The effects of the 24 hour voluntary irrigation shutdown on flows in the Taieri River: 15th–16th January 2015

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1. Introduction

The Taieri River has a catchment area of approximately 5,704 km², and flows for 318 km from the headwaters in the Lammerlaw and Lammermoor ranges before reaching the Pacific Ocean 30 km south of Dunedin.

The Taieri River has a total primary allocation of 28,088 l/s, of which 174 permits to take water have been granted under the Resource Management Act (RMA) with a combined rate of take of 20,452 l/s, and 104 of which are "Deemed Permits" with a combined rate of take of 8,636 l/s.

Deemed Permits were historically granted under mining legislation by the Wardens Court, initially for the purpose of gold mining. These permits operate under a priority system (where the oldest permits have highest priority) and are not subject to any of the environmental restrictions that can be placed on RMA takes such as minimum and residual flows. All Deemed Permits are due to expire in 2021.

There are five minimum flow sites in the main stem of the Taieri River: Outram (2.5 m^3/s), Sutton (1.250 m^3/s), Tiroiti (1.1 m^3/s), Waipiata (1 m^3/s) and Paerau (0.85 m^3/s). Although these minimum flows are included in Schedule 2A of the Regional Plan: Water (RPW), almost all RMA takes in the Taieri are not subject to a minimum flow in their consent conditions.

January 2015 saw one of the driest starts to the irrigation season on record for the middle and upper reaches of the Taieri catchment, with very little rainfall occurring between October and December. The severity of the dry period is shown in Figure 1 where a Standardised Precipitation Index (SPI) map has been created for the Otago Region. The SPI method calculates the long term average rainfall for a site or area and then creates an index which measures the deviation from this average. Further details on this method can be found in the The Standardised Precipitation Index User Guide (Word Meteorological Organisation, 2012).

Following an extended period of low flows in the Taieri catchment resulting from this lack of rain, the community agreed to a 24 hour voluntary irrigation shutdown to observe the effects on flows in the Taieri River and its tributaries, and to give the community a better understanding of how the system behaves with travel times, attenuation as well as how much water was available in the system. This work would not have been possible without the excellent level of cooperation from the irrigation community in the Taieri catchment.

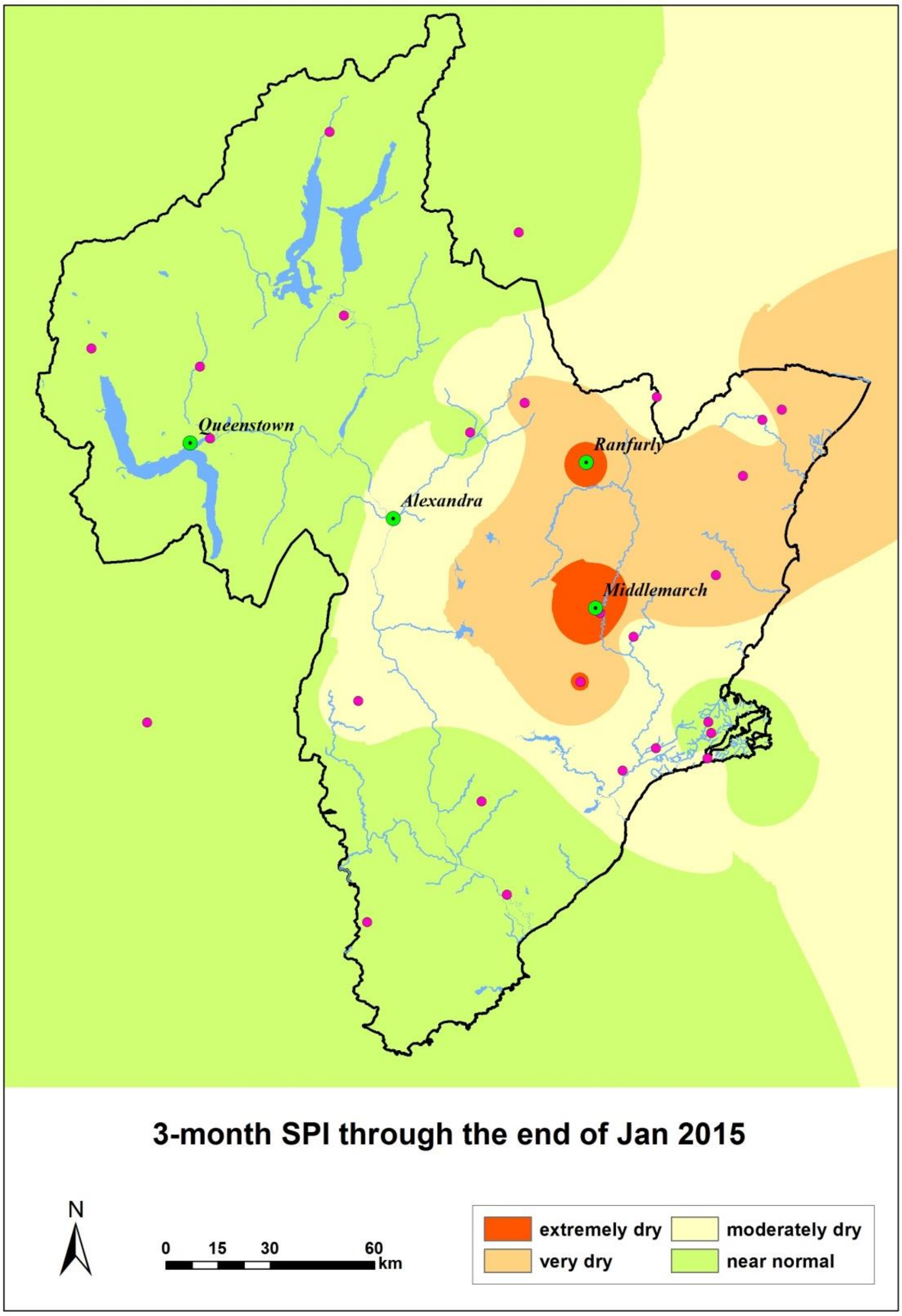

Figure 1 **Standardised Precipitation Index for the three month period ending January 2015**

The SPI map for Otago shows that much of the Maniototo and Strath Taieri area was either "Severely Dry" or "Extremely Dry", with a return period of over 1 in 50 years around Ranfurly and Middlemarch.

Following an extended period of low flows in the Taieri catchment, the community agreed to a 24 hour voluntary irrigation shutdown to observe the effects on flows in the Taieri River and its tributaries, and to give the community a better understanding of how the system behaves with travel times, attenuation as well as how much water was available in the system. The shutdown ran from 12 pm on January 15th 2015 and finished at 12 pm on January 16th.

This report discusses the hydrology of the tributaries and main stem of the Taieri River as well as on the ground observations over this period.

2. Hydrological monitoring

Flows were monitored at six recorders in the Taieri catchment during the shutdown period; five in the main stem (Canadian Flat, Waipiata, Tiroiti, Sutton, and Outram) and one in the Kye Burn at Scotts Lane (Figure 2). In addition, flow gaugings were undertaken at 19 sites (14 tributaries, 5 main stem) in the Strath Taieri and Maniototo (Figure 2).

Rainfall sites were also monitored throughout the shutdown period, with the only rain recorded being a small amount of drizzle (0.5-1 mm) that occurred at midnight on the January 15th in the hill country downstream of Sutton. No rainfall was recorded upstream of Middlemarch.

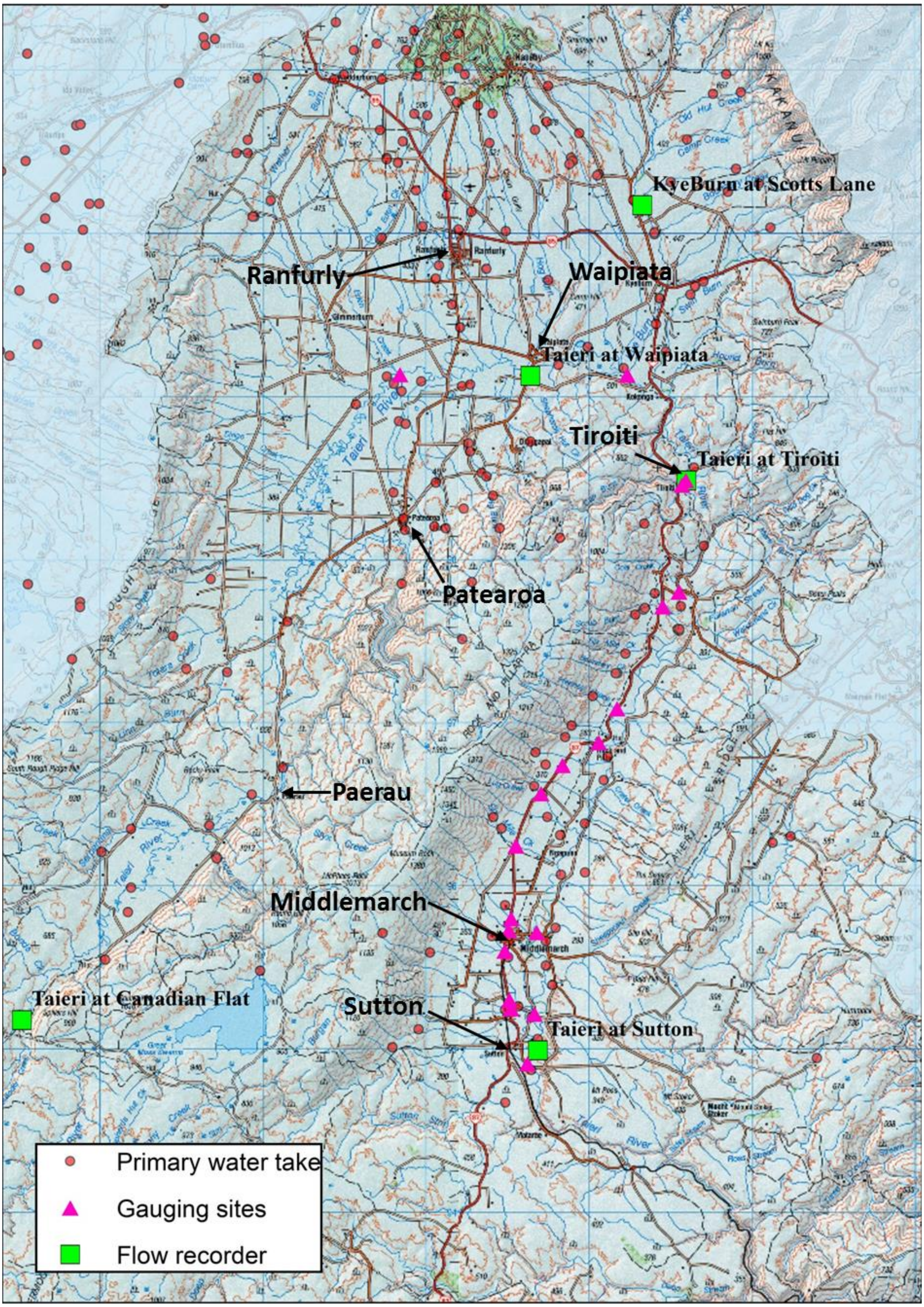

Figure 2 **Flow monitoring and gauging sites**

The flows recorded at these sites over the shutdown period are shown in Table 1.

Table 1 **Recorded flows at hydrological monitoring sites in the upper and mid-Taieri**

	Taieri at Canadian Flat	Taieri at Paerau Weir	Taieri at Waipiata	Kye Burn at Scotts Lane	Taieri at Tiroiti	Taieri at Sutton	Taieri at Outram
Daily average (l/s)	**688**	**1,020**	**984**	**182**	**1,102**	**1,100**	**2,406**
Daily max flow (l/s)	**754**	**1,072**	**1,007**	**282**	**1,161**	**1,152**	**2,577**

The effects of the shutdown were not observed at Canadian Flat (no upstream takes), and Sutton due to a combination of travel time and the resumption of water abstraction after the shutdown period (Figure 3). Maniototo Irrigation Company (MIC) maintained a flow of around 1,000 l/s at the Paerau Weir for the duration of the shutdown period. The increase in flows observed at the Outram flow recorder were due to a slight increase in tributary inflows in the lower catchment caused by some overnight drizzle on the 15th, rather than the cessation of water takes. The red shaded area indicates the period of the voluntary shutdown.

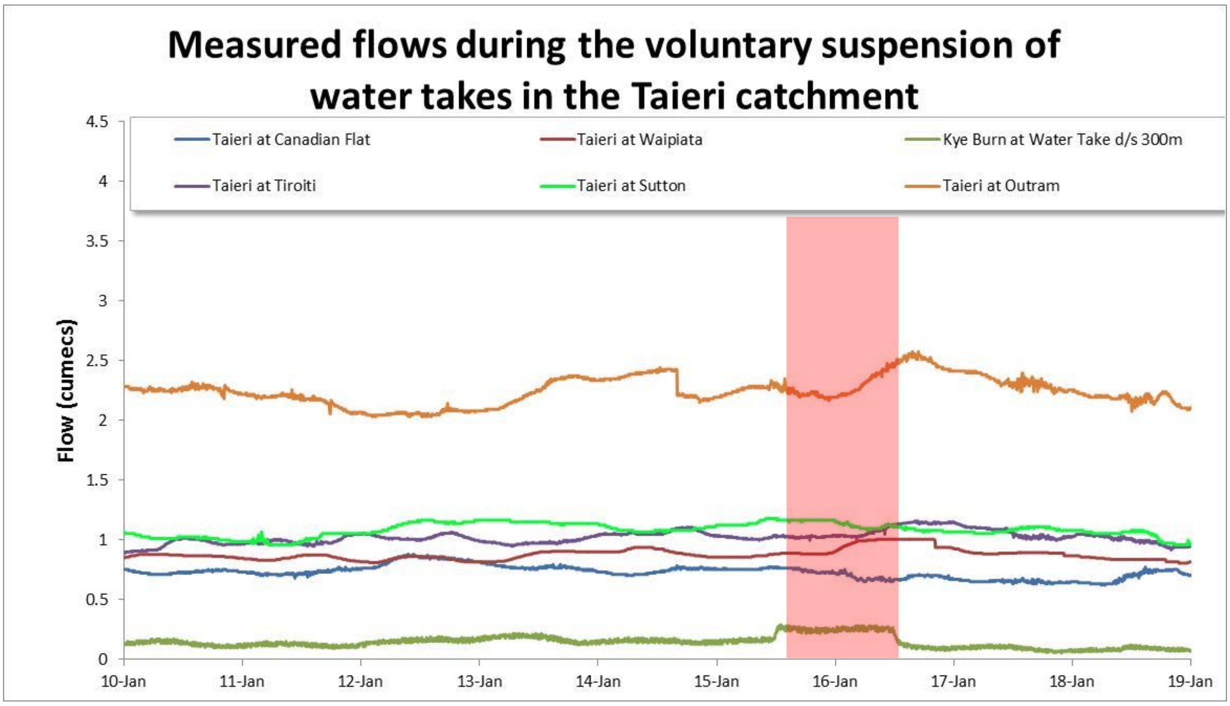

Figure 3 **Measured flows during the January 15-16 shutdown**

By observing the pulse of flow moving down the catchment, as well as smaller flow events over January/February 2015, it has been possible to estimate the travel time between the major flow sites in the Taieri during times of low flows (Table 2). This information can be used to inform the timing and duration of water management mechanisms such as community-led rostering.

Table 2 **Calculated travel time between flow sites in the mid and upper-Taieri**

	Travel time (hr)			
Site	**Waipiata**	**Tiroiti**	**Sutton**	**Outram**
Canadian Flat	96	106	133	152
Waipiata		9.5	37	56
Kye Burn at Scott's Lane		15	42	61
Tiroiti			27	46
Sutton				19

A more detailed view of the effect of the shutdown is shown in Figure 4, with the red shaded area indicating the period of the voluntary shutdown. The flow "pulse" as water abstraction ceased is shown by the red brackets.

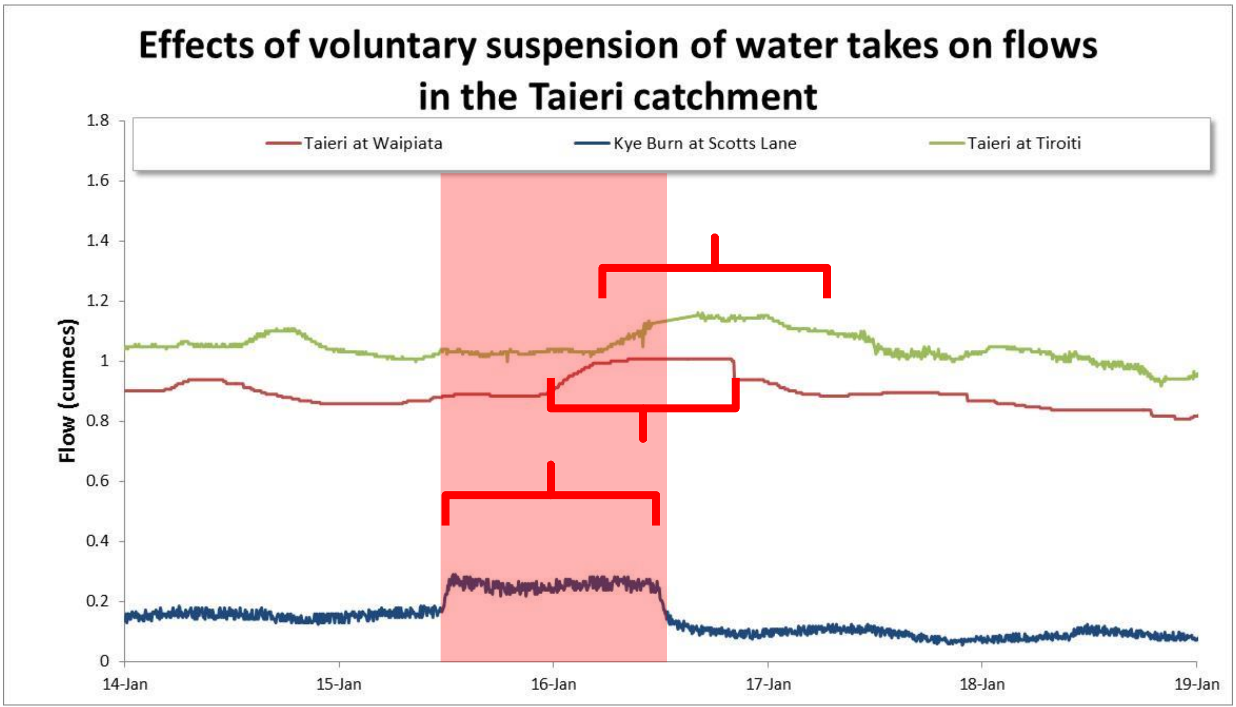

Figure 4 **Effects of the 15th/16th January shutdown on flows at Waipiata, Scotts Lane, and Tiroiti**

The cessation of water abstraction from the Taieri upstream of the Waipiata flow recorder caused flows to increase by 130 l/s and met the Waipiata minimum flow of 1000 l/s.

Kye Burn flows increased by 100 l/s to approximately 260 l/s for the 24 hour shutdown period. However due to the inadvertent abstraction of approximately 40 l/s in the lower reaches of the Kye Burn (due to the setup of the race intake) and further losses to groundwater, the surface water contribution of the Kye Burn to the main stem of the Taieri was measured at 41 l/s at the confluence.

Monitoring undertaken in the period before the shutdown indicated that there was a gain in flow of approximately 140 l/s between Waipiata and Tiroiti, and this increased to 200 l/s during the shutdown due mainly to inputs from the Kye Burn.

The shutdown of takes above Tiroiti and in the Kye Burn meant the Tiroiti minimum flow (1,100 l/s) was met, with a maximum 1,161 l/s recorded. The flow pulse at Tiroiti was more prolonged than that of the upstream sites due to differences in travel time between the Kye Burn and Waipiata. There was also a 50 l/s abstraction occurring from the Taieri River between Waipiata and Tiroiti.

2.1. Flow gauging

The results of the stream gaugings taken on the morning of January 16th are shown below (Table 3).

Table 3 Results of the 16th January flow gauging run

Site	Flow (l/s)
Doughboy Creek at SH87	0
Kirklands Creek at SH87	0
Rock Creek at SH87	39
March Creek at SH87	28
Dewar Stream at SH87	9
Six Mile Creek at SH87	48
Lug Creek at SH87	27
Wandle Creek at SH87	<10
Last Creek at SH87	<10
Heeney Creek at SH87	16
Cap Burn at SH87	15
Scrub Burn at SH87	15
Kye Burn at Taieri Confluence	41
Sow Burn at Taieri Confluence	59
Taieri at Tiroiti	1,009
Taieri at Macraes-Hyde Road	1,058
Taieri at Moonlight	1,120
Taieri at Lonford	1,235
Taieri at Sutton	1,176

A separate flow gauging undertaken in the Sow Burn at Taieri confluence on 14th January (before the shutdown) measured a flow of 56 l/s. The gauging of 59 l/s on the 16th was 3 l/s more than that measured on the 14th, and is well within the margin for error. This indicates that the contribution of the Sow Burn to the Taieri River did not increase as a result of the shutdown, which is supported by the large reach of dewatered stream both upstream and downstream of Duffy Lane that was observed on January 16th. The sharp decrease in flows observed at Waipiata late on the 16th was due to the resumption of abstraction from upstream takes earlier in the day once the shutdown period had ended.

3. Visual observations

During the shutdown period, visual observations and reference photos were taken at bridges and crossings of both the main stem and the major tributaries (Figure 5).

Observations were made at the following tributaries, with photos and detailed site notes shown in Appendix 1.

- Six Mile Creek
- Dewar Stream
- Doughboy Creek
- Kirklands Creek
- Lug Creek
- March Creek
- Rock Creek
- Last Chance Creek
- Heeney Creek
- Swin Burn
- Kye Burn
- Pig Burn
- Ewe Burn
- Wether Burn
- Gimmer Burn
- Sow Burn

Disconnected pools with trapped fish were observed in the Swin Burn and Sow Burn, and it is likely that significant fish kills would have occurred as these refuge pools dried up.

The drying reach in the Sow Burn was centred on Duffy Lane, and the same pattern was observed during a flyover undertaken by ORC staff on February 17th, which showed over 4 km of disconnected or dry river bed. A similar pattern has also been observed in the Swin Burn, with a dry middle reach and a return of surface flows closer to the Taieri confluence.

Heavy algal growth was observed in the Swin Burn, Kye Burn, Little Kye Burn, Pig Burn, and Sow Burn.

Other than the Kye Burn, none of the Maniototo tributaries regained connection to the Taieri River as a result of the shutdown, with the only evidence of any increase in surface flows being several metres of re-wetted channel in the Sow Burn upstream of Duffy Lane (Appendix 1, Figure 38).

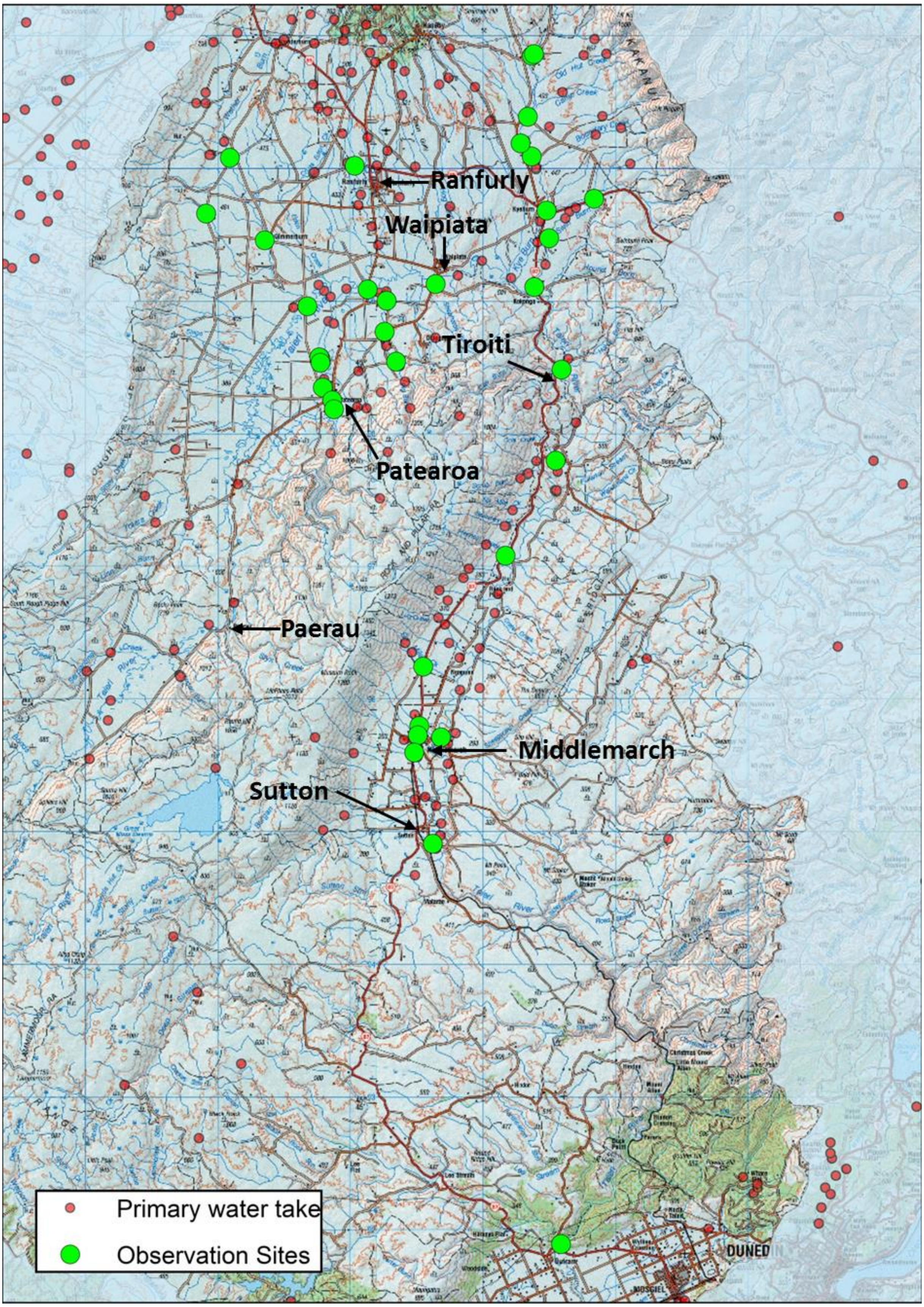

Figure 5 **Observation points for the 15th/16th January voluntary shutdown**

Observations were also made in the main stem of the Taieri River (Outram, Sutton, Moonlight Rd, Hyde-Macraes Rd, Tiroiti, Kokonga, Waipiata, Ranfurly-Patearoa Rd, Pateoroa-Maniototo Rd), and showed moderate to heavy algal grown at Tiroiti and Kokonga (Appendix 2).

By comparing photos taken during the shutdown to those taken two days earlier, it is possible to assess the visual effects of the reduction in abstraction in the tributaries of the Strath Taieri (

Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12).

The comparison of the January 14^{th} and 16^{th} photos does not show a visual change in flows at any of the sites.

Figure 6 **Dewar Stream at SH87 on January 14th (left) and 16th January (right**

Figure 7 **Heeney Creek at SH87 on January 14th (left) and 16th January (right)**

Figure 8 **Six Mile Creek at SH87 on January 14th (left) and 16th January (right)**

Figure 9 **March Creek at SH87 on January 14th (left) and 16th January (right)**

Figure 10 Rock Creek SH87 on January 14th (left) and 16th January (right)

4. Conclusions

The voluntary shutdown returned 130 l/s to the main stem of the Taieri River upstream of Waipiata, while an additional 60 l/s was gained between Waipiata and Tiroiti. This was sufficient to bring flows above the minimum flows at both Waipiata and Tiroiti. The short-term nature of the shutdown meant that the pulse of water released by this event did not reach the Sutton flow recorder due to abstraction over the subsequent days.

It was also clear that the shutdown did not result in the resumption of surface flows in the middle reaches of the Sow Burn and Swin Burn, however it is unclear if a longer period of shutdown would result in the resumption of surface flows once alluvial gravels became saturated.

Observations on January 16th showed evidence of fish stranding in the Swin Burn and Sow Burn, and those fish remaining in refuge pools were showing signs of thermal stress. Significant algal growth was observed in the Swin Burn, Kye Burn, Little Kye Burn, Pig Burn, Sow Burn and the main stem of the Taieri River at Kokonga and Tiroiti.

Appendix 1: Tributary observations

Six Mile Creek and Heeney Creek

Flows in Six Mile (Figure 11) and Heeney (Figure 12) Creeks appeared to be slightly increased from base flows, and algal cover and macroinvertebrates indicated that both Creeks had been flowing before the shutdown period.

Figure 11 Six Mile Creek at SH87 – 16th January

Figure 12 Heeney Creek at SH87 – 16th January

Swin Burn

Flows were disconnected both upstream and downstream of the Cemetery Rd Bridge, with no indication of any recent re-wetting. There were two isolated refuge pools approximately 50m downstream of the Cemetery Rd Bridge (Figure 13); one of which contained approximately 50 brown trout fry showing signs of thermal stress (Figure 14), and another that contained one adult Central Otago Roundhead galaxias and approximately 12 galaxias fry. There was evidence that these pools had only recently disconnected from the larger pool at the bridge, including discolouration of substrate, damp areas under cobbles and live macroinvertebrates (Figure 15).

Figure 13 **Swin Burn refuge pools downstream of Cemetery Rd - 16th January**

Figure 14 Brown trout fry in downstream refuge pool - 16th January

Figure 15 Signs of recent dewatering (darker cobbles in middle of channel) downstream of Cemetery Rd - 16th January

Further upstream at SH85 (upstream of water takes); there was continuous flow both upstream and downstream of the bridge. Heavy periphyton growth could be seen from the bridge (Figure 16) as well as 30+ brown trout fry.

Figure 16 **Swin Burn at SH85 (no irrigation takes operating upstream of this point) - 16th January**

Kye Burn

Continuous flows were observed at all sites in the Kye Burn; SH85 (Figure 17), Scotts Lane (Figure 18), Campbells Crossing (Figure 19), Kye Burn Diggings Rd (Figure 20), and Little Kye Burn (Figure 21). Heron were observed feeding on juvenile trout in the Little Kye Burn downstream of Kye Burn Diggings Rd (Figure 22).

Figure 17 **Kye Burn at SH85 - 16th January**

Figure 18 **Kye Burn at Scotts Lane - 16th January**

Figure 19 **Kye Burn at Campbells Crossing - 16th January**

Figure 20 **Kye Burn at Kyeburn Diggings Rd - 16th January**

Figure 21 **Little Kye Burn at Kye Burn Diggings Rd - 16th January**

Figure 22 **Heron feeding on brown trout fry in Little Kye Burn downstream of Kyeburn Diggings Rd - 16th January**

Pig Burn

Flows in the Pig Burn at O'Neil Rd were low and stable, with no signs of recent drying or re-wetting (Figure 23). Further upstream at Patearoa-Waipiata Rd, surface flows ceased approximately 30m downstream of the bridge due to losses to gravel (Figure 24). The most upstream site at Hamilton Rd showed higher flows than those further downstream, with several schools of brown trout fry present.

Figure 23 **Pig Burn at O'Neil Rd - 16th January**

Figure 24 **Beginning of dewatered reach in the Pig Burn 40 m downstream of the Patearoa-Waipiata Rd Bridge - 16th January**

Figure 25 Pig Burn at Hamilton Rd - 16th January

Ewe Burn at Allison Lane

Surface flow in the Ewe Burn ceased approximately 20m downstream of the Allison Rd Bridge (Figure 26).

Figure 26 Ewe Burn at Allison Lane - 16th January

Wether Burn

The Wether Burn at Devenney Rd was mostly dry (Figure 27), with several disconnected pools showing signs of very poor water quality (Figure 28). Flows were similar further downstream at Sharkeys Rd, with disconnected pools at the bridge and a dry channel both upstream and downstream.

Figure 27 Wether Burn downstream of Devenney Rd - 16th January

Figure 28 **Disconnected pools in the Wether Burn at Devenney Rd - 16th January**

Figure 29 Wether Burn at Sharkeys Rd - 16th January

Figure 30 Isolated pool at the Sharkeys Rd Bridge - 16th January

Gimmer Burn at Puketoi-Highfield Rd

The Gimmer Burn was mostly dry in the reach around Puketoi-Highfield Rd, with only small isolated pools remaining (Figure 31).

Figure 31 Isolated pools upstream of the Puketoi-Highfield Rd bridge - 16th January

Sow Burn

The Sow Burn was dry under bridge at Duffy Lane, with disconnected pools downstream (Figure 32). The number of pools increased downstream, with surface flow resuming approximately 300 m downstream at E136775, N4985601 (Figure 33). Many (several hundred) trout fry were trapped in refuge pools and were showing signs of thermal stress. The refuge pool immediately upstream of the resumption of surface flow (Figure 34) showed signs of recent dewatering. Professionalism

Surface flow resumed 150 m upstream of Duffy Lane (Figure 35), with several isolated pools with dense cover of green filamentous algae (Figure 36). Between these pools there were obvious signs of that this reach had only recently dewatered, and that approximately 10 m of steam bed had re-wetted due to the shutdown (Figure 37 & Figure 38).

Continuous flow was observed further upstream at Halls Ford (Figure 39), with the estimated total flow less than 20 l/s. Flows were higher (over 100 l/s)at the the Styx-Patearoa Rd Bridge (Figure 40 & Figure 41), however a large bund approximately 100 m below the bridge significantly reduced downstream flows (Figure 42). Flows at the Aitkin Rd Bridge were similar to those at Styx-Patearoa Rd (Figure 44).

Figure 32 Refuge Pool downstream of Duffy Lane - 16th January

Figure 33 Resumption of surface flow downstream of Duffy Lane - 16th January

Figure 34 **Recently disconnected refuge pool downstream of Duffy Lane - 16th January**

Figure 35 **Surface flow upstream of Duffy Lane showing heavy growth of green filamentous algae - 16th January**

Figure 36 **Recently disconnected refuge pool upstream of Duffy lane showing heavy growth of green filamentous algae - 16th January**

Figure 37 **Recently dewatered section immediately below upstream surface flow - 16th January**

Figure 38 **Evidence of recent re-watering as a result of shutdown - 16th January**

Figure 39 **Sow Burn at Halls Ford - 16th January**

Figure 40 **Sow Burn upstream of the Styx-Patearoa Rd bridge - 16th January**

Figure 41 **Sow Burn downstream at Styx-Patearoa Rd - 16th January**

Figure 42 Gravel bund downstream of Styx-Patearoa Rd - 16th January

Figure 43 Reduced flow downstream of gravel bund - 16th January

Figure 44 Sow Burn upstream of Aitkin Rd - 16th January

Appendix 2: Taieri River main stem observations

Taieri River at Outram

Figure 45 Taieri River at Outram, looking downstream - 16th January

Figure 46 Taieri River at Outram, looking upstream - 16th January

Taieri River at Sutton

Figure 47 Taieri River at Sutton, looking downstream - 16th January

Figure 48 Taieri River at Sutton, looking upstream - 16th January

Taieri River at Moonlight Rd

Figure 49 Taieri River at Moonlight Rd, looking downstream - 16th January

Figure 50 Taieri River at Moonlight Rd, looking upstream - 16th January

Taieri River at Hyde-Macraes Rd

Figure 51 Taieri River at Hyde-Macraes Rd, looking upstream - 16th January

Figure 52 Taieri River at Hyde-Macraes Rd, looking downstream - 16th January

Figure 53 Build-up of algae on the banks of the Taieri River at Hyde-Macraes Rd - 16th January

Taieri River at Tioiti

Significant filamentous green algae was observed both upstream and downstream of the bridge.

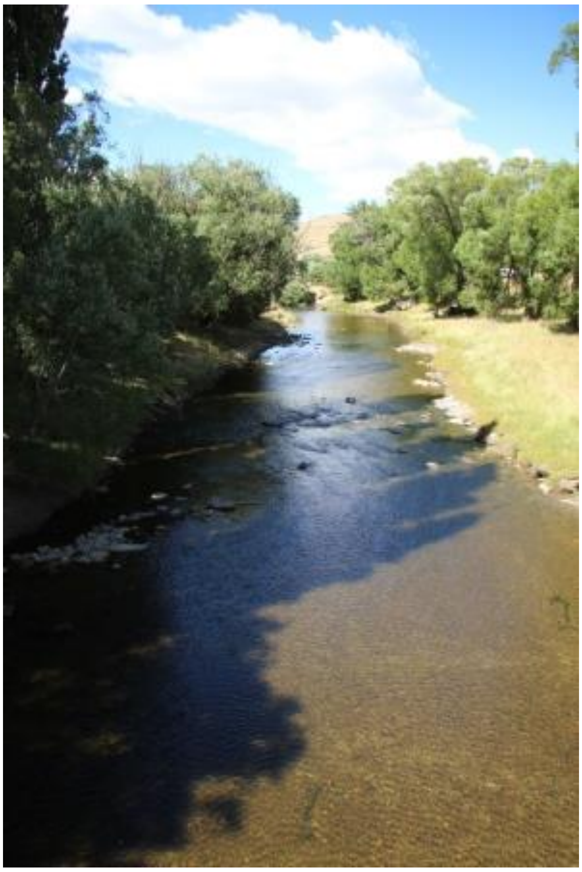

Figure 54 Taieri River at Tiroiti, looking downstream - 16th January

Figure 55 **Taieri River at Tiroiti, looking upstream - 16th January**

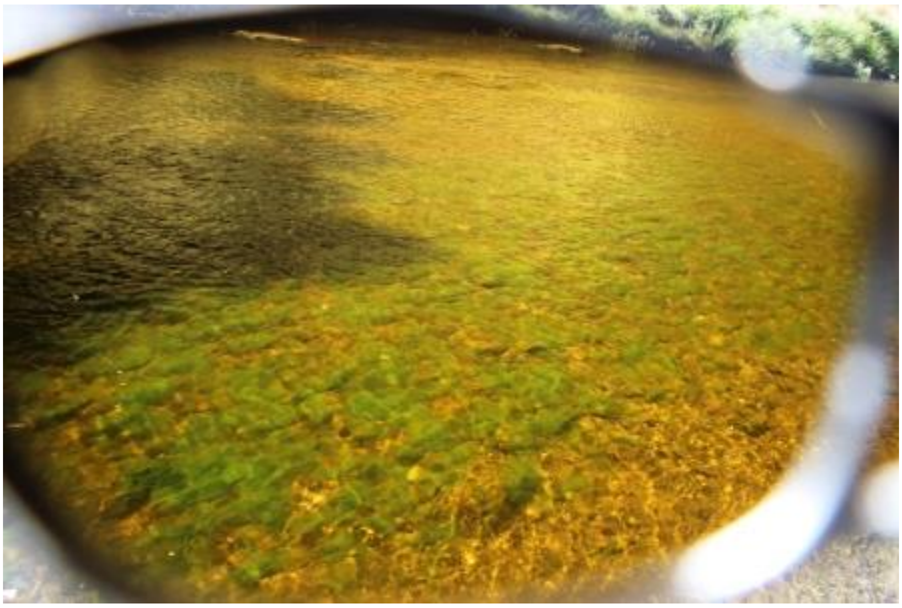

Figure 56 **Thick green filamentous algal growth at Taieri River at Tiroiti - 16th January**

Figure 57 **Extent of green filamentous algal growth at Taieri River at Tiroiti - 16th January**

Taieri River at Kokonga

Heavy cover of green filamentous algae was evident on the channel margins, but less than observed at Tiroiti.

Figure 58 **Taieri River at Kokonga, looking downstream - 16th January**

Figure 59 Taieri River at Kokonga, looking upstream - 16th January

Figure 60 Filamentous green algal growth in the Taieri River at Kokonga - 16th January

Taieri River at Waipiata

The swimmers seen in Figure 62 mentioned that the flows on the 16th January were noticeably higher than those on the previous day.

Figure 61 Taieri River at Waipiata, looking upstream - 16th January

Figure 62 Taieri River at Waipiata, looking downstream - 16th January

Taieri River at Ranfurly-Patearoa Rd

Figure 63 **Taieri at Ranfurly-Patearoa Rd, looking downstream - 16th January**

Figure 64 **Figure 55. Taieri River at Ranfurly-Patearoa Rd, looking upstream - 16th January**

Taieri River at Pateoroa-Maniototo Rd

Figure 65 Taieri River at Pateoroa-Maniototo Rd, looking upstream - 16th January

Figure 66 Taieri River at Pateoroa-Maniototo Rd, looking downstream - 16th January