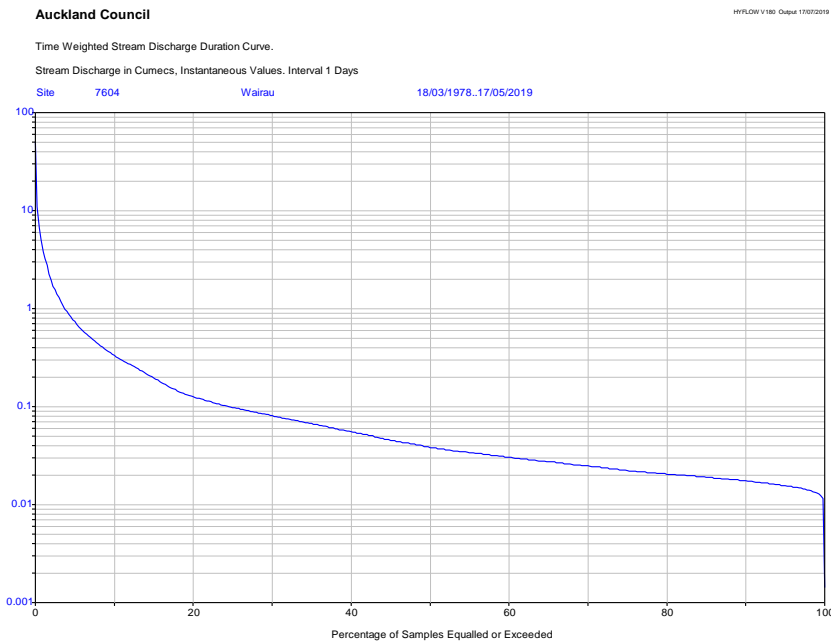
Easting: 1756064.000 Northing: 5928087.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 10.095

Comment: Site originally installed by NIWA for North shore city council as part of Wairau catchment flood modelling, site taken over by consultants prior to Auckland Council. Data used Civil Defence, Stormwater Modelling, Future Development Planning, Site has significant record for flooding or Wairua catchment. Continuous stream flow and temperature, Data for National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Wairau Creek @ Motorway site performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived.



### 7.45. 8516 Wairoa River

Commence: 13/02/1979

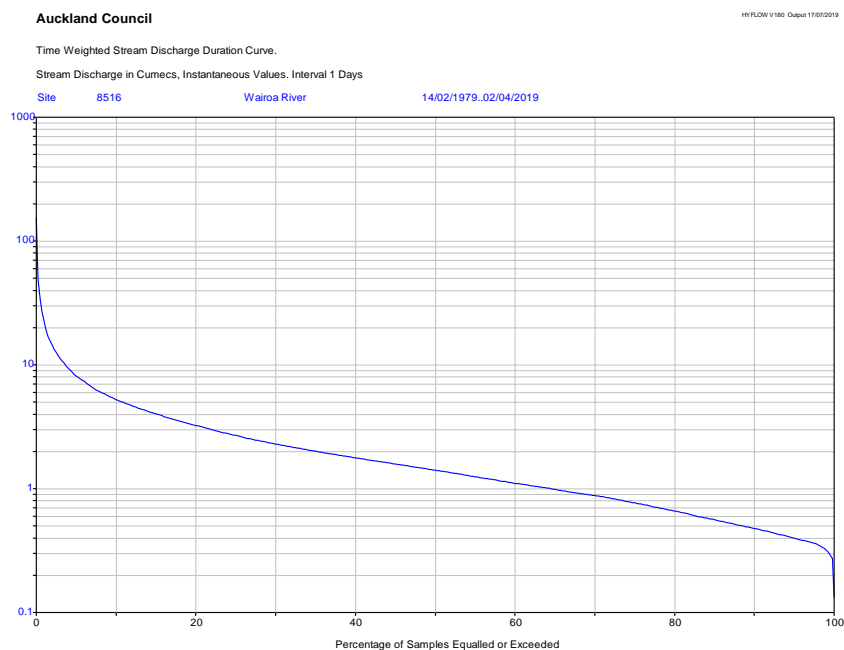
Cease:

Easting: 1782663.000 Northing: 5901676.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 20.000

Comment: Site established for continuous long term baseline flow and level monitoring site, sediment, dissolved oxygen and temperature monitoring. Stream water quality site, Data used Civil Defence , Environmental Monitoring, Stormwater Modelling, Water care services have minimum flow settings for the upstream dams linked to this site. National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.46. Waitangi @ S H Bridge

Commence: 1/04/1966

Cease:

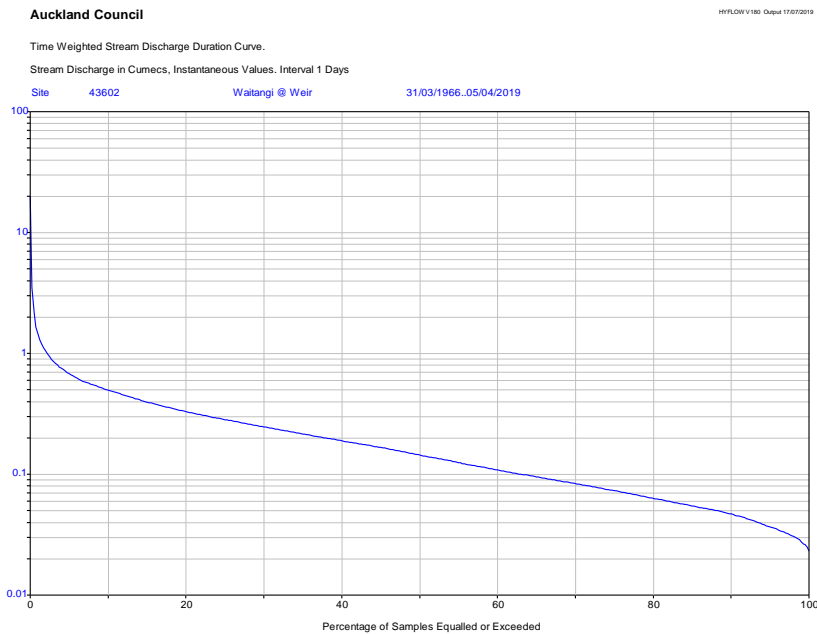
Easting: 1755195.000 Northing: 5878315.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 20.000

Comment: This site is owned and maintained by NIWA, AC get a data feed from their system and request processed water level data every 6 months. Continuous dissolved oxygen and temperature data collected by AC, Data used by Consent Monitoring major flow monitoring site in South Auckland used for minimum flow settings, Downstream water quality site, Civil Defence, Environmental Monitoring, NPS Policy Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,

The Waitangi @ S H Bridge level site performed well over the 5 year calibration period in terms of the quality of the level data. This site has an engineered flow weir control structure from which the rating and flow is derived. This site is owned and maintained by NIWA and not maintained to NEMS standard. Although Council don't control this site the data from this location will still be collected to robust NIWA standards and can be considered reliable.



### 7.47. 45705 Waiteitei Stream

Commence: 21/02/1996

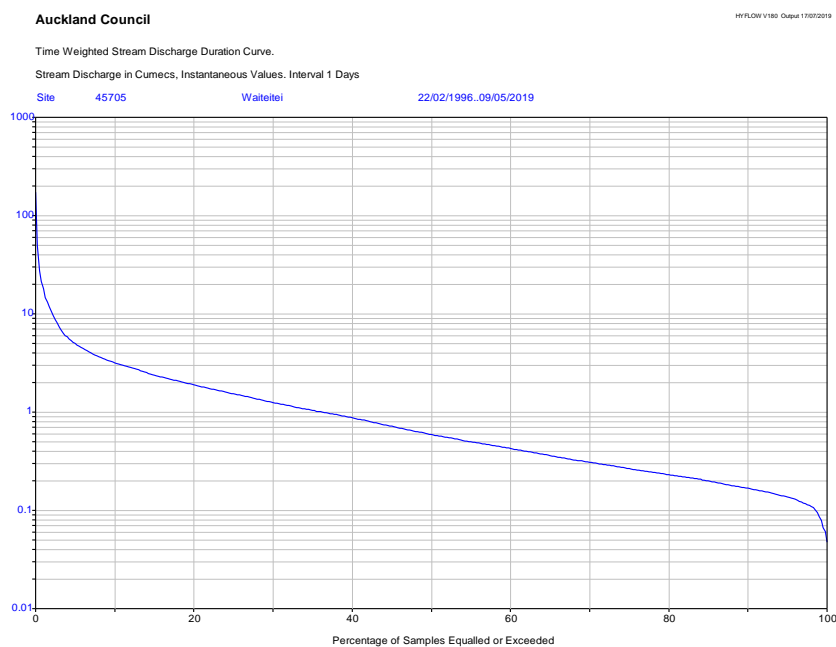
Cease:

Easting: 1742460.000 Northing: 5985481.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 2.547

Comment: Long term baseline Water level and flow record. Turbidity and sediment monitoring as part of the Kaipara harbour monitoring from December 2011. Data used for Civil Defence flood warning of the Whangaripo valley and Hoteo catchments, Environmental Monitoring, Stormwater Modelling, National policy statement of freshwater management. Data used to validate minimum flows for consenting in the area. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.48. 45702 Waiwhiu Stream

Commence: 10/02/2012

Cease:

Easting: 1746434.000 Northing: 5975851.000

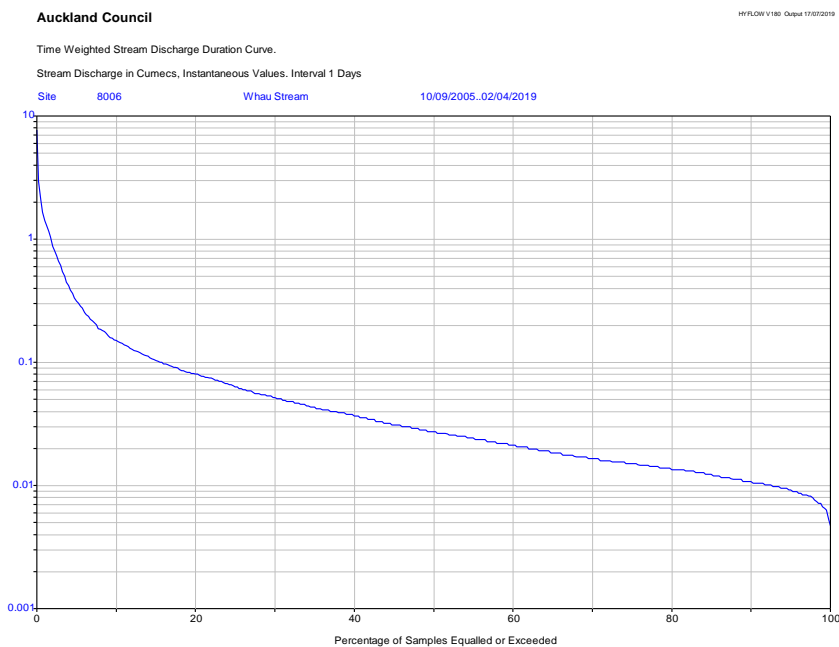
Grid Datum: NZTM New Zealand Transverse Mercator 2000

Latitude: -36.351290000 36°21'04.6"S

Longitude: 174.631940000 174°37'55.0"E

Lat/Long Datum: NZMG49 NZ Geodetic Datum 1949

Comment:



### 7.49. 7202 West Hoe Stream

Commence: 25/02/2003

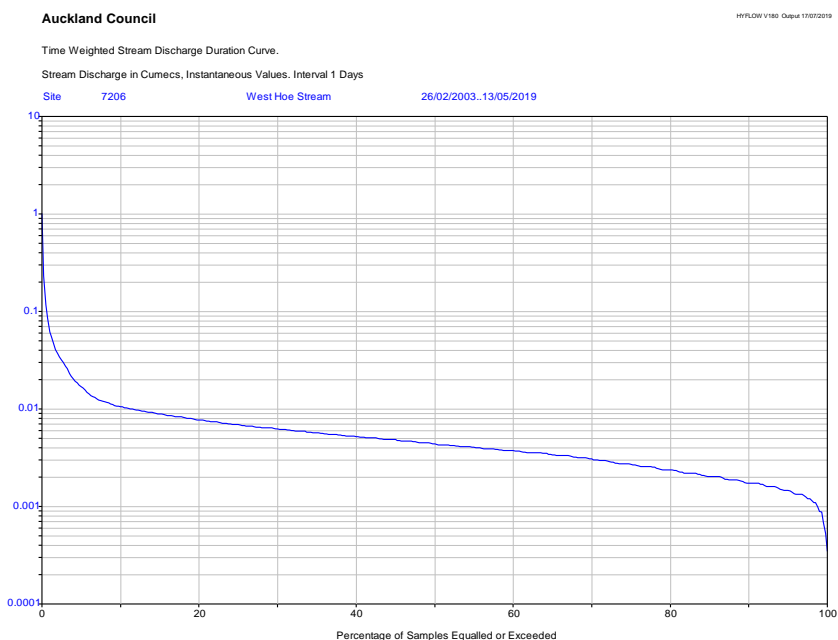
Cease:

Easting: 1748302.000 Northing: 5950580.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 40.000

Comment: 1st Order stream site. 05aug08 - changed coords to NZTM Site established as first order stream study, but is actually a second order stream as per the overland flow path GIS layer, Water level and flow, Water Temp, Turbidity record, Dissolved Oxygen, Multiparameter sonder, Sediment monitoring site, long term baseline site, Streams water quality, This site has become a long term reference site for the Auckland Region and is a long term climate change reference site. Data used by Environmental Monitoring, Stormwater Modelling, Future Development Planning, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan. Auckland Plan chapter 7,8,



### 7.50. 43811 Patamahoe Weir

Commence: 29/09/1976

Cease: 27/02/2015

Map: R12

Local Map Reference: 736440

Easting: 1763321.000 Northing: 5882374.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

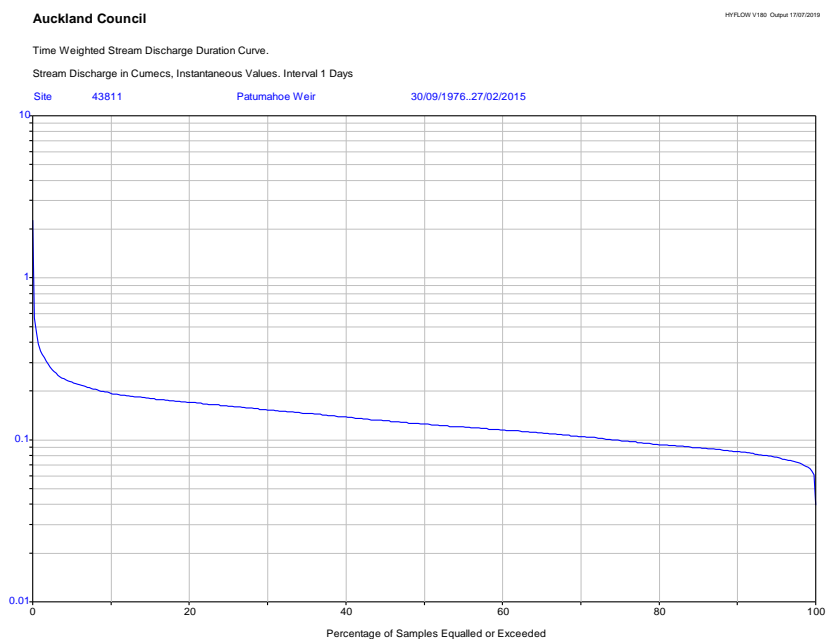
Latitude: -37.194944440 37°11'41.8"S

Longitude: 174.839027780 174°50'20.5"E

Lat/Long Datum: NZMG49 NZ Geodetic Datum 1949

Elevation: 57.000

Comment:



### 7.51. Whau @ Blockhouse Bay Rd

Commence: 9/09/2005

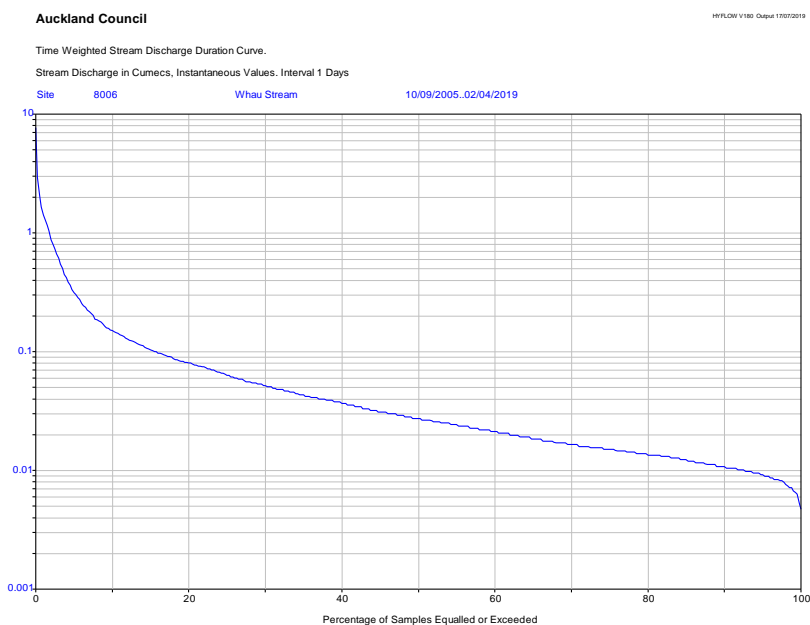
Cease:

Easting: 1751678.800 Northing: 5913591.000

Grid Datum: NZTM New Zealand Transverse Mercator 2000

Elevation: 8.348

Comment: Site originally established by Auckland City Council taken over after Auckland Council amalgamation, Continuous water level flow and temperature. Civil Defence and Emergency Management Planning, Stormwater network modelling, Future development planning, Linked to Whau catchment study 2017-2020 emerging contaminants primary monitoring site, National policy statement of freshwater management. Data is indirectly linked to freshwater quantity Chapter B,D,E operative unitary plan.





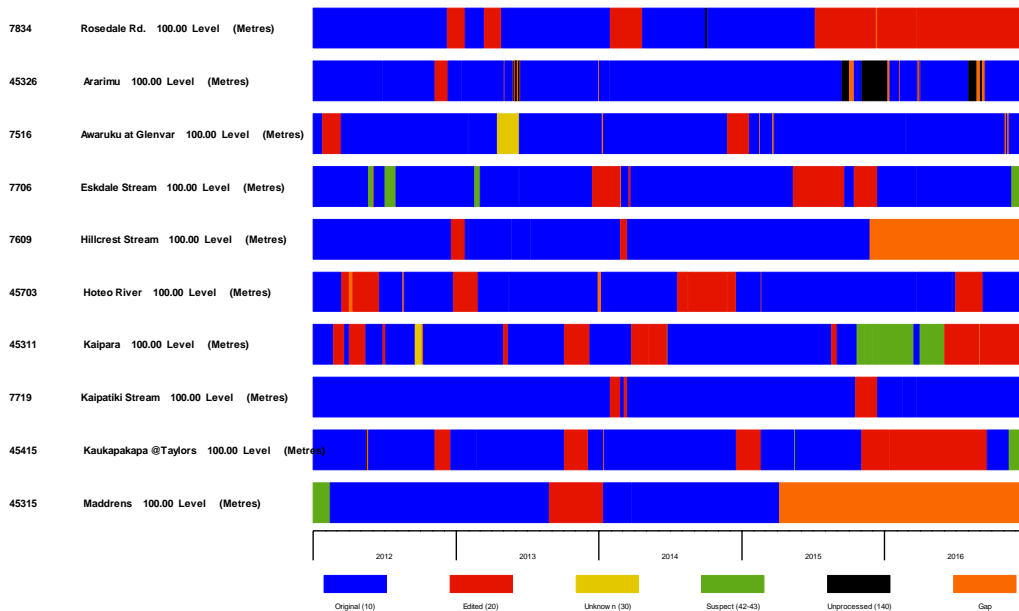
## 8. Appendix 1 - Quality Plots 2012 to 2017

### Auckland Council

HYQPL01 V106 Output 07/11/2019

Data Quality Plot

Period 00:00\_01/01/2012 to 00:00\_01/01/2017

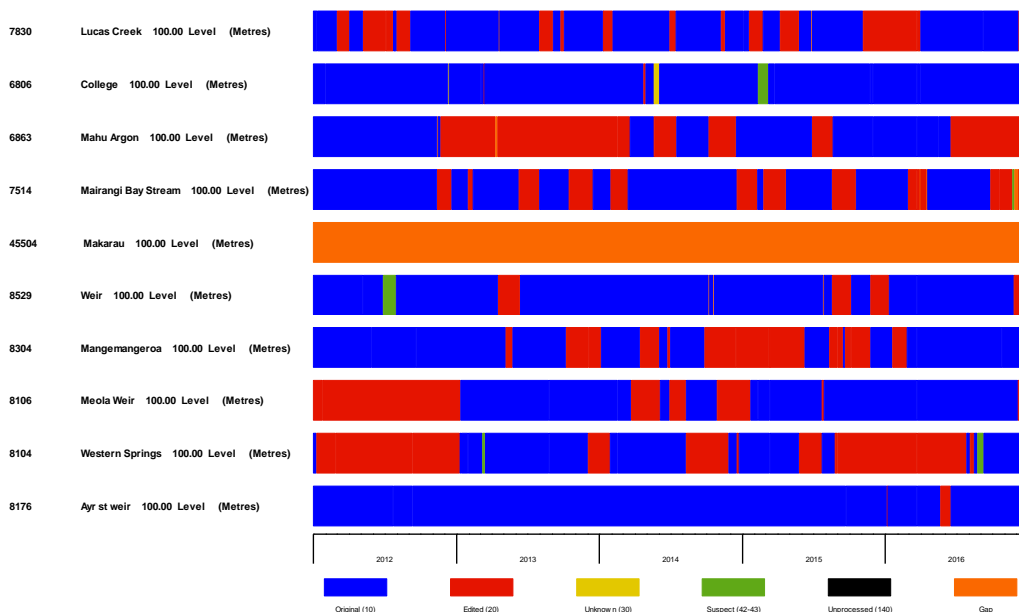


### Auckland Council

HYQPL01 V106 Output 07/11/2019

Data Quality Plot

Period 00:00\_01/01/2012 to 00:00\_01/01/2017

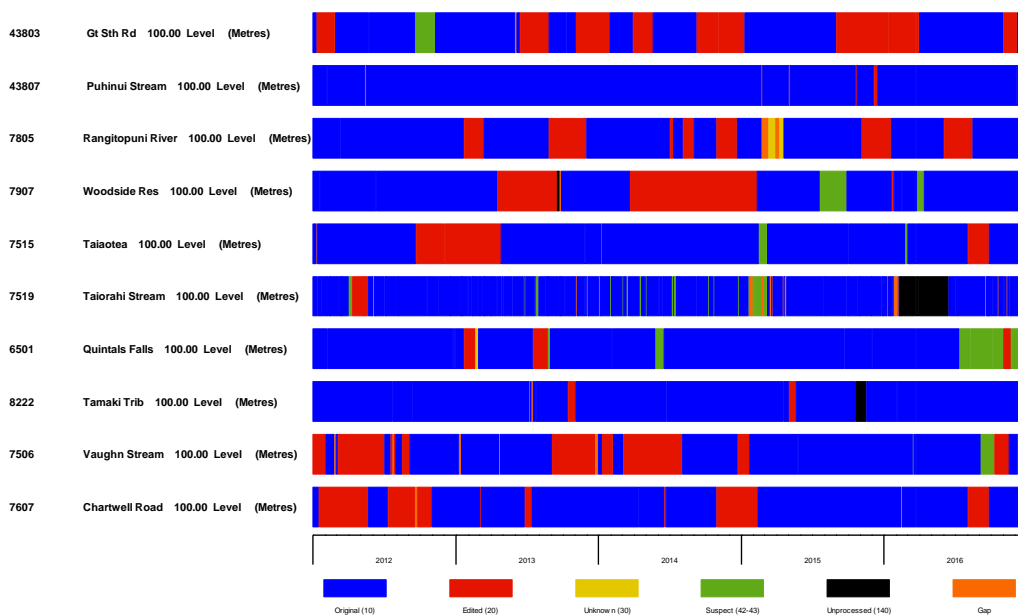


**Auckland Council**

HYGLOT V106 Output:07/11/2019

Data Quality Plot

Period 00:00\_01/01/2012 to 00:00\_01/01/2017

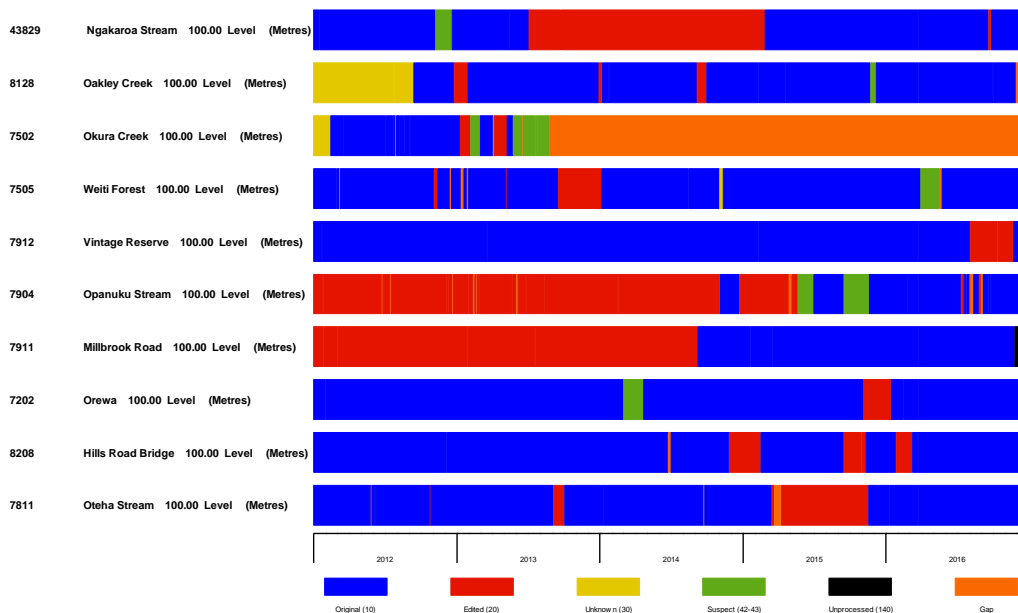


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HYGLOT V106 Output:07/11/2019

Data Quality Plot

Period 00:00\_01/01/2012 to 00:00\_01/01/2017

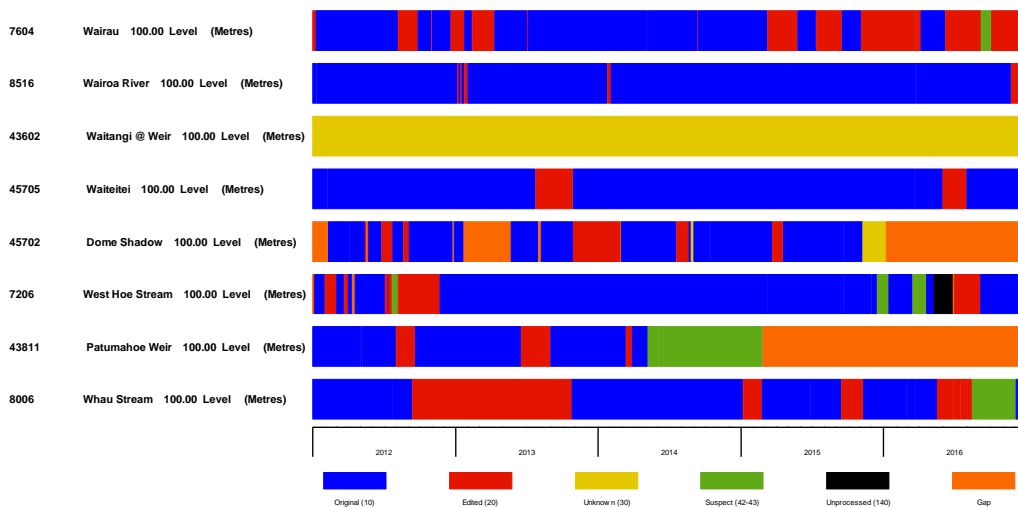


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HYGPILOT V1.06 Output 07/11/2019

Data Quality Plot

Period 00:00\_01/01/2012 to 00:00\_01/01/2017



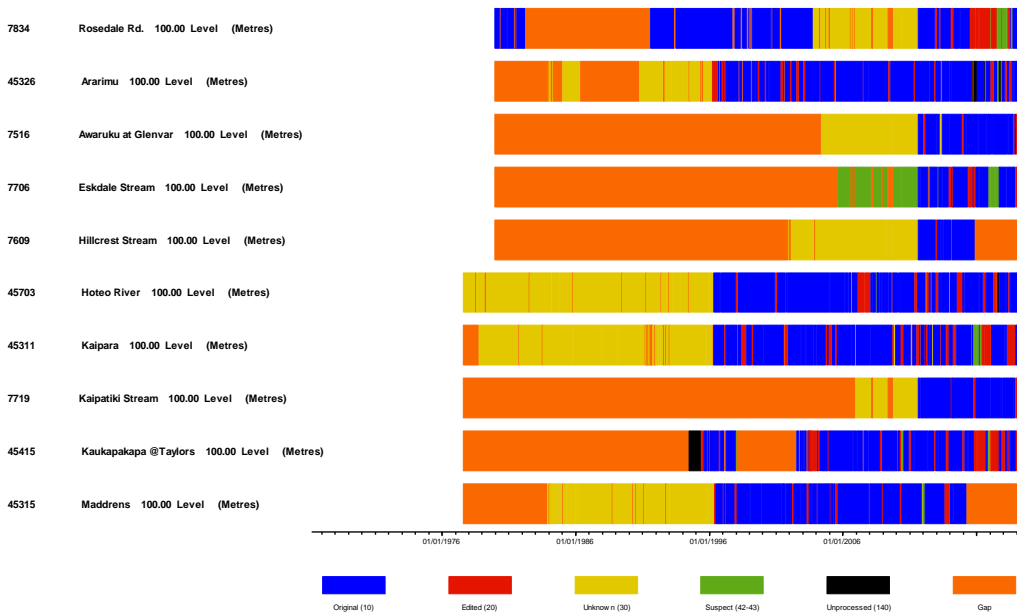
## 9. Appendix 2 - Quality plots full record

### Auckland Council

HYQPL0T V 106 Output 07/11/2019

Data Quality Plot

Period 17:20\_30/03/1966 to 09:10\_17/10/2019

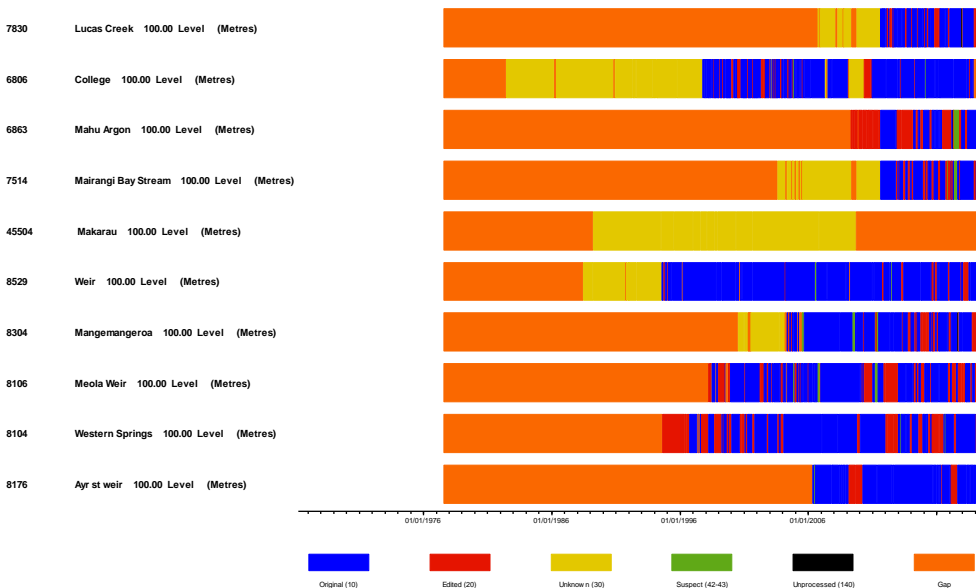


### Auckland Council

HYQPL0T V 106 Output 07/11/2019

Data Quality Plot

Period 17:20\_30/03/1966 to 09:10\_17/10/2019

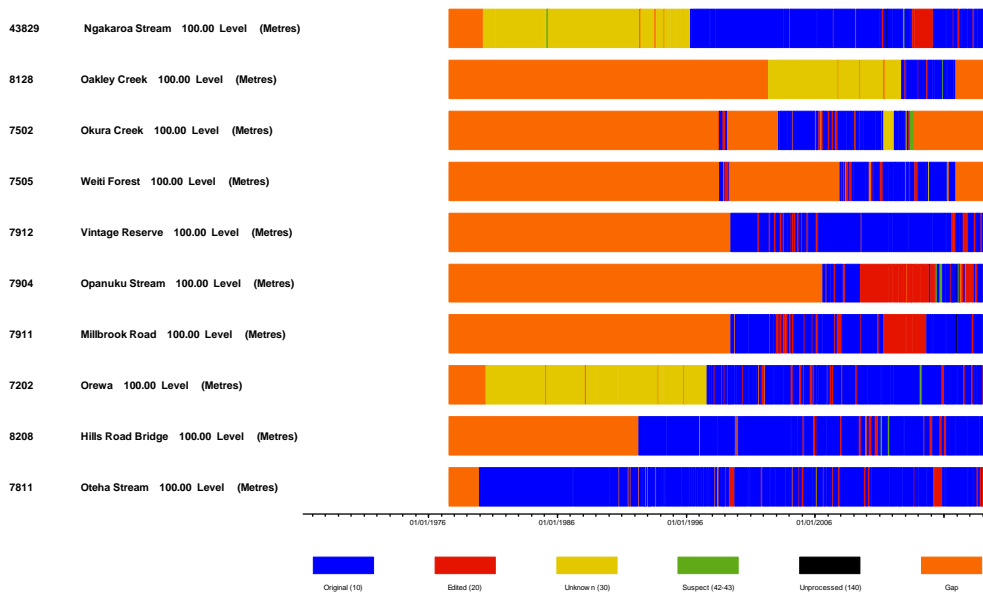


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HYDROLOT V106 Output 07/11/2019

Data Quality Plot

Period 17:20\_30/03/1966 to 09:10\_17/10/2019

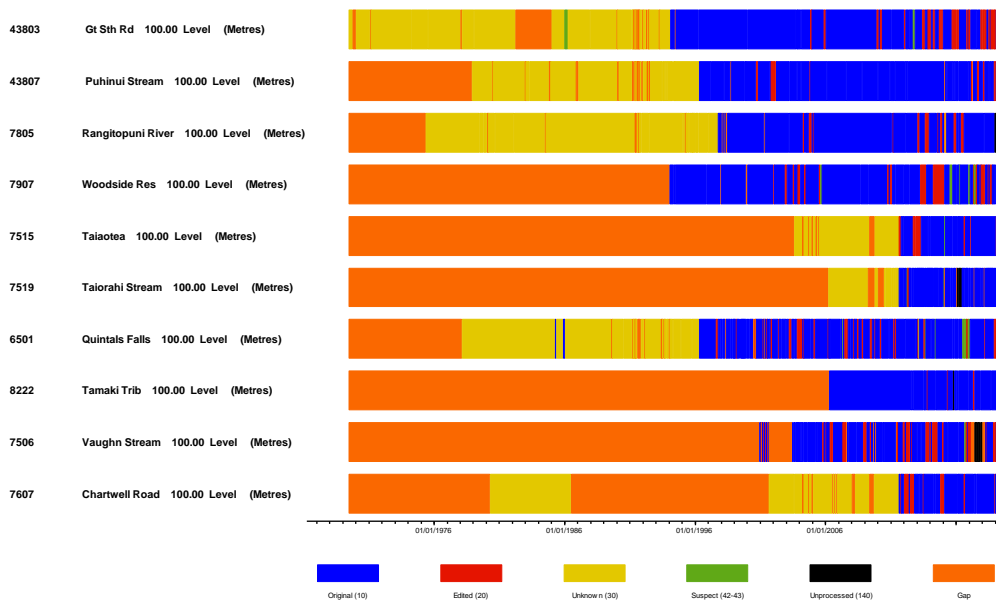


**Auckland Council**

HYDROLOT V106 Output 07/11/2019

Data Quality Plot

Period 17:20\_30/03/1966 to 09:10\_17/10/2019

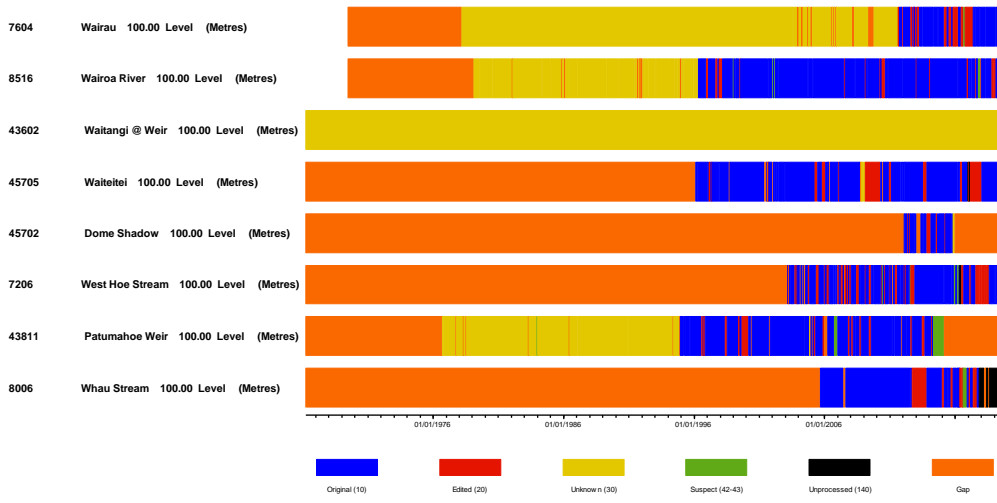


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HYDROLOT V106 Output 07/11/2019

Data Quality Plot

Period 17:20\_30/03/1966 to 09:10\_17/10/2019



## 10. Appendix 3 – Flow Assessment

Site	Site	MAX Gauged Flow (cumecs)	2 year flow (cumecs)	Maximum Gauged flow as % 2 year flow
Alexandra @ Rosedale Rd.	7834	0.803	11.339	7.1
Ararimu River @ Old North Rd Bridge	45326	33.126	41.972	78.9
Awaruku stream at Glenvar Road	7516	0.196702	8.932	2.2
Eskdale Stream at Lauderdale Reserve	7706	0.875183	11.692	7.5
Hillcrest Stream at Hillcrest Avenue	7609	1.293487	13.405	9.6
Hoteo River @ Gubbs	45703	249.373	152.9	163.1
Kaipara River @ Waimauku	45311	283.948032	75.619	375.5
Kaipatiki Stream at Kaipatiki road	7719	0.284852	2.454	11.6
Kaukapakapa @ Taylors	45415	61.832	85.156	72.6
Kumeu @ Maddrens Weir	45315	34.462	33.179	103.9
Lucas @ Gills Road	7830	6.254	22.411	27.9
Mahurangi @ College	6806	68.693011	94.092	73.0
Mahurangi Argonaut @ College	6863	32.742	94.092	34.8
Mairangi Bay Stream at Tennis Club	7514	0.541057	3.133	17.3
Makarau at Coles	45504			
Mangawheau Stream @ Weir	8529	8.009	38.282	20.9
Mangemangeroa	8304	2.577429	7.078	36.4
Meola Creek at Motions Road Weir	8106	3.986017	10.349	38.5
Motions Stream @ Western Springs.	8104	2.622	21.454	12.2
Newmarket Stream @ AYR Street crump weir	8176	0.177383	22.692	0.8
Ngakoroa Stream @ Mill Rd	43829	1.088605	3.201	34.0
Oakley Creek at Richardson Road	8128	6.355	10.062	63.2
Okura Creek @ Awanohi Rd	7502	4.003829	11.84	33.8
Okura @ Weiti Forest	7505	1.541222	1.866	82.6
Opanuku @ Vintage Reserve	7912	52.37561	48.041	109.0
Opanuku Stream @ Candia Road Bridge	7904	28.459915	41.887	67.9
Oratia @ Parrs Cross Road	7909			0.0
Oratia @ Millbrook Road	7911	30.188	57.188	52.8
Orewa @ Kowhai Ave	7202	15.274	37.356	40.9
Otara @ Hills Road Bridge	8208	29.17	30.477	95.7
Oteha River @ Days Bridge	7811	15.734	32.422	48.5
Papakura @ Great South Road Bridge	43803	59.687	33.851	176.3
Puhinui @ Drop Structure	43807	15.6706	19.411	80.7
Rangitopuni River @ Walkers	7805	187.99	107.976	174.1
Swanson Stream @ Woodside Reserve	7907	36.001	53.336	67.5
Taiaotea stream at Freyberg Park	7515	1.533	12.878	11.9
Taiorahi Stream at Westbourne ave	7519	1.348461	6.381	21.1
Tamahunga River @ Quintals Falls	6501	23.336	31.206	74.8
Tamaki Trib at Bowden Road Crump Weir	8222	2.402	12.217	19.7

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Vaughn Stream @ Lower Weir	7506	8.019	10.203	78.6
Wairau Creek @ Chartwell Road	7607	8.26637	11.446	72.2
Wairau Creek @ Motorway	7604	56.2	42.752	131.5
Wairoa River @ Tourist Road	8516	337.513	120.167	280.9
Waitangi @ S H Bridge	43602	6.02186	15.303	39.4
Waiteitei River @ Sandersons	45705	113.505	122.563	92.6
Waiwhiu Stream @ Dome Shadow	45702	8.415		0.0
West Hoe @ Halls	7206	0.727206	1.63	44.6
Whangamaire @ Patumahoe Weir	43811	0.313727	1.078	29.1
Whau Stream at Blockhouse Bay Road Crump Wier	8006	0.608232	11.399	5.3