Naturalisation of Whanganui River at Te Maire flow record and analysis of 7-day and 1-day MALF

NIWA Client Report: CHC2010-009
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Prepared for

Horizons Regional Council
Genesis Energy Limited

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Contents

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Executive Summary

Naturalised flows for the flow recorder on the Whanganui River at Te Maire have been extended from previous work (ending in June 2003) to the end of June 2008.

Updated mean annual low flow (MALF) values have been calculated from the extended dataset. The recommended values are 28.8 ± 0.9 m^3/s for 7-day MALF and 26.6 ± 0.8 m^3/s for 1-day MALF (using data up to the end of water year 2008).

1. Introduction

Horizons Regional Council and Genesis Energy wish to have the natural flow series at Te Maire on the Whanganui River extended beyond 2003 (as used in the data analysis prepared for the One Plan). From this extended series they wish to have an updated MALF estimate.

2. Naturalisation process

The original methodology for naturalisation of the Whanganui River flow records downstream of the Tongariro Power Scheme (TPS) intakes is described in full in Henderson (1989). The complex nature of the process originated from a need to represent natural flows in the Whakapapa and other tributaries of the upper Whanganui since the diverted water from each is not directly measured. The sum of all diversions is measured at the Wairehu Canal flow recorder. Operational changes including diversion at intakes followed by spill below the Otamangakau Dam further complicate matters. The best available understanding of this complex system has been simulated using Tideda PSIM. Modifications have been made over time as rules were adjusted according to various hearing outcomes, and as new flow records of parts of the scheme operation became available.

An alternative method, suitable for any flow recorder below the junction of the Whanganui and Whakapapa Rivers, is to simply add the Wairehu Canal flows to the recorded Whanganui flows with an appropriate time offset. This approach has been adopted in the present work on Te Maire. The lag for flows between Whakapapa and Wairehu is the same as the lag for flows between Whakapapa and Te Maire (9 hours), so in this case no offset was required. The resulting modelled time series has been supplied to Genesis Energy as three-hourly mean flows.

3. 7-day and 1-day MALF

Flow statistics provided to Horizons for the One Plan process used previous work with simulated natural flows up to June 2003. The present work reports to the end of June 2008 as requested. The flow data recorded at Te Maire (net of diversions) is also presented. Table 1 below shows the 1-day and 7-day annual minimum flows at Te Maire as simulated natural flow and the ‘as recorded’ data.

The water year used for these calculations is from July to June in order that the lowest flows (generally in March or April) and the recessions that lead to them (often starting in December) are included in a single year.

Table 1: **1-day and 7-day annual minima, for each water year (1 July the previous year to 30 June in the current year), for simulated natural flows and 'as recorded' flows.**

Water Year	7-day simulated natural cumecs	7-day as recorded cumecs	1-day simulated natural cumecs	1-day as recorded cumecs
1963	29.2	29.2	27.4	27.4
1964	28.8	28.8	28.0	28.0
1965	40.9	40.9	38.9	38.9
1966	46.9	46.9	41.6	41.7
1967	31.8	31.8	31.5	31.5
1968	27.9	27.9	27.7	27.7
1969	29.5	29.5	28.6	28.6
1970	19.3	19.3	18.6	18.6
1971	21.6	20.6	19.8	19.8
1972	29.3	27.7	27.6	25.8
1973	21.8	21.2	21.3	19.5
1974	17.4	13.2	13.7	12.9
1975	28.7	18.2	24.6	16.5
1976	29.7	18.8	26.7	18.1
1977	24.7	15.2	23.0	14.8
1978	18.9	12.6	14.0	12.3
1979	30.6	19.1	23.9	17.4
1980	40.6	28.1	38.1	25.0
1981	33.9	23.8	30.7	21.3
1982	29.0	19.9	28.2	19.5
1983	28.7	17.2	27.1	16.3
1984	30.4	21.5	27.1	20.4
1985	23.8	16.8	22.9	16.2
1986	26.3	16.3	25.7	15.8
1987	28.4	19.2	24.1	18.2
1988	26.9	17.8	24.6	16.2
1989	28.2	18.7	23.7	17.8
1990	28.1	18.1	26.2	17.5
1991	28.9	21.9	24.4	20.8
1992	36.6	22.6	33.4	20.9
1993	30.2	28.4	28.3	26.7
1994	24.2	23.7	23.1	23.1
1995	35.7	30.7	31.0	29.4
1996	38.8	31.0	34.5	30.0
1997	28.2	26.7	26.6	25.2
1998	34.9	31.6	33.3	29.7
1999	25.5	25.4	24.3	24.3
2000	23.8	23.8	23.4	23.4
2001	30.1	23.7	27.4	23.1
2002	26.5	22.5	26.0	21.3
2003	22.1	22.1	21.9	21.9
2004	32.9	24.0	28.3	23.0
2005	29.0	28.9	28.1	28.1
2006	29.3	24.8	26.9	22.9
2007	28.6	28.6	27.5	27.5
2008	19.2	19.2	18.8	18.8
2009	26.8	26.8	26.0	26.0

Figures 1 and 2 illustrate the time series of annual minima of the simulated natural flows, with 1-day and 7-day averaging intervals, with a progressive calculation of the MALF, its standard error and a 10-year moving average shown on each graph.

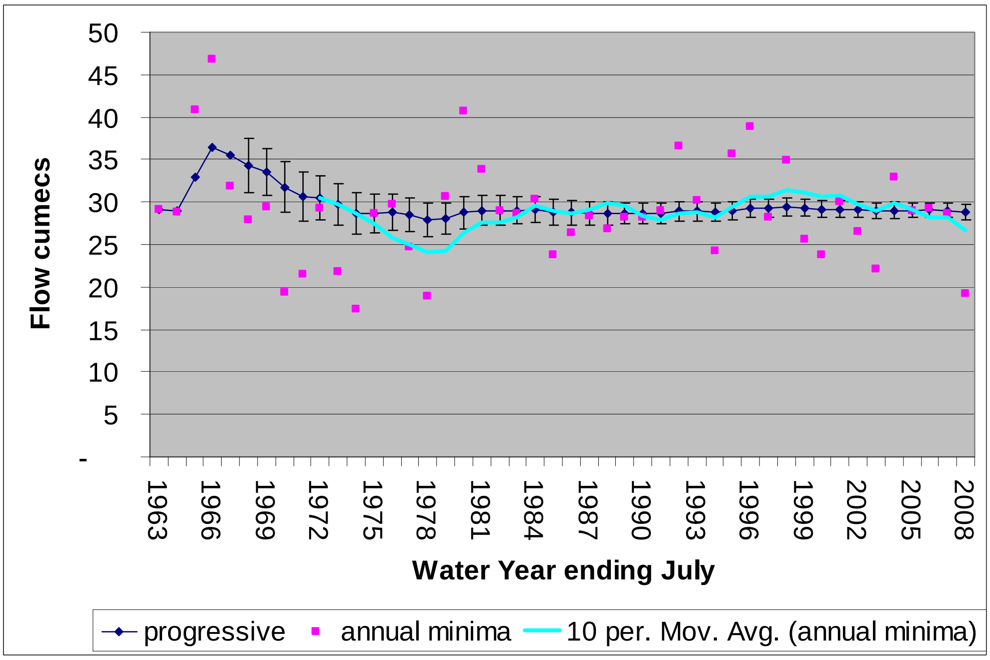


Figure 1: **7-day minima of simulated natural flows from the water years 1963 to 2008. Individual minima are pink, progressive MALF calculation is in dark blue with standard error bands, and the 10-year moving mean MALF is in bright blue.**

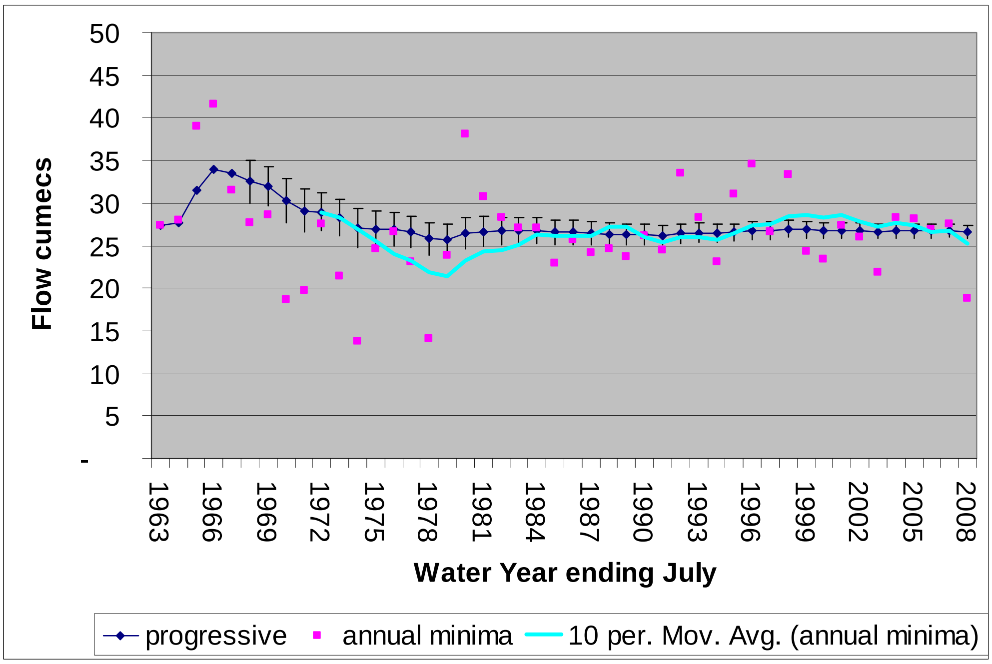


Figure 2: **1-day minima of simulated natural flows from the water years 1963 to 2008. Individual minima are pink, progressive MALF calculation is in dark blue with standard error bands, and the 10-year moving mean MALF is in bright blue.**

Since the mid 1970s, after periods of wet and dry years, the value of the naturalised MALF has varied from the 1963-2008 estimate by a few hundred litres/second, which is less than the standard error of each year's estimate. The 10-year moving mean value however shows a number of short-term trends, most notably in recent years; since 2004 the annual 7-day minima have been at or below the long-term mean. This recent trend appears more severe because of the 2008 low flows, which were the lowest recorded since the droughts of the 1970s. In the longer context however this behaviour is not unusual – annual low flows have been both higher and lower than those in the period 2005-2008.

Figure 3 shows the 'as recorded' minima, with a MALF estimate over each period during which operating rules have been constant. These are the pre-diversion period (1962-1972), 'Shand Rules' (1973-1983), 1983 rule (1984-1992) and the planning Tribunal regime (1993 to present). These periods are as used in the report on flow statistics to Horizons (Henderson and Diettrich, 2007).

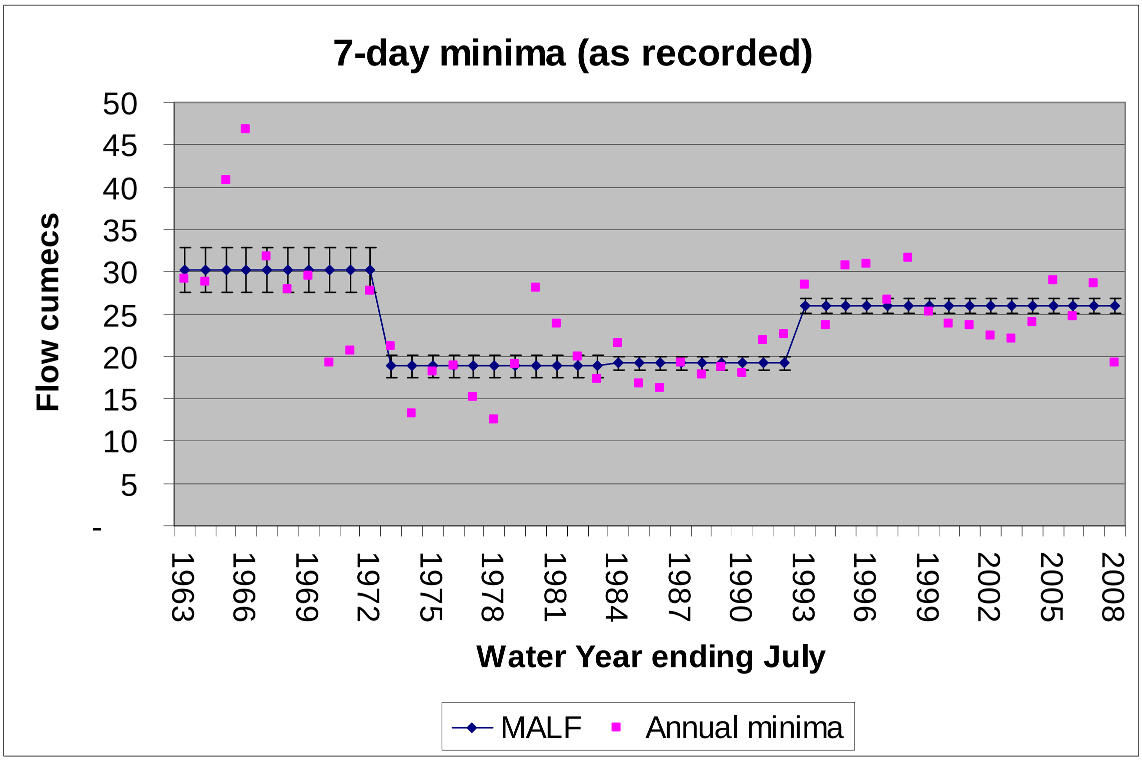
4. Discussion

The behaviour observed in MALF estimates for naturalised flows since the records began is generally consistent with observations in other catchments in the central New Zealand region reported in McKerchar and Henderson (2003). There are no significant effects of Interdecadal Pacific Oscillation in central New Zealand, and the variation observed in the progressive MALF estimates is well within the estimation errors. Shorter term behaviour such as that seen since 2004 is also observed in other parts of the record, and may be reversed in future.

However, there may conceivably be other factors at play. If forest planting were increasing significantly in the catchment, there could be a visible reduction in low flows that might persist. Similarly, if changing climate (temperature, wind, humidity) led to increased evaporation, a falling trend in flows could result. No work has been done on these aspects of the catchments in question. A first step would be to examine whether variations in rainfall could explain the variations in low flows.

Based on the data in Table 1, the recommended current naturalized MALF values are presented in Table 2. The 7-day MALF using data up to the end of water year 2008 is 28.8 ± 0.9 m^3/s. The 1-day MALF using data up to the end of water year 2008 is 26.6 ± 0.8 m^3/s.

Thus with the uncertainties inherent in modelling the natural flow regime of the catchment, and with the natural variability of behaviour over time, the long-term 7-day MALF is still very close to the previous estimate of 29 cumecs.



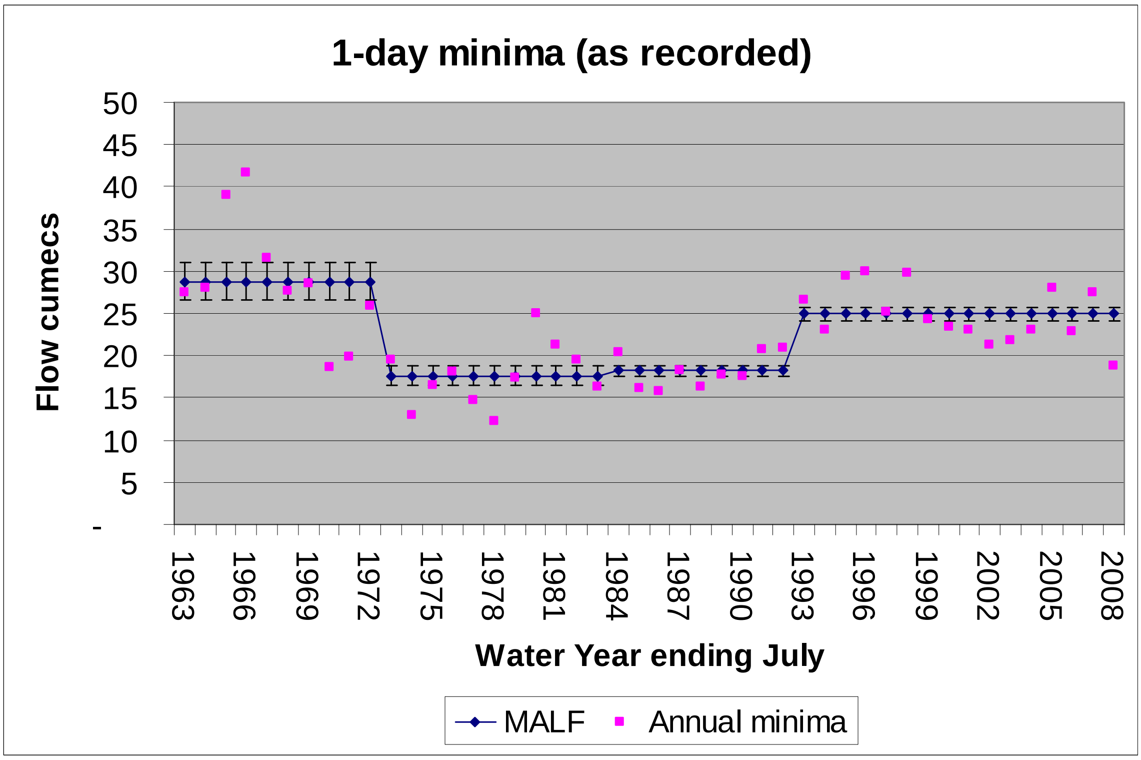


Figure 3: **1-day minima and 7-day minima as recorded at Te Maire. Individual minima are pink. MALF calculations and their standard errors for different periods of consistent management are in dark blue.**

Table 2: MALF values from 1-day and 7-day intervals of the naturalized flow series, and from the consistent management periods of the 'as recorded' series. Errors are one standard error of the calculated mean value.

Data	Minimum Flow Te Maire	1-day MALF cumecs	7-day MALF cumecs
Simulated Natural to 30 June 2008	N/A	26.6 ± 0.8	28.8 ± 0.9
As recorded pre-diversion 1962-72	N/A	28.8 ± 2.3	30.3 ± 2.6
As recorded Shand Rules 1973-83	None	17.6 ± 1.1	18.8 ± 1.3
As recorded 1983 rules 1984-92	22 cumecs, 1 Dec to 15 Feb & Easter 16 cumecs otherwise	18.2 ± 0.7	19.2 ± 0.8
As recorded Planning Tribunal Rules 1993-present	29 cumecs,1 Dec to 31 May	25.0 ± 0.8	26.0 ± 0.8
Previous simulated natural values to 30 June 2003, from Henderson (2008) and Henderson and Diettrich (2007)	29 cumecs,1 Dec to 31 May	27.9	29.7

The ratio between MALF estimates over 7-day and 1-day intervals is 108%. This is close to the ratio of 106% reported in Henderson (2008) using data up to 2003, and typical of the behaviour of the streams flowing from the Whanganui and Rangitikei headwaters areas..

Note that the 'as recorded' MALF values are lower than the regulated minimum in those periods with a minimum flow because of years when the natural flow is lower than the minimum flow rule, and diversion ceases.

5. References

Henderson, R.D. (1989). Evidence of Roderick Donald Henderson in the matter of the Water and Soil Conservation Act 1967 and in the Matter of two Appeals under Section 25 of the said Act between ECNZ (Appeal 781/88), Whanganui River Maori Trust Board (Appeal 840/88) Appellants and The Rangitikei-Wanganui Catchment Board Respondent. (The Wanganui Minimum Flow Appeal Hearing). Vol. II, 61p + 47 exhibits. Planning Tribunal, Taumarunui, Wanganui and Wellington, New Zealand.

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