Document Id: **A1355271**

MEMORANDUM

To: **Kirstyn Lindsay**

From: **Sarah McCrorie**

Date: **11/06/2020**

Re: **RM20.005 - historical water use analysis**

This memorandum is in relation to application RM20.005 to replace 95789 from Amisfield Burn for the purposes of irrigation and domestic potable supply. Abstraction of water under this permit occurs through water meter WM1214.

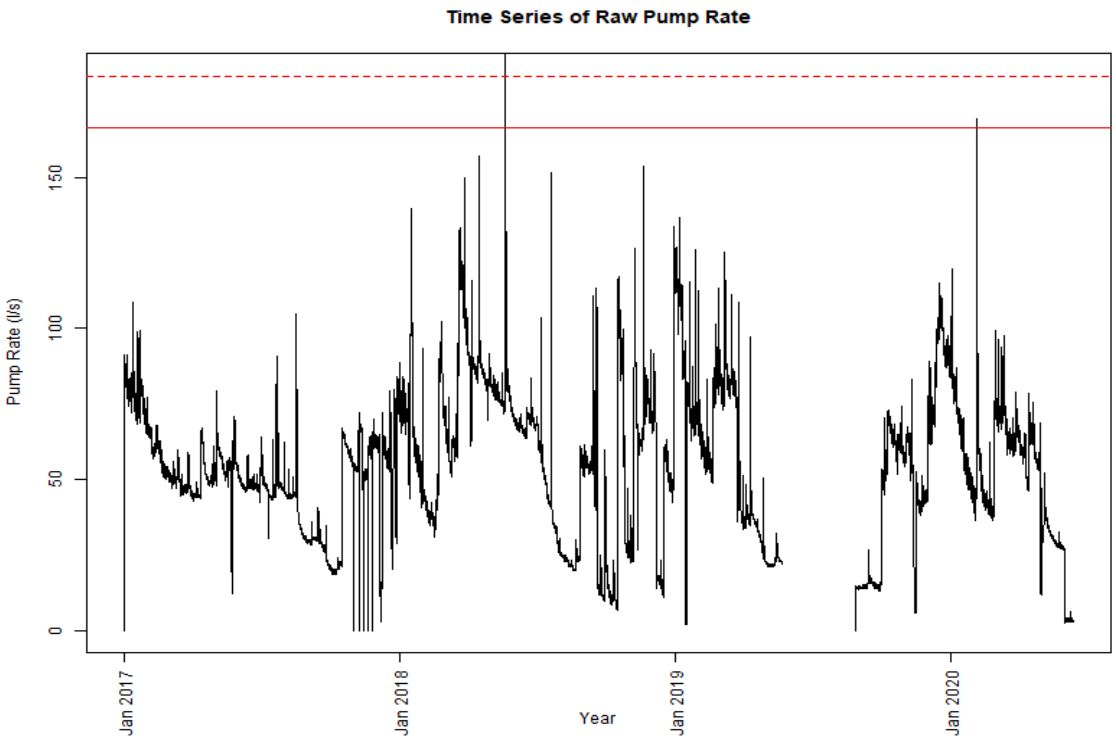
All analyses, graphs, and calculations were performed using RStudio version1.2.5033 and RGui version 3.6.3.

Data taken through WM1214 extends from 01 January 2017 to 10 June 2020 with a total of 27,852 hourly measurements.

In addition to analysing the raw data, the following steps were taken:

- Rates less than, or equal to zero were set to NA.
- The maximum average rate of take authorized by the permit this application seeks to replace is 166.7 l/s and water is taken through an open channel. A 10% margin of error was applied to this and rates in excess of 183.37 l/s were set to NA.
- Rates between 166.7l/s and 183.37l/s were set to 166.7l/s.
- The resultant data set had 27,844 hourly measurements

A time series showing the pump rate, the maximum consented rate, and the upper error limit is presented below:

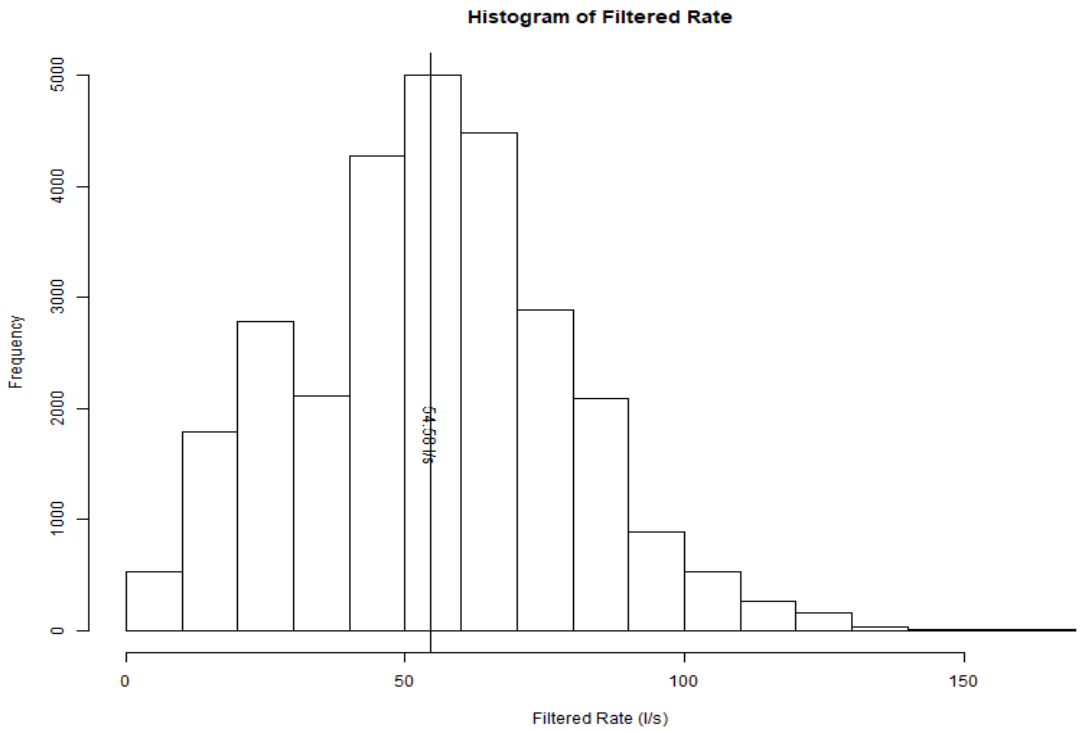


The solid red line represents the consented maximum rate of 166.7 l/s, and the broken red line represents 166.7 + 10% (183.37 l/s).

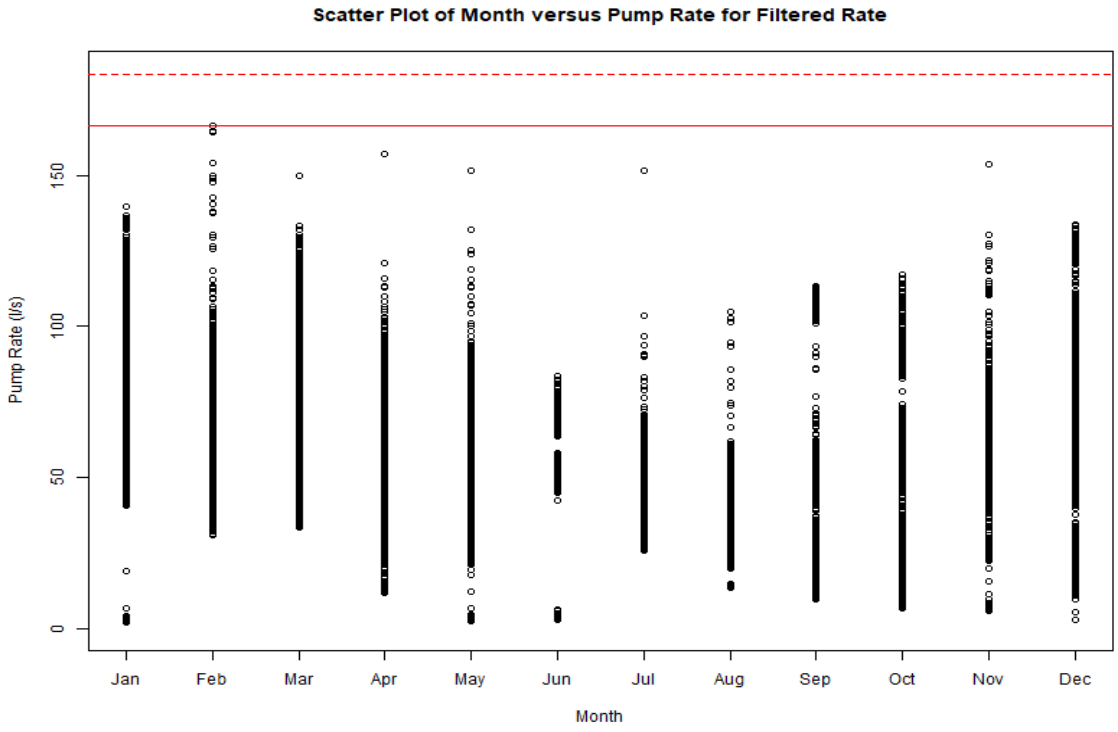
There doesn't appear to be any consistent pattern, 2019 and 2020 have some evidence of seasonality. The gap in the data during 2019 appears to be the result of a request to reset the data.

The filtered data set contains 27,844 measurements with an average take of 54.6 l/s, a median rate of take of 54.6 l/s, and a modal (most common) rate of take of 23 l/s.

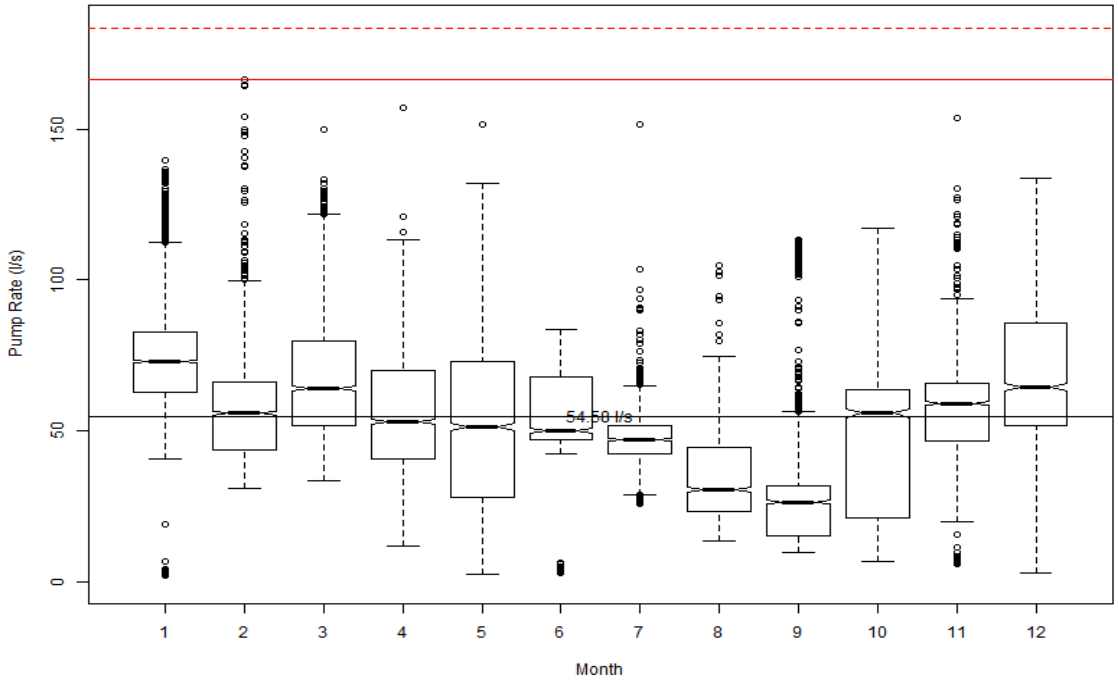
The histogram of the filtered rate of take below shows a relatively normal distribution, 67.4% of measurements fall between 30 l/s and 80 l/s.



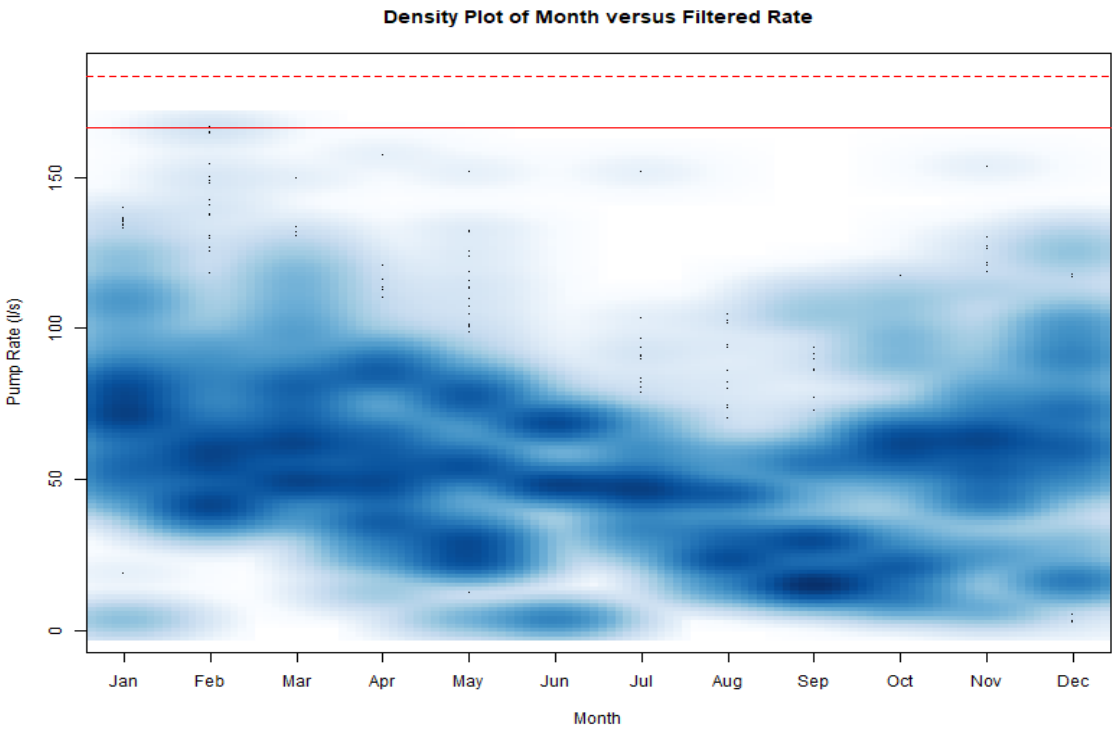
The scatter plot below shows higher rates of take are likely to occur between September and May, this is consistent with taking for the purposes of irrigation.



The box plot shows a clearer picture of the distribution of the rates. September has quite a few outliers and is more likely to be a lower rate of take. The higher average rates of take are likely to occur between October and March, this is consistent with taking for the purposes of irrigation. The taking during the non-irrigation season is higher than a single domestic potable use, it may be supplying multiple households or stock drinking.



The density plot supports the findings from the box plot.



The high use data set was selected by filtering for those months in which the median usage exceeded the median for the filtered data set. The mean for the high use data set is 62.3l/s, the median is 61.92 l/s and the modal value is 62.08 l/s.

Percentiles are not a percentage of the maximum rate, but rather the rate that is exceeded x% of the time. Percentiles are calculated by ranking the data from lowest to highest and taking the weighted average of the nth highest and the n+1th highest values. The 80th percentile is the pump rate that is exceeded 20% of the time. The 90th percentile is the pumping rate that is exceeded 10% of the time. The 95th Percentile is exceeded 5% of the time. What this means in terms of the analysis is that if the applicant is pumping at the maximum consented rate more than 5% of the time, the 95th percentile will equal the maximum consented rate. If they are pumping at the maximum consented rate more than 10% of the time, the 90th percentile will equal the maximum consented rate. If they are pumping at the maximum consented rate more than 20% of the time, then the 80th percentile will equal the maximum consented rate. In practical terms if the applicant is pumping 24 hours/day and 2160 hours for a 90-day season then:

- The 80th percentile is the rate that is exceeded for 5 hours per day, or 432 hours per season.
- The 90th percentile is the rate that is exceeded for 2.5 hours per day, or 216 hours per season.
- The 95th percentile is the rate that is exceeded for 1.5 hours per day, or 108 hours per season.

What this means is that if a consent holder is consistently using their maximum consented rate for more than 5%, 10%, or 20% of the time they are pumping, it will show up in the table of percentiles.

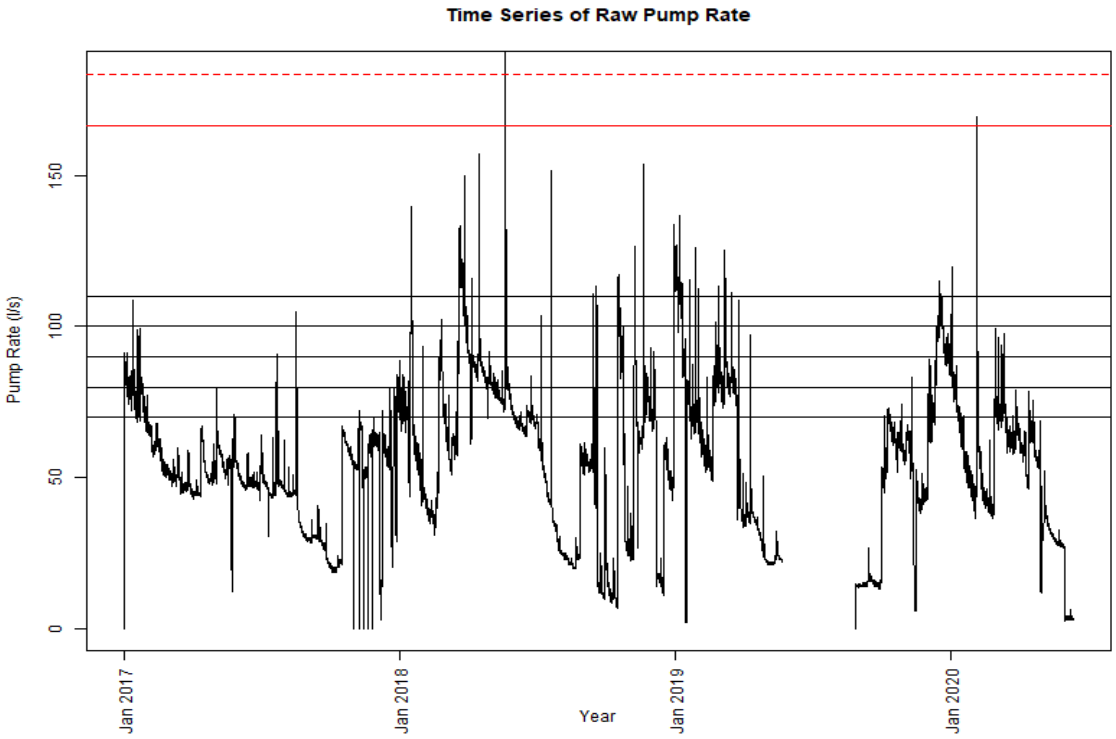
The 80th, 90th, and 95th percentiles for the flow rate were calculated, without modelling the distribution, for the raw data set, the filtered data set, and the high rate data set. The results are presented to three significant figures below.

	80th %ile	90th %ile	95th %ile
Raw rate	73.8	84.8	94.4
Filtered rate	73.9	84.8	94.4
High use rate	79.8	91.3	103

A summary of rates and volumes for the period 1 July 2012 to 30 June 2017, prepared according to proposed Method 10.A.4 is presented below:

	Max Take Rate	Max Daily Volume	Max Monthly Volume	Max Annual Volume
2012/2013	NA	NA	NA	NA
2013/2014	NA	NA	NA	NA
2014/2015	NA	NA	NA	NA
2015/2016	NA	NA	NA	NA
2016/2017	109	8230	208000	893000
Mean	109	8230	208000	893000

A time series with reference lines at 70 l/s, 80 l/s, 90 l/s, 100 l/s, & 110 l/s is presented below to provide context for the percentiles and where they sit in relation to the history of taking by the resource consent holder.


Time Series of Raw Pump Rate
Pump Rate (l/s)
0
50
100
150
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Year

The number of days in each month of the historical record that the 80th, 90th, and 95th percentiles have been exceeded for all three data sets is presented below:

73.8 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	29	0	0	0	1	0	1	2	0	0	0	11
2018	15	9	17	30	29	3	2	0	5	9	14	7
2019	25	11	26	1	0	NA	NA	0	0	1	1	27
2020	8	7	11	2	0	0	NA	NA	NA	NA	NA	NA

84.8 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	15	0	0	0	0	0	1	1	0	0	0	1
2018	5	6	14	24	7	0	2	0	5	9	7	5
2019	18	9	13	1	0	NA	NA	0	0	0	0	24
2020	4	5	3	0	0	0	NA	NA	NA	NA	NA	NA

94.4 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	5	0	0	0	0	0	0	1	0	0	0	0
2018	4	3	13	5	4	0	2	0	4	7	4	3
2019	15	5	5	1	0	NA	NA	0	0	0	0	13
2020	2	3	2	0	0	0	NA	NA	NA	NA	NA	NA

73.9 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	29	0	0	0	1	0	1	2	0	0	0	11
2018	15	9	17	30	29	3	2	0	5	9	14	7
2019	25	11	26	1	0	NA	NA	0	0	1	1	27
2020	8	7	11	2	0	0	NA	NA	NA	NA	NA	NA

79.8 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	22	0	0	0	0	0	1	2	0	0	0	6
2018	10	7	14	30	17	1	2	0	5	9	11	5
2019	21	11	23	1	0	NA	NA	0	0	0	1	24
2020	8	5	5	0	0	0	NA	NA	NA	NA	NA	NA

91.3 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	7	0	0	0	0	0	0	1	0	0	0	0
2018	4	4	14	9	4	0	2	0	5	7	5	4
2019	16	6	6	1	0	NA	NA	0	0	0	0	19
2020	3	3	3	0	0	0	NA	NA	NA	NA	NA	NA

103 l/s	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	1	0	0	0	0	0	0	1	0	0	0	0
2018	3	0	9	2	3	0	2	0	4	4	3	3
2019	13	3	4	0	0	NA	NA	0	0	0	0	6
2020	2	2	0	0	0	0	NA	NA	NA	NA	NA	NA

A summary of daily volumes, in m^3, filtered for a maximum daily take of 14,400 m^3 and then rounded to three significant figures is presented below:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	314	3030	3120	1270	316	281	2280	1210	931	725	570	1130
Mean	6480	4990	5910	4930	4240	4440	4130	2870	2570	4030	4830	5500
Median	6420	4830	5600	4600	4460	4330	4100	2640	2400	4800	5090	5480
80%	7500	5900	7040	7150	6520	5970	4760	3880	4570	5570	5770	7720
90%	8910	7200	8210	7520	6870	6040	5210	4100	4730	6040	6660	8420

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
95%	9630	7600	9390	7870	7150	6160	5840	4720	5010	8020	6830	8800
Max	10600	10800	10700	8560	8380	6430	6100	5570	9340	9640	9700	11100

A summary of monthly volumes, based on daily volumes that have been filtered for a maximum daily take of 14,400m³ and then rounded to three significant figures is presented below.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	208000	145000	134000	130000	149000	126000	129000	110000	74600	105000	126000	148000
2018	184000	124000	214000	224000	213000	178000	127000	74500	117000	110000	164000	134000
2019	229000	164000	202000	92300	43600	NA	NA	4880	39200	160000	120000	229000
2020	176000	131000	183000	145000	80900	2840	NA	NA	NA	NA	NA	NA

In summary:

- The seasonal pattern is complex but is consistent with irrigation.
- The pattern of taking indicates that water may be being taken for domestic potable and stock drinking water.
- The maximum volume taken in any day is 11,100 m^3
- The maximum volume taken in any month is 229,000 m^3.
- The maximum taken in any irrigation year is 1,829,600 m^3
- The applicant has applied for 120/s with a ±10% accuracy.
- The lowest rate at which water can be taken and still be in the range 120 l/s ±10% is 109 l/s.
- Historic data indicates that actual average maximum water use for the period 1 July 2012 to 30 June 2017 is 109 l/s.
- The highest rate at which water can be taken and still be in the range 109 l/s ±10% is 119.9 l/s.
- These ranges do overlap and are therefore they cannot be considered 'Different.

Reviewed:

Sean Leslie

Systems and Information Analyst