Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River

Report No. U07/21

Prepared by

Aquatic Ecology Limited for
Environment Canterbury

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Executive summary

Salmonid spawning (Chinook salmon, brown trout) surveys were conducted during the winter of 2006 along the middle reach of the Waitohi River, a tributary of the Hurunui River. These surveys indicated that no salmonid spawning took place in the reach between the Ginders Road end and the Powers Road Bridge in 2006. Historically, there is some evidence that salmonid spawning occurred in the Waitohi River, although the distribution of spawning activity is currently unknown.

A WAIORA analysis of the reach downstream of Powers Road indicated that at low flow the river habitat is suitable for some native fish expected to reside there (i.e. upland bully, and common river galaxias). With the river at stable winter median flows, flows would be suitable for spawning, although the flow record indicated that frequent floods occur which could jeopardise trout fry development and recruitment. During summer, the river is not suitable as trout rearing habitat because of a paucity of pools, and there is doubt that water velocities would be sufficiently high to maintain invertebrate values, which would be particularly important for trout feeding.

The middle reaches of the Waitohi River will dry under natural low flow conditions regardless of irrigation effects, and the ecology of the middle reaches has almost certainly adapted to the ephemeral conditions, and possible winter flood flows. Stream depletion effects would increase the natural dewatering trend, both in geographical extent and duration. Invertebrate ecology is important in assessing ecological effects, and the invertebrate fauna is likely to be compromised by the dewatering nature of the bed. Groundwater level data from 1987-1993, in the vicinity of Bakers Road Ford, indicates that the stream bed thoroughly dried out before much of the recent irrigation demand was placed on the groundwater.

In contrast to the ephemeral habitat in the middle reaches, a recent survey indicates that ecological values in the lower reach, near S.H. 7, are probably higher compared to the middle reach, and some, albeit limited, brown trout spawning is known to occur there. There are indications that flows in the lower reach of the Waitohi River, near the minimum flow site, more reflect the flows in the Hurunui River nearby than the residual flow rising from the upstream reach. A secondary minimum flow monitoring site in the upper reaches would have more relevance to habitats upstream of the Powers Road Bridge, although there is no information on the ecology in that section of the river; the instream values are likely to be higher due to its permanent flow.
Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River
## Table of Contents

Executive summary ........................................................................................................................................1

1 Introduction and catchment description .......................................................................................5

2 Background to the fish fauna ...........................................................................................................6

3 Objectives .........................................................................................................................................7

4 Study Area .......................................................................................................................................7

5 Sources of information ....................................................................................................................8

6 Methods ..........................................................................................................................................9

   6.1 Field Methods ............................................................................................................................9

       6.1.1 Salmonid redd survey ......................................................................................................................9

       6.1.2 Flow assessment .........................................................................................................................9

       6.1.3 Substrate assessment .................................................................................................................9

       6.1.4 WAIORA analysis .....................................................................................................................10

   6.2 Computer Methods ....................................................................................................................10

       6.2.1 Distancing techniques ...............................................................................................................10

   6.3 Assumptions ...............................................................................................................................11

   6.4 WAIORA limitation ......................................................................................................................11

7 Analysis .........................................................................................................................................11

   7.1 Hydraulic character and fish habitat ..........................................................................................11

       7.1.1 Flowtype composition and location of shallow reaches .........................................................11

       7.1.2 Distribution of pools and springs .............................................................................................13

       7.1.3 Substrate composition and coarseness .....................................................................................14

       7.1.4 Salmonid spawning .................................................................................................................15

       7.1.5 Other observations ................................................................................................................15

       7.1.6 WAIORA flow analysis in the vicinity of the Powers Road Bridge ........................................15

8 Discussion ......................................................................................................................................17

   8.1 Spawning and rearing habitat for salmonids ..............................................................................17

       8.1.1 Chinook salmon access to spawning grounds ........................................................................21

   8.2 Native fish values of the Waitohi River .....................................................................................21

   8.3 Ecological effects of extended bed dewatering ........................................................................22

9 Conclusions .....................................................................................................................................25

10 Acknowledgements ........................................................................................................................25

11 References ......................................................................................................................................26

12 Appendix I. Depth statistics by flowtype .....................................................................................28

13 Appendix II. Summary depth statistics across all flowtypes .......................................................29

14 Appendix III. WAIORA WUA curves for resident fish .................................................................29
List of Figures

Figure 1.1. The Waitohi River, with the study reach ringed................................. 5
Figure 2.1. A small trout redd. Note how the cobbles from the upstream end have been excavated and dislodged downstream to cover the eggs. ......................... 7
Figure 4.1. The study area, indicating features mentioned in the text. Blue grid squares = 10 km²................................................................. 8
Figure 7.1 Distribution of shallow sections in the middle reach of the Waitohi River (as of 1st June 2006). Green dot = downstream limit of survey, red dot = upstream limit of survey (Powers Road bridge), violet dot = shallow reaches along the mainstem. ...................................................... 12
Figure 7.2. A shallow run upstream of the Bakers Road Ford (locality “c” in Figure 7.1). 13
Figure 7.3. A shallow riffle in the lower part of the study reach (locality “d” in Figure 7.1). .......................................................................................... 13
Figure 7.4 The location of pools (red dots), along the middle reaches of the Waitohi. Green dots = downstream/upstream limits of survey (Ginters to Powers Road). Blue grid = 1 km²......................................................... 14
Figure 7.5. WAIORA output. Green line = Powers Road 7DMALF (103 L/s). Guideline lower threshold = 0.15 m. Red arrow = observed low flow on 21/02/06 (ca. 153 L/s). ........................................................................ 16
Figure 7.6. WAIORA output. Green line = Powers Rd 7DMALF. Red arrow = observed low flow on 21/02/06 (ca. 153 L/s). ................................................... 16
Figure 7.7. WAIORA output. Green line = Powers Rd 7DMALF. Red arrow = observed low flow on 21/02/06 (ca. 153 L/s). ................................................... 17
Figure 8.1. The synthetic 2005/2006 flow record of the Waitohi River at Powers Road Bridge. These data is based on mean daily flow from White Gorge, Waipara River......................................................... 19
Figure 8.2. The synthetic 2006 flow record of the Waitohi River at Powers Road Bridge, based on mean daily flow from White Gorge, Waipara River. Red and green arrows indicate respective salmon spawning and brown trout spawning dates, ........................................................................................................ 20
Figure 8.3. Downstream of Powers Road Bridge, the bed of the Waitohi River developed filamentous algal growth under low summer flow........................................ 21
Figure 8.4. A dewatering isolated pool near Bakers Ford (21 February, 2007). Note the ‘tide marks’ of recent groundwater levels around the pool sides. ................. 23

List of Tables

Table 7.1 Percentage composition of recorded flowtypes........................................ 12
Table 7.2 Depths and widths of shallow reaches in the Waitohi River (June, 2006)..... 13
Table 7.3 Number of springs and pools along the middle reaches of the Waitohi River (see Figure 7.4 for locations)................................................................. 13
Table 7.4 Substrate coarseness index from the middle reach of the Waitohi River..... 14
Table 7.5 Hydraulic characteristics of WAIORA transects in the vicinity of the Powers Road Bridge.............................................................. 15
1 Introduction and catchment description

The Waitohi River, which runs through grazing land in North Canterbury, is a lowland tributary of the Hurunui River. The Waitohi is largely rain fed, but receives some spring water, and rises from an altitude of ca. 1200 m a.s.l. from the coastal Puketeraki Range. The catchment area is approximately 257 km², and flows for approximately 50 km until it joins the Hurunui River in the vicinity of the State Highway 7 Bridge (Figure 1.1).

The river shares a similar upper basin geohydrology as the neighbouring Waipara River, and gauged low to medium flows in the upper reaches of the Waitohi (i.e. Powers Road Bridge) correlate well to the flows from the long-term flow-recorder at White Gorge on the Waipara River ($r^2 = 0.91$, Gabites 2006). This relationship was used to obtain a median flow of the Waitohi River at the Powers Road Bridge, which is approximately 470 L/s (ECan data to 31 March 06), with an estimated 7DMALF (seven day MALF) of 103 L/s (Gabites 2006).

In the lower reaches, the natural (i.e. estimated flow without abstractions) 7DMALF is estimated to be approximately 330 L/s just upstream of the Hurunui Confluence (Facer 2003 cited in Gabites 2006). The current minimum flow of 350 L/s has been set by the Hurunui River Water Management Plan (1980) (HRP) in this locality. A major objective of this plan was to preserve the flow regime in the Hurunui River which has widely recognised environmental values (Mosley 2002). In a recent NIWA review of selected minimum flows in a number of North Canterbury streams, the minimum flow in the lower Waitohi River was recommended to be set to the 7DMALF (i.e. 330 L/s) (Wilding et al. 2005).

The recent report of low flows in the Waitohi River (Gabites 2006) analysed flow data from about 16 gauging runs undertaken along the river course. This analysis indicated that the river lost about 150 L/s of surface flow between the Powers Road Bridge and Bakers Road Ford, with little variation between summer and winter months. However, downstream of the
ford, the river gained flow, especially between the Medbury Road Bridge and State Highway 7.

Since 1996, allocation of surface and hydraulically connected groundwater has risen significantly in the Waitohi River catchment, and by April 2006, the catchment had an abstraction allocation of just less than 300 L/s. Given the low flows, the surface water resource of this river is regarded as highly allocated (Gabites 2006). Significant sections in the middle reach of the Waitohi River currently become dry over the spring, summer and autumn months. However, local irrigators have claimed that the river dewatered almost every year before irrigation commences (Gabites 2006).

2 Background to the fish fauna

An older resource survey provided some information on the acclimatised sports fish in the Hurunui catchment, the Chinook salmon (Oncorhynchus tshawytscha), brown trout (Salmo trutta), and rainbow trout (Oncorhynchus mykiss) (Docherty 1979). At least in the past, the Waitohi River did support salmon spawning, and was surveyed in 1979, where its utilisation was considered as moderate, with the following comment: “some suitable gravels; conditions periodically stable; 10% - 30% of the available streambed used for spawning; few holding areas for juveniles” (Docherty 1979).

There is some information on the fish resident in the Waitohi catchment, and electric fishing has recently been carried out by North Canterbury Fish and Game Council (NCFGC in July 2007), with brown trout and longfin eels recorded (Brian Webb, NCFGC, pers. comm.). The New Zealand Freshwater Fish Database (NZFFDB) lists two survey records from the lower Waitohi River catchment (January 2004). Brown trout and native fish species; upland bullies (Gobiomorphus breviceps), longfin eel (Anguilla dieffenbachii), and the Canterbury galaxias (Galaxias vulgaris) have been recorded from the mainstem, with shortfin eels (Anguilla australis) and upland bullies also recorded from Washpen Stream. None of these species are considered rare or endangered at a national or local level (McDowall 1990), and may be considered as a typical fauna of many lowland stony streams in Canterbury. However, the longfin eels stocks are considered to be declining nationally, largely due to overfishing (Chisnall et al. 2002; Hoyle & Jellyman 2002).

However, brown trout and Chinook salmon fishing has always been major recreational activities for the Hurunui River. The brown trout fishery was considered to be one of the best in North Canterbury (Teirney et al. 1987), and the fishery was ranked 18th nationally (Unwin & Brown 1998). Particularly high values were placed on the upper and middle reaches of the mainstem (Bonnett & Docherty 1985; Teirney et al. 1987). However, relatively little documentation is available on the specific value of the Waitohi River for recreational fishing. However, given the potential importance of these fisheries in the catchment, the potential impact of current and future water abstractions on the surface flows of the Waitohi River had to be considered in respect to spawning habitat. This is because of the potential for salmonid spawning in the Waitohi River to enhance the salmon run not only in the Waitohi River, but in reaches downstream of the Waitohi River confluence, including the Hurunui River mouth, where a third of salmon were caught (Mosley 2002).

Brown trout and Chinook salmon spawn in river gravels, but outside of the irrigation season. Both species deposit their eggs amongst stream gravels in fast-flowing reaches of streams during winter and early spring. Each ripe female (known as a hen) deposits her eggs in small evacuations in the gravel (called pockets). These are then fertilised by the attendant male (or jack), are then buried by upstream gravels dislodged by the hen fish (McDowall 1990). This process is repeated in an upstream direction, producing a distinctive gravel mound containing all of the female trout’s eggs. The final construction is called a redd (Figure 2.1).
Chinook salmon spawn once in their lives, and die after spawning, and their carcasses can often be observed on the river bed during and after the spawning season. Brown trout, on the other hand, normally recover condition after spawning, and will spawn several times during their lives.

3 Objectives

The main objective of this study was to ascertain the ecological values in the middle reaches of the Waitohi River, and investigate how these values change with flow. These were broken down into three tasks:

- Determine the distribution of brown trout and Chinook salmon spawning in the middle reaches of the Waitohi River using GPS (Global Positioning System) techniques, as used in a brown trout spawning survey in coastal Canterbury (Taylor & Good 2005). This work will clarify the current value of the middle reaches of the Waitohi for salmonid spawning.

- Undertake a WAIORA analysis with the participation of ECan staff. This work will facilitate understanding on how potential fish habitat changes with flow.

- Given the above analyses and other available information, assess the ecological values of the middle reaches of the Waitohi River.

4 Study Area

The study reach, with an approximate distance of 14 km, forms the stony semi-braided middle reach of the Waitohi River as it flows across the Amuri Plains. Geographically the
surveyed reach extended from near the road end of Ginders Road, west to the Powers Road bridge (Figure 4.1).

![Figure 4.1](image-url) The study area, indicating features mentioned in the text. Blue grid squares = 10 km².

## 5 Sources of information

Data for the study have been obtained from various sources including:

- Field data compiled as part of this study, and commissioned by ECan.
- Records accessed from the North Canterbury Fish and Game Council (NCFGC).
- Various reports prepared or commissioned by ECan (as mentioned in the text).
- Fisheries Reports commissioned by the North Canterbury Catchment Board, and the North Canterbury Acclimatisation Society.
- Various Research papers
- Anecdotal accounts on the ecology from various landowners.
- Flow records compiled by Environment Canterbury.
6 Methods

6.1 Field Methods

6.1.1 Salmonid redd survey

Two foot surveys were undertaken; one for Chinook salmon spawning and the other for brown trout. The Chinook salmon spawning survey was carried out from the 31st of May to the 2nd of June 2006, over which time the flow at Powers Road declined from 849 L/s to 719 L/s. The brown trout spawning survey was undertaken over the 7th and 8th of September, while the flow at Powers Road declined from 529 L/s to 496 L/s. These survey periods were chosen to represent the time when most redds for those respective species would have been excavated, but before the redd excavations would become inconspicuous because of bed movement or algal growth.

For both surveys, the Waitohi River was surveyed by foot in an upstream direction, with the location of redds and suitable spawning gravels logged onto a Garmin GPS (Global Positioning System) receiver. It was proposed that written records and waypoints were to be kept for redds, suitable spawning gravel, and the size of observed trout. Surveys were conducted between 9 am and 4 pm, at which time the sun was sufficiently high to reduce water-surface glare. Polaroid sunglasses were worn to improve the detection of trout redds and fish. Visual water clarity was good during both surveys, with the river at winter baseflow during both surveys.

6.1.2 Flow assessment

During the September survey, at approximately 100 m intervals along the channel course, (as approximated by GPS), the wetted width of the channel (or widths of each braid), was estimated by pacing. The pace measurements were calibrated against channel widths measured by tape during the day. The mean mid-channel depth was recorded when channel widths were obtained. Mean depths were based on 3 replicate readings with a measuring stick. This process was conducted across all channels where the river braided. The nature of the flow (i.e. riffle, run, rapid etc.), was assigned by the general descriptions provided in the NZFFDB (New Zealand Freshwater Fish Database) booklets (NIWA undated). The locations of pools, shallow reaches, conspicuous spring channels, and other physical features were also recorded.

6.1.3 Substrate assessment

Substrate composition was estimated by eye, based on the substrate particle proportions across the channel width. Categories for substrate particle size were based on the modified Wentworth scale commonly used in fish habitat assessment, invertebrate studies (Jowett et al. 1991; NIWA undated), and by the NZFFDB. The substrate coarseness index (SI) was calculated on the basis of the formula used by a number of fisheries and invertebrate studies in New Zealand (Hayes et al. 1989; Jowett et al. 1991).

\[
SI = (0.02 \% \text{silt}) + (0.03 \% \text{ sand}) + (0.04 \% \text{ fine gravel}) + (0.05 \% \text{ coarse gravel}) + (0.06 \% \text{ cobbles}) + (0.07 \% \text{ boulders})
\]

Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River

Where:

SI = Substrate index
% Silt = % wetted area with particles less than 1mm in diameter (pasty to the touch)
% Sand = % wetted area with particles between 1 mm and 2 mm in diameter (grainy to the touch)
% Fine gravel = % wetted area with particles between 2 mm and 32 mm
% Coarse gravel = % wetted area with particles between 33 and 64 mm
% Cobbles = % wetted area with particles between 65 mm and 256 mm
% Boulders = % wetted area with particles greater than 256 mm.

Hypothetical derived values for the substrate index can range from 2 (i.e. a substrate of 100 % silt) to 7 (i.e., a substrate of 100% boulders).

6.1.4 WAIORA analysis

An assessment of flow-depletion effects was undertaken on the river reach in the vicinity of Powers Road. A computer-modelling technique called WAIORA (Water Allocation Impacts on River Attributes) was employed, which was developed by NIWA (National Institute of Water and Atmospheric Research). The outputs from the model are WUAs or weighted usable areas for freshwater fish species of interest. The WUAs can be considered as relatively how much of the wetted habitat could be potentially suitable for a chosen fish species at a specified flow.

It was proposed that field data into the model would be based on hydraulic data obtained from six representative transects; three riffles, and three runs. The stream geometry of each transect (wetted width, cross-sectional area and mean depth) was measured at two different known flows. Pools were not represented in the reach, so transects were not established on this flowtype.

Each of these transects were pegged on the 6th of September 2006, with river stage height marked on a temporary staff gauge (i.e. Waratah™) installed at each transect. The recommended WAIORA approach is to calculate mean transect depth (i.e. cross-sectional area/wetted width) during the first visit, and record the change in stage height (depth change as measured on the Waratah) after flow change. However, when the site was revisited during low flow on the 21st of February 2007, many of the waratahs had been disturbed. Therefore, the mean water depth at each transect was estimated by re-measuring the cross-sectional area, and dividing it by the reduced channel width.

6.2 Computer Methods

6.2.1 Distancing techniques

Maps of trout redd distribution were constructed by downloading the GPS data into MapToaster Topo software (ver. 3.0). Substrate index and inland distance were calculated using an Excel spreadsheet, and Excel pivot tables were used to summarise categorical data. Inland distance was calculated as the straight-line distance from the most downstream point of the survey. Thus, inland distance was estimated from the following Euclidian distancing formula, based on eastings downloaded from the GPS receiver:

\[
\text{Inland distance (m)} = \sqrt{(\text{Begin easting} - \text{easting})^2 + (\text{Begin northing} - \text{northing})^2}
\]

Where: Begin easting = 7 digit easting at downstream point
    Begin northing = 7 digit northing at downstream point
6.3 Assumptions

The simple distancing algorithm defined above is based on a Pythagorean approach, and while simple to calculate from GPS data, is only intended to provide an approximation of inland distance. When the distance between waypoints is small compared to the natural meander of a river channel, then errors are probably small. However, where waypoints do not follow the shape of the natural river bend, then the algorithm will underestimate inland distance relative to distance along the water course. However, for the purposes of this study the technique was considered adequate for describing general longitudinal changes in flow-type as sequenced along the channel.

The WAIORA technique assumes that the same measured flow is passing through the selected transects.

6.4 WAIORA limitation

The WAIROA model provides a summary of potential fish habitat suitability (i.e. WUA) as a function of various stream flows. However, a range of unknown variables can reduce actual habitat suitability. These can include fish access limitation to the habitats caused by drying downstream reaches, and inter-specific interactions between fish. The Weighted Usable Area (WUA) vs. flow curves can therefore be considered as representing maximum values than need to be considered in respect to other considerations outside of the models scope.

7 Analysis

7.1 Hydraulic character and fish habitat

7.1.1 Flowtype composition and location of shallow reaches

Overall, most of the recorded transects were runs or riffles (Table 7.1), with the proportion of flat runs increasing downstream. Rapids, which can be generally defined as deep, swift, water with a cobble/boulder substrate, were relatively rare in the study reach. Statistics for the depths and widths of recorded flowtypes may be found in Appendices 1 & 2. Pools made up a negligible component of the reach area, and are excluded from this table, but are discussed in a later section.

At the time of the salmonid spawning surveys, there was continuous surface flow throughout the reach from the Ginders Road end to Powers Road Bridge. However, four mainstem reaches were particularly shallow, in respect to salmonid passage, and these were widely distributed along the study reach (Figure 7.1). The depths of these reaches are provided in Table 7.2. Some of the braids were shallow, but always when deeper neighbouring braids were available which could offer alternative passage routes.

A main-channel reach upstream of Bakers Road ford was particularly shallow (Figure 7.2), and alternated between a riffle and a run. This reach was probably the longest encountered during the survey and exceeded 50 m in length. Another shallow reach was recorded further downstream near Buschs Road (Figure 7.3).
Table 7.1 Percentage composition of recorded flowtypes.

<table>
<thead>
<tr>
<th>Flow-type</th>
<th>Upstream limit of reach from Ginders Rd</th>
<th>to Shimmins Rd</th>
<th>to Bakers Rd ford</th>
<th>opposite Hobans Rd</th>
<th>to Powers Rd bridge</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>flat run</td>
<td>Total no. transects</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>15.8%</td>
<td>10.4%</td>
<td>7.1%</td>
<td>5.4%</td>
<td>9.9%</td>
</tr>
<tr>
<td>run</td>
<td>Total no. transects</td>
<td>20</td>
<td>26</td>
<td>8</td>
<td>24</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>35.1%</td>
<td>38.8%</td>
<td>19.0%</td>
<td>42.9%</td>
<td>35.1%</td>
</tr>
<tr>
<td>fast run</td>
<td>Total no. transects</td>
<td>5</td>
<td>16</td>
<td>7</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>8.8%</td>
<td>23.9%</td>
<td>16.7%</td>
<td>21.4%</td>
<td>18.0%</td>
</tr>
<tr>
<td>riffle-run</td>
<td>Total no. transects</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>14.0%</td>
<td>1.5%</td>
<td>11.9%</td>
<td>5.4%</td>
<td>7.7%</td>
</tr>
<tr>
<td>riffle</td>
<td>Total no. transects</td>
<td>14</td>
<td>16</td>
<td>17</td>
<td>13</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>24.6%</td>
<td>23.9%</td>
<td>40.5%</td>
<td>23.2%</td>
<td>27.0%</td>
</tr>
<tr>
<td>riffle-rapid</td>
<td>Total no. transects</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>0.0%</td>
<td>1.5%</td>
<td>0.0%</td>
<td>1.8%</td>
<td>0.9%</td>
</tr>
<tr>
<td>rapid</td>
<td>Total no. transects</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>% of total</td>
<td>1.8%</td>
<td>0.0%</td>
<td>4.8%</td>
<td>0.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Total no. transects</td>
<td>57</td>
<td>67</td>
<td>42</td>
<td>56</td>
<td>222</td>
<td></td>
</tr>
<tr>
<td>Total % of total</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.1 Distribution of shallow sections in the middle reach of the Waitohi River (as of 1st June 2006). Green dot = downstream limit of survey, red dot = upstream limit of survey (Powers Road bridge), violet dot = shallow reaches along the mainstem.
Table 7.2 Depths and widths of shallow reaches in the Waitohi River (June, 2006)

<table>
<thead>
<tr>
<th>Letter reference in Figure 7.1</th>
<th>Mid-channel depth (m)</th>
<th>Approx. width (m)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.1m</td>
<td>20</td>
<td>Wide shallow reach, probably too shallow for Chinook salmon passage. No photo.</td>
</tr>
<tr>
<td>b</td>
<td>0.15</td>
<td>15</td>
<td>A riffle.</td>
</tr>
<tr>
<td>c</td>
<td>0.15</td>
<td>17</td>
<td>A 50 m long shallow reach upstream of Bakers Road Ford, Figure 7.2</td>
</tr>
<tr>
<td>d</td>
<td>0.16</td>
<td>12</td>
<td>A shallow fast riffle/rapid, Figure 7.3</td>
</tr>
</tbody>
</table>

Figure 7.2. A shallow run upstream of the Bakers Road Ford (locality “c” in Figure 7.1).

Figure 7.3. A shallow riffle in the lower part of the study reach (locality “d” in Figure 7.1).

7.1.2 Distribution of pools and springs

Pools were infrequently and unevenly distributed along the river course (44 pools over 13.8 km). Almost all pools were evidently created by current scour around the bases of willow trees. Generally, pools became more frequent with distance upstream, although they were never common, and absent in the upper-most reach near Powers Road (Figure 7.4). A number of particularly deep (ca. > 1.5 m deep) pools were observed between McClellends Road and Westenras Road where a copse of large willows encroached into the channel. Spring-fed channels and spring heads were also occasionally encountered and recorded; these are tabulated below (Table 7.3).

Table 7.3. Number of springs and pools along the middle reaches of the Waitohi River (see Figure 7.4 for locations).

<table>
<thead>
<tr>
<th>Flow-type</th>
<th>Ginders to Shimmins Rd</th>
<th>Shimmins to Bakers Rd ford</th>
<th>Bakers Rd ford to opposite Hobans Rd</th>
<th>Hobans Rd to Powers Rd bridge</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool</td>
<td>6</td>
<td>14</td>
<td>11</td>
<td>13</td>
<td>44</td>
</tr>
<tr>
<td>Spring-fed feeders</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Spring-heads</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>17</strong></td>
<td><strong>17</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>
7.1.3 Substrate composition and coarseness

Substrate coarseness, as reflected by the substrate index (S.I.), did not vary markedly across flowtypes (Table 7.4). Rapids, and flows that were a mixture of rapids and riffles, had a slightly coarser substrate than runs. The substrate within pools did not differ significantly from the average substrate index. At many locations, the substrate was loose, the particles rounded, and flood debris was apparent well above (ca. 1.5 m) the baseflow water level. In September 2006, flood damage was apparent to adjoining pastureland and flood control works.

Table 7.4. Substrate coarseness index from the middle reach of the Waitohi River.

<table>
<thead>
<tr>
<th>Flow-type</th>
<th>n</th>
<th>S.I. (mean)</th>
<th>S.I (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riffle-rapid</td>
<td>1</td>
<td>5.35</td>
<td>-</td>
</tr>
<tr>
<td>Rapid</td>
<td>3</td>
<td>4.85</td>
<td>0.363</td>
</tr>
<tr>
<td>Riffle</td>
<td>43</td>
<td>4.75</td>
<td>0.066</td>
</tr>
<tr>
<td>Pool</td>
<td>31</td>
<td>4.71</td>
<td>0.074</td>
</tr>
<tr>
<td>Fast run</td>
<td>27</td>
<td>4.59</td>
<td>0.119</td>
</tr>
<tr>
<td>Flat run</td>
<td>19</td>
<td>4.56</td>
<td>0.089</td>
</tr>
<tr>
<td>Run</td>
<td>53</td>
<td>4.54</td>
<td>0.066</td>
</tr>
<tr>
<td>Riffle-run</td>
<td>14</td>
<td>4.42</td>
<td>0.096</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>191</td>
<td><strong>4.63</strong></td>
<td><strong>0.035</strong></td>
</tr>
</tbody>
</table>

Figure 7.4 The location of pools (red dots), along the middle reaches of the Waitohi. Green dots = downstream/upstream limits of survey (Ginters to Powers Road). Blue grid = 1 km².
7.1.4 Salmonid spawning

In early June 2006, no salmon redds, salmon carcasses, nor salmon observed in the reach of the Waitohi River from near Ginders Road (in the lower reaches) westwards to the Powers Road Bridge. No trout redds were identified from the September 2006 survey over the same river reach. Nor were any trout observed, despite there being good visibility, and the use of Polaroid sunglasses.

7.1.5 Other observations

Occasionally, during the winter surveys, small native bullies (Gobiomorphus sp.) were seen in the shallows of runs and riffles. The invertebrate fauna, visually assessed by looking under the larger cobbles and boulders, was generally composed of a sparse distribution of mayflies and caddisflies.

7.1.6 WAIORA flow analysis in the vicinity of the Powers Road Bridge

No pools were present in the vicinity of reach in which the WAIORA analysis was undertaken (i.e. vicinity of Powers Road Bridge). Therefore, the analysis was limited to those flow-types present; riffles and runs (Table 7.5). For the two runs, a flow reduction of 403 L/s was manifested by a reduction in mean depth of approximately 4 cm. Over the same flow drop, the two riffles declined in depth by an average of about 7 cm.

Table 7.5. Hydraulic characteristics of WAIORA transects in the vicinity of the Powers Road Bridge.

<table>
<thead>
<tr>
<th>Flow type</th>
<th>Width$_1$ (m)</th>
<th>Mean depth$_1$ (m)</th>
<th>Width$_2$ (m)</th>
<th>Stage Change (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run, replicate 1</td>
<td>16.82</td>
<td>0.181</td>
<td>16.20</td>
<td>0.033</td>
</tr>
<tr>
<td>Run, replicate 2</td>
<td>10.00</td>
<td>0.296</td>
<td>9.06</td>
<td>0.048</td>
</tr>
<tr>
<td>Riffle, replicate 1</td>
<td>6.25</td>
<td>0.183</td>
<td>6.70</td>
<td>0.076</td>
</tr>
<tr>
<td>Riffle, replicate 2</td>
<td>12.80</td>
<td>0.138</td>
<td>12.35</td>
<td>0.069</td>
</tr>
<tr>
<td>Flow type-weighted averages</td>
<td>12.13</td>
<td>0.21</td>
<td>11.61</td>
<td>0.05</td>
</tr>
</tbody>
</table>

1 The flow on the 6/9/06 was 556.3 L/s,
2 The flow on the 21/02/06 was 153.0 L/s.

Research has shown that for a wide range of streams, invertebrates have a distribution centred around the mean depth across the channel (i.e. midway between the water’s edge and the mid-channel zone (Jowett 2000). In this context, the WAIOIRA model estimated that as the flow reduced towards the seven-day mean annual low flow (7DMALF), the mean depth (i.e. flow/wetted width) declined to approximately 0.15 m, as estimated by eye (Figure 7.5). For the maintenance of aquatic communities in lowland stony streams, The WAIOIRA threshold mean depth was 0.10 m (Table 1, page 45 in Jowett et al. 2004). This value is the model’s default minimum mean depth value for lowland streams with a gravel bed,, but the WAIOIRA model does not specify a minimum mean channel depth for upland stony streams. It was expected that the invertebrate community in the Waitohi River would be typical in respect to flow/depth preferences and therefore the lowland stony stream value was maintained, despite the Waitohi River being an upland river (i.e. > 100 m a.s.l.) than a lowland one. When reduced flows were modelled across the transects, The model indicated that under reduced flow, overall channel width, and therefore wetted area, did not decline sharply (Figure 7.6).

The WAIOIRA threshold value for average velocities for upland stony rivers for trout and trout spawning is 0.15 m/s (Table 1, page 45 in Jowett et al. 2004). However, under reduced flow
at Powers Road, the mean velocity (i.e. obtained by dividing the flow by the transect’s cross-sectional area) reduced well below this minimum velocity (Figure 7.7). The mean velocity threshold was reached at a flow of approximately 345 L/s, somewhat less than the year-round median flow at Powers Road of 470 L/s (ECan Data).

At the observed low flow of 153 L/s at Powers Road (on 21/02/07), and when irrigation was occurring downstream, there was no surface water at Bakers Rd Ford, although there was shallow sub-surface flow about 1 m below the bed which supported some occluded pools (per. obs). Bullies were observed swimming in these pools which contained water, but no stranded or dead fish were found in dewatered pools or dewatered reaches along the stream course. Despite the absence of surface flow in the middle reach, the surface flow in the lower Waitohi River was still above the minimum flow of 350 L/s (H. Familton, ECan. pers. comm.).

![Figure 7.5. WAIORA output. Green line = Powers Road 7DMALF (103 L/s). Guideline lower threshold = 0.15 m. Red arrow = observed low flow on 21/02/06 (ca. 153 L/s).](image1)

![Figure 7.6. WAIORA output. Green line = Powers Rd 7DMALF. Red arrow = observed low flow on 21/02/06 (ca. 153 L/s).](image2)
Weighted usable area curves (WUA) were generated from the WAIORA model for known and possible fish lifestages resident in the reach downstream of Powers Road (Appendix III). For adult trout, the WUA declined to about 30% or less for flows at or lower than the year-round median flow (470 L/s), and very low habitat available at the 7DMALF (i.e. < 0.1 %). For juvenile brown trout (yearling), the decline in WUA was less severe, with about 85% WUA available at median flow, declining to about 50% at 7DMALF. For brown trout fry, while WUA was a little less (80% WUA) than that of juveniles at the median flow, WUA declined to around 30% at the 7DMALF.

Trout spawn during the winter, and the median winter flow is approximately 1344 L/s at Powers Road (ECan data based on regression data from Waipara River data, n=1748). The WAIORA WUA curve indicated almost 100% WUA close to this value (Appendix III), but spawning habitat reduced significantly with lower flows. For example, during the 2006 brown trout spawning survey, flows were quite low (496-529 L/s; cf. winter median 1344 L/s); and at that level the WAIORA model predicts trout spawning WUA ranging from about 55-60 %.

In contrast to trout, there was little reduction in native fish WUA (i.e. upland bullies and small longfin eels (T.L. < 30 cm)) at flows close to the predicted 7DMALF (103 L/s) at Powers Road Bridge (Appendix III). The Canterbury galaxias (Galaxias vulgaris) has been identified from the lower reaches, and they may also be present in perennial reaches near the location of Powers Bridge. However, the generated WUA curve for this species indicated little habitat reduction for this species, even at flows close to the 7DMALF. Collectively, for these three native fish species, the WUA remained well above 80% at the 7DMALF flow. There currently is no WUA vs. flow model for larger longfin eels (i.e. T.L. > 30 cm) in the WAIORA program.

8 Discussion

8.1 Spawning and rearing habitat for salmonids

There is some documented information which suggests that the river supported trout and salmon spawning in the past. For example, an early fisheries report categorises the Waitohi River as having intermediate levels of suitable spawning gravels for Chinook salmon, evidently based on a spawning survey (Table 1 in Docherty 1979). However, that report does not provide any information on the extent of the survey, or the distribution of spawning gravels.
Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River

It has been suggested that the lower reach of the Waitohi is hydrogeologically distinct from the remainder of the river, because its flow can be fed by seepage through floodplain gravels from the Hurunui River (Talbot & Callander (1985) cited in Gabites 2006). This is the section of the river downstream of the study area, and the lower Medbury Road Bridge (in the vicinity of State Highway 7 (see Figure 4.1)). A recent field study in this permanently-flowing reach was undertaken by NCFG (July 2007, email correspondence). Their study reach was also aligned with the reach considered by NIWA in a minimum flow study of a number of North Canterbury Streams (Wilding et al. 2005). The NCFG study revealed that some, albeit very limited, brown trout spawning occurred there (3 redds over 2 kilometres), and several spent (post-spawned) trout were also found, along with juvenile trout. However, no Chinook salmon were identified, but NCFG report that salmon definitely did spawn in this area at a time when the Hurunui river salmon run was larger. It was the view of NCFG that there was little holding (rearing) habitat for larger trout in the lower reach of the Waitohi River, and that flooding could be an issue for the survival of young salmonids. This is broadly the same conclusion that I came to further upstream in the study reach to the Powers Road Bridge.

The evident demise of the salmon run in the Waitohi River is likely to have origins beyond this catchment, because there is an overall impression that the salmon fishery in the Hurunui River has generally declined, suggesting that a common factor may be affected salmon stocks and spawning in both the Hurunui and Waitohi Rivers. The term ‘generally’ is used here, because salmon runs are notoriously variable over time due to the large number of factors that can affect their populations. For example, floods can lower fry recruitment due to the destruction of redds, or high flows can increase the mortality of fry (McDowall 1990). Sea conditions are also thought to reduce survival of juveniles at sea due to poor feeding or predation, and at maturity, (after 2-4 years) low winter flows during spawning could elevate water temperatures to those un-preferred by migrating salmon (Docherty 1979), or reduce access to spawning grounds altogether (Glov & Duncan 1985).

NIWA undertook a WAIORE study in the lower reach of the Waitohi River (near the Hurunui confluence) in January 2004 (Wilding et al. 2005). On the basis of that study, NIWA recommended that the minimum flow in the lower reach should be 330 L/s, the same as the 7DMALF at this location, compared to the current minimum flow of 350 L/s. However, our field observations are consistent with the view of Gabites (2006), that surface flow is not preserved along the River course when the river is near the current minimum flow of 350 L/s in the lower reach.

The current WAIORE analysis in the upper reaches showed that when flows drop below year-round median flows, even under natural conditions, water velocity in the reach near Powers Road becomes less than the optimal for the maintenance habitat for adult trout (i.e. < 0.15 m/s) (Jowett et al. 2004). This was exemplified by the WAIORE WUA curve for adult trout, which indicated that there was little habitat for these fish over a wide range of flows. However, brown trout spawn in the winter months when flows are higher, and the WAIORE analysis indicated that the July-to-September median flow would appear to be suitable for spawning, assuming fish can negotiate shallow reaches to reach the spawning grounds.

There are currently no WAIORE WUA curves available for Chinook salmon, but their hydraulic preferences for spawning are for deeper and faster flows than those preferred by brown trout. It is possible that some salmon spawn below the lower Medbury Bridge where NCFG recorded brown trout spawning. Should winter flows approach median flows, the middle and upper reaches of the Waitohi River would provide suitable flow conditions for spawning, but with the caveat of borderline access through shallows, as they require even deeper water for passage than brown trout. Studies on the Rakaia River, and elsewhere have indicated that some Chinook salmon fry (called stream-type fry) can rear in freshwater for one year before migrating to sea (Unwin & Taylor 2007). This is expected to be the case in the Waitohi River should salmon spawn there. These resident juveniles take up habitats confined to the shallows along the margins of braids or the mainstem, and in any available pools and backwaters, especially if macrophytes were present (Unwin & Taylor 2007). I would expect that the middle and upper reaches of the Waitohi River are too unstable for
Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River

salmon rearing due to the Rivers affinity for summer dewatering, low numbers of pools and backwaters and winter floods.

Floods would reduce the suitability of a river as a spawning habitat for both salmon and trout, and notably flood and flow variation is not factored into the WAIORA analysis. Floods with a return period of greater than 4 years are known to reduce brown trout fry recruitment (Hayes 1995), and floods greater than 20 x the median flow are considered to cause ‘substantial’ reductions in both invertebrate densities and species richness (Biggs et al. 1990). Given that the annual median flow at Powers Road is approximately 470 L/s (ECan data), then flows in excess of 9400 L/s could be considered deleterious to the invertebrate fauna.

An estimate of mean daily flows at Powers Road was generated from White Gorge data (Figure 8.1). However, this was based on a linear regression of concurrent low-flow data up to an estimated flow of 2000 L/s at Powers Road. While the accuracy of estimated flows greater than 3000 L/s would be uncertain, it is clear that in 2005 and 2006 substantial winter floods occurred, with one in late July 2005 and a series of floods through June and August in 2006 (Figure 8.2). These probably would have been large enough to deplete the invertebrate fauna, and destroy salmonid redds. The stone bed of the Waitohi River was quite rounded and loose in places, which suggests that the substrate exhibits frequent movement, at least in some reaches, and this would be detrimental to egg survival in the redds.

Flow variability - especially the coefficient of variation of the mean daily flow - is known to be a strong predictor of the character of a river’s biology (Biggs et al. 1990). The coefficient of variation of the Waitohi River is 2.70 (based on ECan data) which therefore could be considered as a waterway with quite high variability within the context adopted by Biggs et al. (1990). This is distinct from the lake-fed Hurunui North Branch mainstem, which has low flow variability and a high brown trout population. In a nationwide study, rivers with high abundance of brown trout (and rainbow trout) were associated with stable flows and low gradient (Jowett 1990), and invertebrates preferred by trout (i.e. mayfly/caddisfly/stonefly communities) were also associated with habitats exposed to low flow variability.

Figure 8.1. The synthetic 2005/2006 flow record of the Waitohi River at Powers Road Bridge. These data is based on mean daily flow from White Gorge, Waipara River.
In contrast to the flooding habit of the Waitohi River in winter, it is also clear that significant sections of the middle reaches of the Waitohi River dewater over the summer, despite flows being maintained above the minimum flow set in the lower river. The lack of dead trout (or any dead fish) in the dewatered pools and reaches of the Waitohi River was somewhat reassuring, and indicated that either trout are migrating downstream out of the ephemeral reach, or are simply not present in high numbers. If trout are trapped by receding waters, they will naturally congregate in deeper pools, and die there unless salvaged.

To summarise, the winter median flow of the Waitohi River would suggest that the middle reach provides good brown trout and Chinook salmon spawning habitat. However, the flow is quite variable, and there is good hydrological and physical evidence that the river floods frequently in the winter, which could jeopardise trout fry and salmon fry development. There is only a limited amount of trout spawning in the permanently-flowing lower reach, and this habitat is accessible and suitable for Chinook salmon spawning. During summer, even within the natural range of lower flows, the river habitat is not conducive as rearing habitat for trout and probably salmon, because of the lack of pools, and appropriate flow types at low water levels. I am not aware of any evidence, even anecdotal information, to suggest that large numbers of fish are being stranded by retreating surface flow.

During low flows, water velocities may not be sufficiently high to maintain a diverse community of benthic invertebrates, although the WAIORA guidelines for upland rivers have not yet been provided (i.e. altitudes > 100 m.a.s.l.). Certainly, for lowland gravel streams, mean water velocities should be in the range of 0.15-0.5 m/s to support diverse invertebrate communities (Table 1 in Jowett et al. 2004). My observations in February 2007 indicated that there were profuse filamentous algal growths consistent with low sustained velocities (Figure 8.3). Filamentous alga is less favourable for the maintenance of an invertebrate fauna dominated by EPT (mayfly/stonefly/caddisfly) taxa. Rather, filamentous algae supports a low diversity of invertebrates, dominated by snails, midges, and ostracods (Suren et al. 2003). These are small invertebrates which are less inclined to drift downstream on the water current, which EPT taxa tend to do.

Changes in the invertebrate fauna are more likely to have a relatively higher impact on trout ecology than native fish. This is because trout tend to consume larger invertebrates which are most common in the stream drift, such as stoneflies, mayflies and chironomids, which
drift downstream at dusk and dawn (McIntosh 2000), rather than those dwelling on filamentous algae. In contrast, native fish (e.g. bullies, most galaxiids, and eels) tend to browse opportunistically on stream invertebrates, and their diet is more representative of that of the stream bed, regardless of the nature of the invertebrate fauna.

8.1.1 Chinook salmon access to spawning grounds

Chinook salmon need winter access from the sea to spawn, and being large fish, they can be restricted by a lack of water depth in shallow reaches. This topic was broached in the report on instream values and flow regime in the Hurunui River catchment (Mosley 2002), which summarised some of the research on depth requirements for salmon passage. Generally, a depth of 0.25 m is regarded as adequate for Chinook salmon passage, although shallower depths can be negotiated at the price of some abrasion along the fins and lower belly. During the June 2006 survey, there were mainstem reaches in the Waitohi River which were substantially shallower than 0.25 m (Figure 7.1, Table 7.2). However, based on regression functions to the White Gorge flow on the Waipara, the Waitohi River flow at Powers Road was approximately 730 L/s, only 54% of the estimated July-September median flow (i.e. 1344 L/s). The Waitohi River flow during the brown trout survey in September was even lower; possibly only about 500 L/s, and many of the braids GPS-mapped in June were quite dry in early September. Thus, the winter 2006 flows were well below average winter conditions.

It is apparent that low winter flows could inhibit fish access to spawning habitat because of shallow reaches, although flows around the winter median may be adequate for fish to pass through shallow reaches.

8.2 Native fish values of the Waitohi River

There are only two freshwater fish records on the NZFFDB for the Waitohi River. Combined with the recent survey by NCFB, the identified native fish fauna so far is composed of longfin eels, upland bully, and the Canterbury galaxias.

Figure 8.3. Downstream of Powers Road Bridge, the bed of the Waitohi River developed filamentous algal growth under low summer flow.
The Waipara River is a neighbouring catchment lying to the south of the Waitohi River, with similar hydrological characteristics, including stony drying reaches. In contrast to the Waitohi River, the Waipara has been well surveyed, especially in the lower reaches. Over a similar distance from the sea (50 km-60 km), a NZFFDB record on the semi-braided Middle branch of the Waipara has a similar fish fauna as to what has been established in the Waitohi, but also includes brown trout and shortfin eels.

In contrast to trout habitats, the WAIORA habitat analysis indicated that the river can provide habitat for all known and possible native fish species, even at flows near the 7DMALF. This would include all lifestages of the upland bully, and small (T.L. < 30 cm) longfin eels. However, this is not necessarily so for medium-large longfin eels, because their habitat preferences, especially for nocturnal foraging, are not currently defined. An early study pointed out that longfin eel habitat changes with age and fish size, and indicated that large longfin eels require deep, slow-flowing channels (Glova & Duncan 1985). In contrast, smaller eels can cope with shallower water (Jowett & Richardson 1995).

Canterbury galaxias (Gobiomorphus vulgaris) may be present in the upper reach of the Waitohi River, upstream of the Powers Road Bridge. They are a somewhat larger fish than the upland bullies, and because they were not observed in the middle reaches, it probably indicates they were not present, at least in high numbers. The species does not require sea access, and like the upland bully, it spawns close to its rearing habitat. In any case, as flows reduce, the WAIORA analysis suggests that, if this fish is present in the middle reaches, the reduction of its habitat would be minor.

When the river flow reduces to the point at which surface flow ceases, then of course fish habitat is lost, and WAIORA analysis does not model this endpoint, because that requires detailed knowledge of the hydrogeology and contributing flows. Field observations at low flows indicated that as surface flow ceases, upland bullies retreated into the few available pools, which are sustained by cool subsurface flow. The upland bully can survive harsh conditions, does not require sea access to complete its lifecycle, and can breed prolifically (McDowall & Eldon 1997). While dewatering would lead to the loss of upland bully eggs - they spawn on the underside of cobbles - the re-watered reach could repopulate from fish in the perennial reaches further upstream.

8.3 Ecological effects of extended bed dewatering

Based almost entirely on gaugings before 1994, the loss of flow along the Waitohi River was greatest between Powers Rd and Bakers Road (Gabites 2006). Over this reach, the mean flow loss was approximately 165 L/s, with a natural flow loss of about 127 L/s, and an irrigation-induced flow loss of approximately 38 L/s (Fig. 3.3 in Gabites 2006).

However, since 1994, the number of consented takes has approximately doubled, and the loss of flow caused by irrigation has increased significantly. The overall abstraction-induced flow loss from Powers Road to Bakers Road in 2005 was estimated at 175 L/s, with a further loss of 50 L/s downstream between Bakers Ford and Medbury Road Bridge (Gabites, pers. comm., ECan). However, the median late-summer-early autumn (Jan-March) flow at the Powers Road Bridge was estimated at only 139 L/s (mean = 464 L/s). It is therefore of no surprise that the groundwater resource for the Waitohi catchment was considered to be highly allocated (Gabites 2006).

The middle reach of the Waitohi River bed dries up under natural low flows when the lower reach is flowing at the current minimum flow monitoring site (pers obs. and Gabites 2006). Therefore, the potential physical impact of the groundwater loss would be a spatial extension of the naturally dewatered zone, and a probable increase in the length of time that the bed lacks surface flow. Under the current abstraction regime, there would appear to be permanent flow at, and upstream of, the Powers Road Bridge, with surface flow being lost at a point somewhere over the 1.4 km from 700 m downstream of the Powers Road Bridge to
the reach near Westenras Road. On the 21st of February 2007, the dewatered reach extended downstream to somewhat east of Ginders Road, a distance of at least 11.4 km. On that occasion it was unknown exactly where surface flow remerged, but surface flow was observed along the reach flowing parallel to S.H. 7.

Late summer observations (21 February, 2007) on the Waitohi River bed indicated a reduction of groundwater level in respect to the stream bed of the order of 1m near the Bakers Road Ford (Figure 8.4). A later visit by ECan staff on the 15th of March 2007 (three weeks after the first visit) indicated that the water level in occluded pools at the Bakers Road ford were continuing to drop below the stream bed, despite an apparent increase in flow at Powers Road (H. Hamilton, pers. comm., ECAn). There is historical data on the extent of groundwater retreat in the vicinity of Bakers Road Ford when flow ceases (Figure 3.6 in Gabites 2006). Over the time frame 1987-1993, summer groundwater levels on both banks continued to fall over a metre after flow ceased, and it is considered likely that shallow groundwater under the stream bed would retreat by about the same amount. The early data, coupled with recent observations at Bakers Road Ford, indicates that significant drawdown of shallow groundwater in the vicinity of the bed has taken place over a long period of time at Bakers Road Ford.

It is considered that the natural drying behaviour of the middle reaches of the Waitohi River bed is of sufficient magnitude to compromise aquatic invertebrate values. This may appear as an obvious statement, but as a river dries, many aquatic invertebrates can survive amongst the stream gravels, in an area called the hyporheic zone, at least while it remains wet with shallow groundwater. A study on invertebrates of the hyporheic zone on the neighbouring Waipara River showed that, hyporheic sediments remained sufficiently damp to support invertebrate communities at a comparable level to sites with perennial flow, although abundance was reduced at times of no surface flow (Burrell & Scarsbrook 2004). Abundance quickly increased when surface flow resumed, but invertebrate communities were still distinct compared to those in perennial reaches. This indicates that the effect of ephemeral flow can be long-lasting and detectable even when flow resumes. However, during the time of these experiments, groundwater was only 10-15 cm below the substrate surface, at a much higher level than the 1 m decline observed on the Waitohi River bed in the vicinity of Bakers Ford.

Figure 8.4. A dewatering isolated pool near Bakers Ford (21 February, 2007). Note the ‘tide marks’ of recent groundwater levels around the pool sides.
There are likely to be an ecological distinction between a river where the aquatic invertebrates are sustained by shallow groundwater under a dry river bed, and a dry river bed where the shallow groundwater has retreated to a point where aquatic invertebrates are unlikely to be sustained. The latter situation is the one prevalent on the middle reaches of the Waitohi River. When a dried reach re-waters, completely dried stream beds will incur a lower colonisation rate than those where the hyporheic fauna can provide invertebrate recruitment. Severely dried reaches would necessarily require colonisation from upstream reaches; those where shallow groundwater does facilitate recruitment, or from the perennial reaches upstream of Powers Road. All extant (not extinct) New Zealand freshwater fish are solely dependent on invertebrates for food, and lower invertebrate numbers could have food supply implications for fish when they recolonise the reach after it re-waters. Trout, in particular, predate heavily on mayflies and caddisflies, and at least the common mayfly *Deleatidium* sp., is known to have a decreased distribution with depth in the hyporheic zone (Collier & Scarsbrook 2000). The low numbers of mayflies and caddisflies observed during the winter surveys in areas which were dry in the summer are probably linked to poor recolonisation rates after flows return. To summarise, further deleterious ecological effect may not occur in reaches which have always been dry, and lacked shallows, but an extension of the dewatered zone has probably led to deleterious changes in the invertebrate ecology. Unfortunately, there is insufficient data to model how the extension of the dewatered zone varies as a function of groundwater level.

Given the level in which groundwater is drawdown below the stream bed, it is possible that ecological effects could be mediated beyond the irrigation season if the groundwater level is depressed to the point that the re-emergence of autumn/winter surface flow (due to groundwater recharge) is postponed. This could affect flows for salmonid spawning, especially Chinook salmon which spawn earlier in the winter. Possibly even brown trout spawning (July-September) could be affected if winter rains are late. By way of illustration, at the time the salmon spawning survey commenced on 31 May 2006, a local landowner informed us that the lower river had only begun to flow two weeks prior to the survey commencement. However, as suggested above, the decline in the salmon run cannot be attributed solely to the loss of this river for spawning, as the decline in this fishery would appear to more widespread than that, and beyond the flow effects of the Waitohi River.

A critical question is whether the additional stream depletion effects caused by irrigation in the middle reach have a significantly greater ecological impact than those caused by natural dewatering, winter flooding, possibly poor salmon access, and a lack of rearing habitat for brown trout. The discussion above suggests that, for the invertebrate fauna, it may depend on the degree the groundwater retreats below the streambed, and it would appear that shallow groundwater has retreated to ecologically significant depths over a long time frame.

Where permanent flows exist, i.e. where the river approaches S.H.7., and upstream of Powers Road, then ecological values are higher, and these values need to be protected by minimum flow conditions which have relevance to these habitats. The current minimum flow station in the lower river would appear to be relevant to that reach, but not to flows further upstream. However, flows in the upper river are clearly disjoint from those in the lower reach, and a more local minimum flow station would be appropriate. Therefore, it is recommended that a minimum flow site be setup upstream of the Powers Road Bridge which has a stronger relationship to the flow status in the upper reach of the Waitohi River.
9 Conclusions

Based on an assessment of salmonid spawning surveys of the Waitohi River, and a WAIOURA assessment on this river near the Powers Road Bridge, the conclusions of this report are that:

- No salmonid spawning was recorded over the reach between Ginters Road and the Powers Road Bridge, yet at winter median flows (at Powers Road), there could be a significant amount of spawning habitat available. Some limited trout spawning occurs further downstream of Ginters Road in the vicinity of S.H.7.

- There is evidence that the Waitohi River is subjected to winter flood flows which could damage salmonid redds, and has a flow variability of a magnitude which would be detrimental to invertebrate production. During periods of low winter flow in the winter, water depth in some identified reaches may be too shallow to allow passage for adult salmon and possibly trout.

- At low flow, the river supports good habitat for native fish down to flows close to the 7DMALF at Powers Road (i.e. 103 L/s), but algal growth could be a problem as water velocities decline in the summer months. In addition, there was little habitat for trout rearing at low natural flows, and pools for adult fish had a sparse and sporadic distribution. There was no indication that trout were trapped in the drying reaches over the summer months, or that they were present in the drying reach at that time.

- In late summer, it would appear that groundwater levels along the stream bed are sufficiently below the stream bed to affect invertebrate survival, and data indicates that this has been the situation for at least the past 10 years. If this hypothesis is correct, then the significant growth of hydraulically-connected abstractions may not have caused significantly more environmental damage in the reach which had always historically dewatered.

- However, a greater length of the Waitohi River bed may have become dewatered as a function of greater irrigation pressure, and lowered shallow groundwater levels. However, there is no data on how much of the bed now dewatered compared to earlier times when irrigation pressure was less. What is clear is that the reach holds little value for trout or salmon spawning or rearing, and only moderate value for native fish.

- The river has a significant proportion of its flow which is subject to irrigation takes; and while flow depletion effects are likely to be detrimental to the river’s ecology, the ecological value of the river is already defined by its natural flow regime.

10 Acknowledgements

I wish to thank Mr Gilbert for allowing access across his property at the time of the salmonid surveys. Shirley Hayward and Herb Familton, both of Environment Canterbury, assisted in the field. Suzanne Gabites and Shirley Hayward (Environment Canterbury), and Malcolm Main (formerly of Environment Canterbury), provided useful comments on the draft manuscript.
11 References


Salmonid spawning and fish habitat suitability in the middle reaches of the Waitohi River


## 12 Appendix I. Depth statistics by flow-type

<table>
<thead>
<tr>
<th>Flow-type</th>
<th>Data</th>
<th>to Shimmins Rd</th>
<th>to Bakers Rd ford</th>
<th>opposite Hobans Rd</th>
<th>to Powers Rd bridge</th>
<th>Grand Total</th>
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13 Appendix II. Summary depth statistics across all flow-types

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<th>Location category (upstream from start point)</th>
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<th>opposite Hobans Rd</th>
<th>to Powers Rd bridge</th>
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<tr>
<td>Total n</td>
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<td>81</td>
<td>53</td>
<td>69</td>
<td>266</td>
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<tr>
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<td>0.52</td>
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<td>0.358</td>
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<td>0.568</td>
<td>0.481</td>
</tr>
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</table>

14 Appendix III. WAIORA WUA curves for resident fish.

Red arrow indicates estimated annual median flow at Powers Road Bridge (470 L/s). Green line = 7DMALF at Powers Road (103 L/s).

Green line indicates estimated winter (July-September) median flow at Powers Road Bridge (1344 L/s). The observed winter flow during the 2006 winter was to the left of the flow range depicted here, and ranged from 496-529 L/s.
Appendix III (cotd.).

The flat WUA vs. flow curve for Canterbury galaxias for wetted habitat near the Powers Road Bridge.