Comparison of Dunstan Creek at Beattie Road 100m Downstream and Dunstan Creek at Manuherikia Confluence 400m Upstream Flow Records

1. General

Dunstan Creek is a long narrow catchment in Central Otago draining the Dunstan Ranges, Wether Range and St Bathans Range. Much of the catchment is mountainous with its highest elevation being 2089m. The catchment is located between the Lindis Catchment to the west and the Manuherikia catchment to the east. Figure 1 shows the catchment and its location.

Rainfall totals in this catchment range from about 750mm at St Bathans to more than 1200mm in the headwaters.

2. Flow Records

There are three water level and flow recorders in Dunstan Creek. They include:

- Dunstan Creek at Gorge 500m Downstream (March 2020 – April 2021);
- Dunstan Creek at Beattie Road 100m Downstream (November 2019 – February 2021);
- Dunstan Creek at Manuherikia Confluence 400m Upstream (January 2020 – April 2021).

There are earlier records for Dunstan Creek at Gorge (March 1973 – April 1994, March 2007 – September 2010) and Dunstan Creek at Gorge 500m Downstream (3 March 2020 – 30 April 2021) but neither will be used in this analysis because the area of comparison for this analysis is downstream of Beattie Road.

Dunstan Creek at Beattie Road (August 1996 – October 2020) will also not be used because its record length does not cover the same period of record as the Dunstan Creek at Manuherikia 400m Upstream site. Note that this site was replaced with the new site Dunstan Creek at Beattie Road 100m Downstream because this "… new site is more stable than the original Beattie Road site…" (P. Stevenson ORC email dated 11 June 2021).

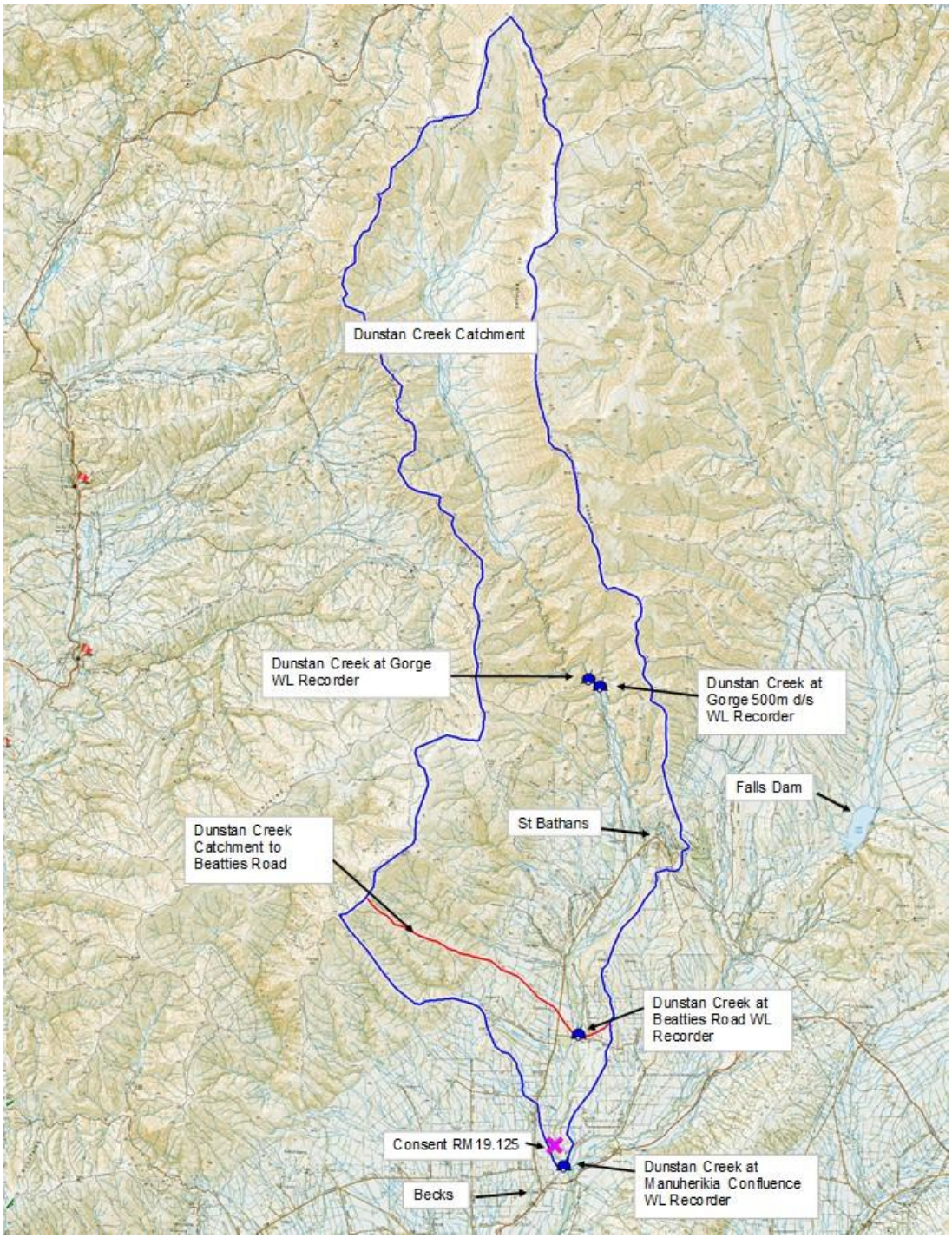
The Beattie Road 100m Downstream recorder site is located on relatively stable alluvium while the Manuherikia Confluence 400m Upstream recorder is located on a mudstone outcrop.

Figure 1 shows the catchment outlines for both sites. The catchment area of the Beattie Road site is 270 km^2 while that to the upstream of Manuherikia site is 302 km^2, about 11% 32 km^2 (11%) larger.

The extra catchment area includes Woolshed Creek (23 km^2), a small tributary entering from the true right bank. Its catchment area is close to 75% of the area increase from the Beattie Road recorder to the upstream of Manuherikia confluence recorder. Woolshed Creek's headwaters are around 1450m high so it will contribute some flow to Dunstan Creek downstream of the Beattie Road recorder.

The remaining 25% of the increased catchment area to Manuherikia Confluence 400m Upstream is low lying and is unlikely to contribute anything significant to Dunstan Creek.

Figure 1. Dunstan Creek Catchment



During the period 2 May 1979 to 15 August 1986, a water level recorder was installed on Woolshed Creek at Lauder Station. The water level recorder was a Foxboro chart recorder, and these recorders were often unreliable. Of the total 7 years of record for this site, only about 27 months from August 1980 to October 1982 is usable due to data quality issues and even this usable period of record can be considered as indicative only. The mean flow for this period of usable data is 0.120 cumecs and the lowest gauged flow is 0.015 cumecs. A

review of a nearby raingauge suggests that the rainfalls over this short period were close to average.

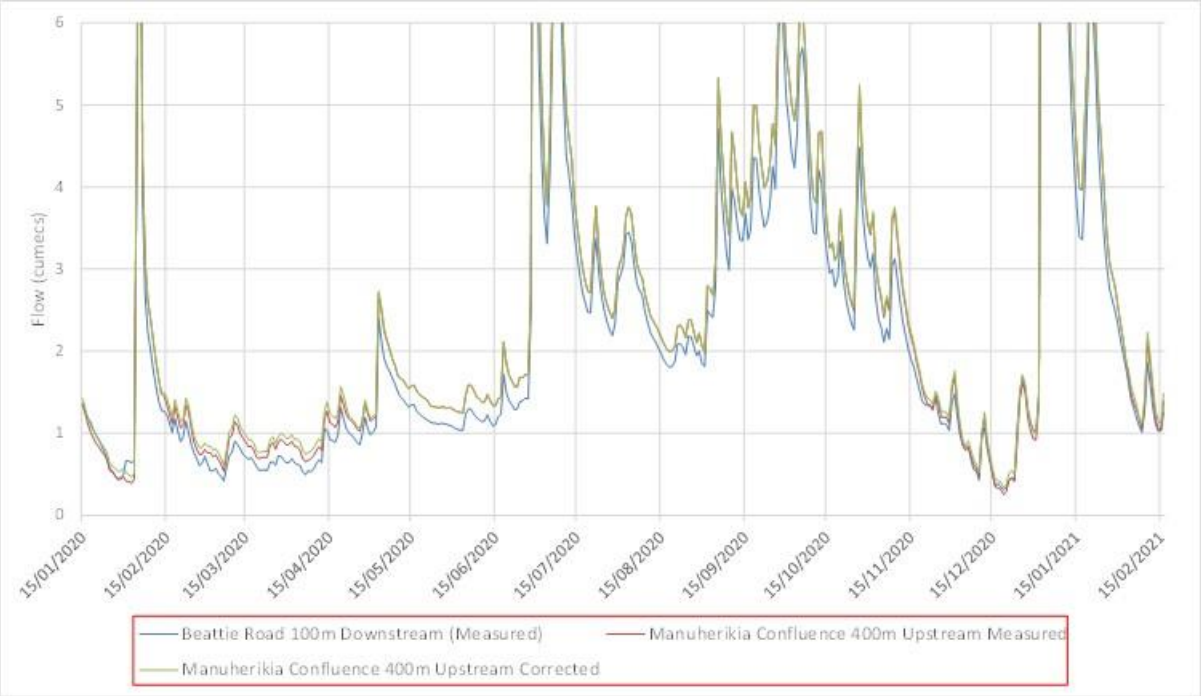
3. Abstraction

In the reach between the Beattie Road 100m Downstream and Manuherikia Confluence 1400m Upstream recorders, there is one abstraction. Consent RM19.125 is located about 1.5 km upstream of the Dunstan Creek/Manuherikia River confluence and is shown on Figure 1. The consent allows the abstraction of 0.111 cumecs. Water is diverted from the river into a race which takes the water to the abstraction site. The consent holder is permitted to divert 0.166 cumecs into the diversion channel from Dunstan Creek. The extra water is allowed because there is seepage into groundwater between the point of diversion from the river to the actual abstraction point. Any remaining water after the 0.111 cumecs is abstracted must be returned to Dunstan Creek via a diversion channel.

4. Flow Comparison Between Beattie Road 100m Downstream and Manuherikia 400m Upstream Sites

There is a 399-day period starting 15 January 2020 and ending on 16 February 2021 when the Beattie Road 100m Downstream and Manuherikia Confluence 400m Upstream sites were concurrent. Using this period of record, the flow increase between the two sites can be analysed. Figure 2 shows this period of flows. Note that the maximum flow has been truncated at 6 cumecs so more detail can be seen on this graph.

Figure 2. Beattie Road and Upstream of Manuherikia Confluence Flows



The daily flows at the Manuherikia Confluence 400m Upstream were corrected for irrigation abstraction. These flows were then compared, and the differences quantified.

The mean flows for the two sites over this 399-day period were:

- Beattie Road 100m Downstream 2.311 cumecs:
- Manuherikia Confluence 400m Upstream site 2.603 cumecs;

a difference of 0.292 cumecs.

It should be noted that these calculated mean flows over all ranges of flows have limitations as to their accuracy because the rating curve for the downstream site is unconfirmed above about 5.000 cumecs and the maximum unconfirmed flow according to the water level recorder at this site is 29.7 cumecs.

During the period 7 May 2020 to 21 October 2020 late autumn/winter/spring period (168 days) when there was no abstraction, the mean flows were:

- Beattie Road 100m Downstream 2.827 cumecs;
- and Manuherikia Confluence 400m Upstream 3.157 cumecs;

a difference of 0.330.

Similarly, the combined spring/summer/autumn periods 15 January 2020 to 6 May 2021 and 22 October 2020 to 16 February 2020 (231 days) mean flows were:

- Beattie Road 100m Downstream 1.935 cumecs;
- and Manuherikia Confluence 400m Upstream 2.199 cumecs;

a difference of 0.264 cumecs.

As expected, there is a considerable difference in mean flow between the colder non irrigation season months and the warmer irrigation season months. Again, all results have the limitations as above due to a rating curve not able to be confirmed at higher flows.

These mean flow increases are more than could be expected from the 32 km^2 catchment area increase between the two recorders including Woolshed Creek. It is likely that this increased catchment area provides only about 40% of this increase. It does need to be recognised that in winter, much of the higher elevation parts of the catchment would be snow-covered and frozen so this may affect the downstream flows but in New Zealand, snowmelt tends to continue throughout winter on ski fields that are also at a similar elevation to the Dunstan Creek catchment's headwaters.

Figures 3, 4 and 5 show the correlation of the Beattie Road 100m Downstream and the corrected Manuherikia Confluence 400m Upstream daily flows.

Figure 3. Beattie Road and Upstream of Manuherikia Confluence Flows (All Data)

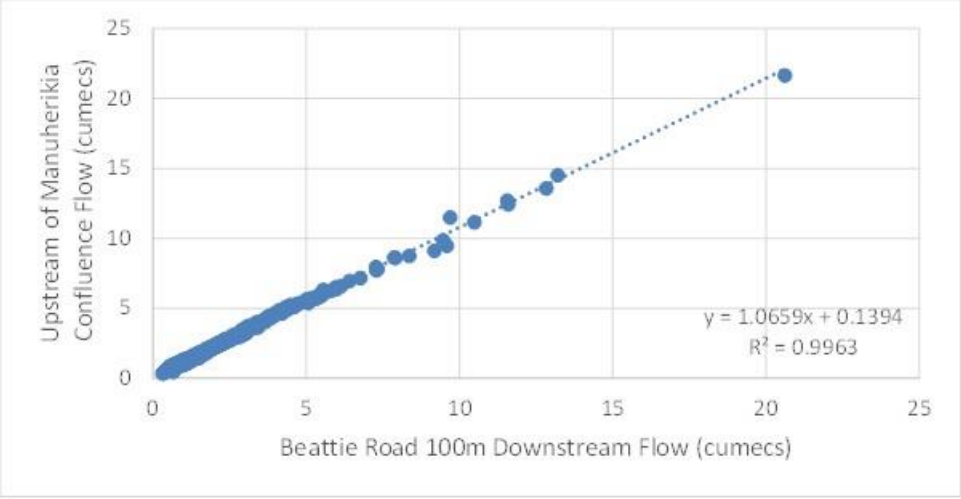


Figure 3 is a correlation of the 399-day concurrent period of daily flows at the two recorder sites. Figure 4 is a correlation of the earlier defined autumn/winter/spring concurrent daily flows (168 days) and Figure 5 is a correlation of the earlier defined spring/summer/autumn flows (231 days).

Figure 4. Beattie Road and Upstream of Manuherikia Confluence Flows (No Irrigation)

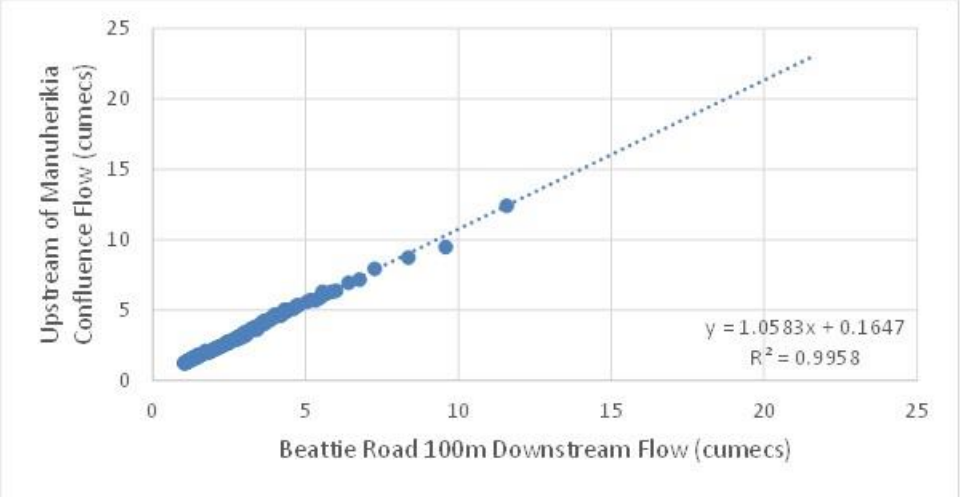
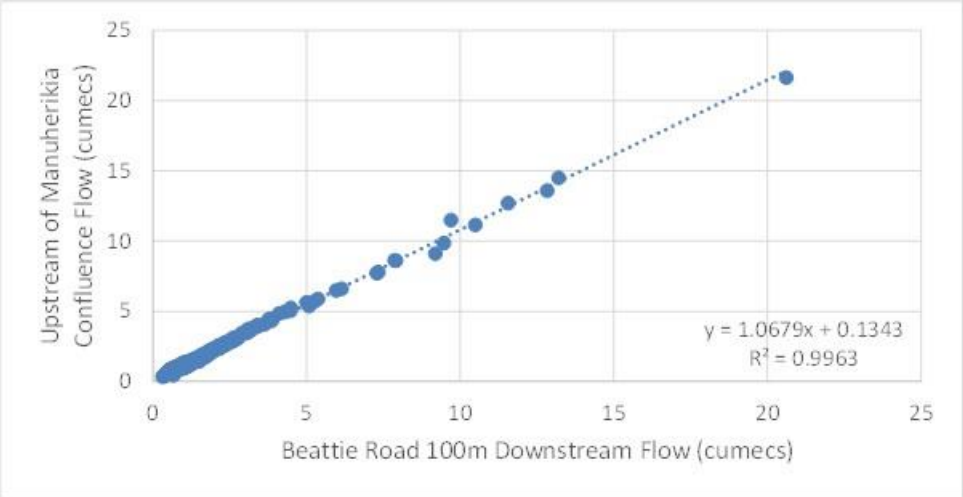


Figure 5. Beattie Road and Upstream of Manuherikia Confluence Flows (Irrigation Season)



Figures 3, 4 and 5 show very good correlations between the two flow monitoring site datasets. In all cases, all pairs of flows less than 5 cumecs at the upstream of the Manuherikia confluence site plot close to the trendline while those higher than 5 cumecs at that site show more scatter which is consistent with the greater uncertainty of the accuracy of these higher flows due to the lack of high flow gaugings as discussed in the previous section.

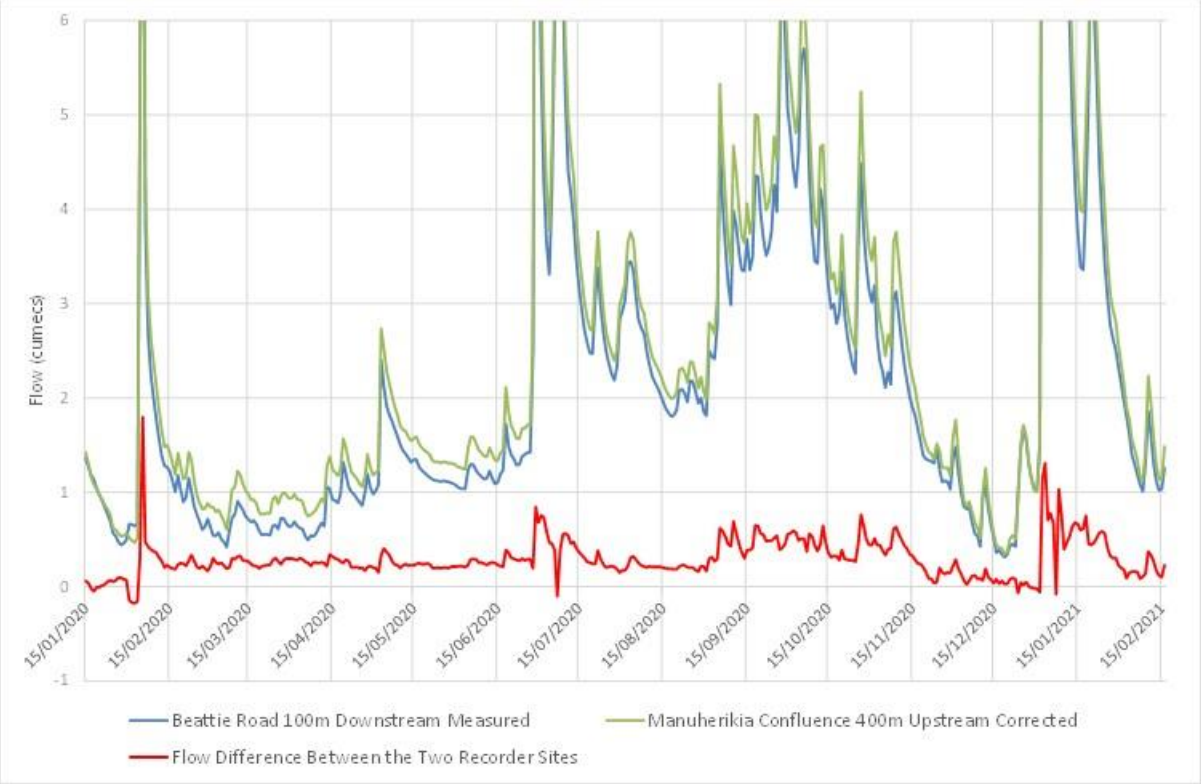
There is a small difference between the correlations, but all have extremely high R^2 values and are very close to a 1 to 1 correlation. The seasonal differences between the correlations are not significant when used to predict flows from the upstream site to the downstream site.

These correlations appear to show that there is a normal natural increase in flow with increasing catchment area in the reach from Beattie Road 100m Downstream to Manuherikia Confluence 400m Upstream when the abstraction in this reach is added to the flows at the downstream site.

5. Flow Differences Between the Beattie Road 100m Downstream and the Manuherikia Confluence 400m Upstream Sites

Figure 6 shows the measured daily flows at the Beattie Road 100m Downstream and the corrected daily flows at the Manuherikia Confluence 400m Upstream sites over the period of concurrent record. Also on Figure 6 is a graph showing the differences in daily flows between the two sites. (Note that the vertical scale has been truncated at 6 cumecs to allow the detail of the graph at lower flows to be seen.

Figure 6. Daily Flows and Flow Differences between the Two Recorder Sites Beattie Road 100m Downstream and Manuherikia Confluence 400m Upstream sites.



The differences curve shows some sharp spikes and some negative values, and these will be mainly due to timing issues between the two sites when flows are changing quickly due to rising stream flows from upstream.

The graph shows some consistency in losses through until the middle of November. After that, the differences are generally less, and it is possible there is a rating issue with one or both of the recorder sites. From November, the losses change and become very small at low flows compared to the previous low flow period when the losses were about 0.250 cumecs.

The mean of the differences between the two sites is 0.292 cumecs and of this, it is estimated that:

-40% is from the catchment area increase.

- 60% remains unaccounted for.

The likely explanation for the remaining 60% increase is the location of the Manuherikia Confluence 400m Upstream site on mudstone and the role of groundwater within the intervening alluvium. It was noted earlier that:

- the Beattie Road 100m Downstream site is located in alluvium and.
- alluvial riverbeds commonly allow the interchange of water between the river and the shallow groundwater.

This alluvium-hosted groundwater is considered to lie beneath the riverbed and flows parallel to the river channel.

It is notable that the Manuherikia Confluence 400m Upstream site is located on mudstone of the underlying Miocene-age Manuherikia Formation, which is relatively impermeable. Such an outcrop of very low permeability basement sediment across a river tend to force the shallow groundwater flowing beneath and parallel to the Dunstan Creek to the surface. This has the effect of tending to increase the flow rate measured at a measuring site compared to the upstream site situated on alluvium where water bypasses the measuring site via the alluvium. This situation of emerging groundwater appears to be supplying the remaining 60% flow increase between the Beattie Road 100m Downstream and Manuherikia Confluence 400m Upstream sites.

6. Summary

The purpose of this investigation was to analyse the flow differences between the two Dunstan Creek flow recorder sites of Beattie Road 100m Downstream (catchment area 270 km^2) and Manuherikia Confluence 400m Upstream (catchment area 302 km^2). The Beattie Road recorder is located on relatively stable alluvium and the upstream of Manuherikia confluence recorder is located on mudstone. The increase in catchment area between the two sites is 32 km^2. In normal circumstances, increased catchment area results in increased flow at the downstream site.

There is one irrigation abstraction in the reach between the two sites and flow records at the downstream site were corrected by adding the abstractions to the daily flows.

There is a period of 399 days when the two water level recorder sites were collecting data concurrently and this period of record is used in this analysis.

Mean flows for the two sites over this period were Beattie Road 2.311 cumecs and upstream of Manuherikia confluence 2.603 cumecs, an increase of 0.292 cumecs to the downstream site.

From previous flow measurement of Woolshed Creek which makes up 75% of the catchment area increase of 32 km^2 between the two sites, this increased catchment area is likely to provide about 40% (0.120 cumecs) of the flow increase to the upstream of Manuherikia confluence site.

The remaining 60% (0.170 cumecs) of the flow increase is likely to be from shallow groundwater being forced to the surface at the Manuherikia Confluence 400m Upstream site. While the Beattie Road recorder is situated on alluvium and shallow groundwater will likely be flowing beneath and parallel to this recorder site and not being measured, the Manuherikia Confluence 400m Upstream recorder is situated on mudstone which is likely to be forcing the shallow groundwater to the surface and is being measured at the downstream site along with surface water contributions.