# Memo

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| Date | 4th May 2018 |
| To | Waimakariri Water Zone Committee |
| CC | |
| From | Jarred Arthur |

# Evaluation of environmental flow regime options for the northern lowland tributaries of the Waimakariri River

## Summary

This memo provides the preferred minimum flow and allocation options for protecting instream ecological values in the northern lowland tributaries of the Waimakariri River. For the most-part, these flow preferences are based on maintaining available resident and/or spawning habitats for species (with an emphasis on threatened indigenous fish), or sufficient fish migration pathways. As it stands, current minimum flows are insufficient for all waterways excluding the Cam River, the three brooks (South, Middle and North Brooks) and Cust Main Drain. There is also an issue of inadequate allocation limits and some streams are over-allocated. In order to adequately protect instream values, these issues need to be addressed.

Instream ecosystem health is susceptible to changing water quality. The water quality of lower reaches in many Waimakariri Water Zone (WWZ) spring-fed waterways is highly responsive to changing flows with tidal pooling common. These flows can result in long water residence times resulting in stagnation. It is important that flow setting maintains water movement and flushing capacity to remove contaminants from the lower reaches of streams. This is of particular significance for Courtenay Stream, where the lower waterway is tidal and impounds behind floodgates.

Protecting cultural, recreational and amenity values is also key when managing water use and flows in the northern lowland tributaries of the Waimakariri River. These values (represented in Appendix 1) need to be assessed alongside the ecological minimum flow (EMF) preferences in this memo, and a moderated recommendation made for each waterway that supports these values.

## Purpose

On the 26th March 2018, the WWZ Committee explored environmental flow regime options for the Ashley River / Rakahuri catchment. These options included minimum flow and allocation limits adequate for the protection of instream ecosystem values. Similarly, the committee will consider minimum flow and allocation options for the northern tributaries of the Waimakariri River in a workshop to be held on the 14th May 2018.

The following memo details the preferred options for environmental flow regimes in the northern Waimakariri tributaries for the purpose of protecting instream values. It outlines:

- preferred ecological minimum flow (EMF) options, including the methodology used and justification for reassessing those previously reported.
- preferred options for allocation based on guidelines and reported findings. Until recently, allocation limits in Waimakariri planning processes have received little empirical guidance for protecting instream ecosystem values.
- effects of groundwater abstraction and allocation scenarios (as documented in the memo entitled '*Groundwater allocation modelling results for northern Waimakariri tributaries catchment*') on ecological, cultural, recreational and amenity values (Appendix 1).

The findings of this memo will guide zone committee decisions for recommending minimum flow and allocation limits in their draft Zone Implementation Plan Addendum (ZIPA).



## Background

Indigenous flora and fauna evolve and adapt to habitats provided by natural flow regimes in streams and rivers. The quantity/availability and quality of these habitats, however, are increasingly compromised as more and more water is abstracted for human use from streams and stream depleting groundwater. It is prudent that the use of water resources is therefore sustainably managed to ensure flows protect ecological, cultural, recreational and amenity values. These flow provisions are collectively known as an 'environmental flow regime'. A simple environmental flow regime uses two management tools:

- A 'minimum flow' to manage the effects of abstractions on surface water values at low flow.
- An 'allocation limit' to preserve the variability of flows, specifically freshes and smaller flood flows.

Environmental and, more explicitly, ecological flow provisions manage the effects of stress caused by low flow conditions on aquatic communities residing in freshwater environments. Low flows can prevent fish passage by exacerbating the spatial and temporal extent of drying reaches, and reduce available habitat for resident and spawning populations. Low flows can also degrade water quality by:

- increasing water temperatures;
- decreasing nutrient dilution potential;
- altering water pH;
- increasing diurnal fluctuations in dissolved oxygen concentrations; and,
- reducing sediment transportation.

The above water quality effects can have multiple physiological and behavioural outcomes for aquatic species, and cause shifts in aquatic community assemblages. The indirect ecosystem effects of low flows on aquatic communities can include:

- an increased risk of nitrate toxicity to flora and fauna;
- increased nuisance algal and aquatic plant growths;
- reduced habitat refugia in bed substrates resulting from excessive bed siltation; and,
- increased invertebrate and fish mortality resulting from depleted dissolved oxygen levels and excessive water temperatures.

Neither a minimum flow nor allocation limit should be considered independently of one another when setting an environmental flow regime for a stream or river. Each function differently, but also complement one another to protect instream values. A minimum flow should be set high enough to guarantee a minimum amount of viable habitat is maintained for a species. It should also provide refuge for invertebrates and fish until higher flows return. An allocation limit requires setting at a low enough value to promote flow variability. This limits the time spent at low flow conditions and the amount of compounding environmental stress a stream community suffers.

The higher an allocation limit is, the longer a stream is likely to spend at a minimum flow level. Figure 1 illustrates how water allocation can reduce flows and lessen flow variability. Lower allocation limits are arguably more important for hill-fed rivers like the Cust River (synonymous with the Cust Main Drain). This is because the Cust River is naturally highly variable and dependent on freshes and floods to turn over the river bed, remove algal growths, and provide connectivity for fish passage. Spring-fed waterways are naturally less variable, but still rely on smaller flood flows to flush contaminants. Minimum flow and allocation limits must be considered collectively when ensuring the low flow protection of instream values. The effect of an excessive allocation limit can be mitigated to some extent by setting a higher and more conservative minimum flow. This is likely to be the case in the WWZ where many streams are over-allocated or contain large allocation limits. Likewise, the effect of a low minimum flow can be offset to some degree by a more constrained allocation limit.

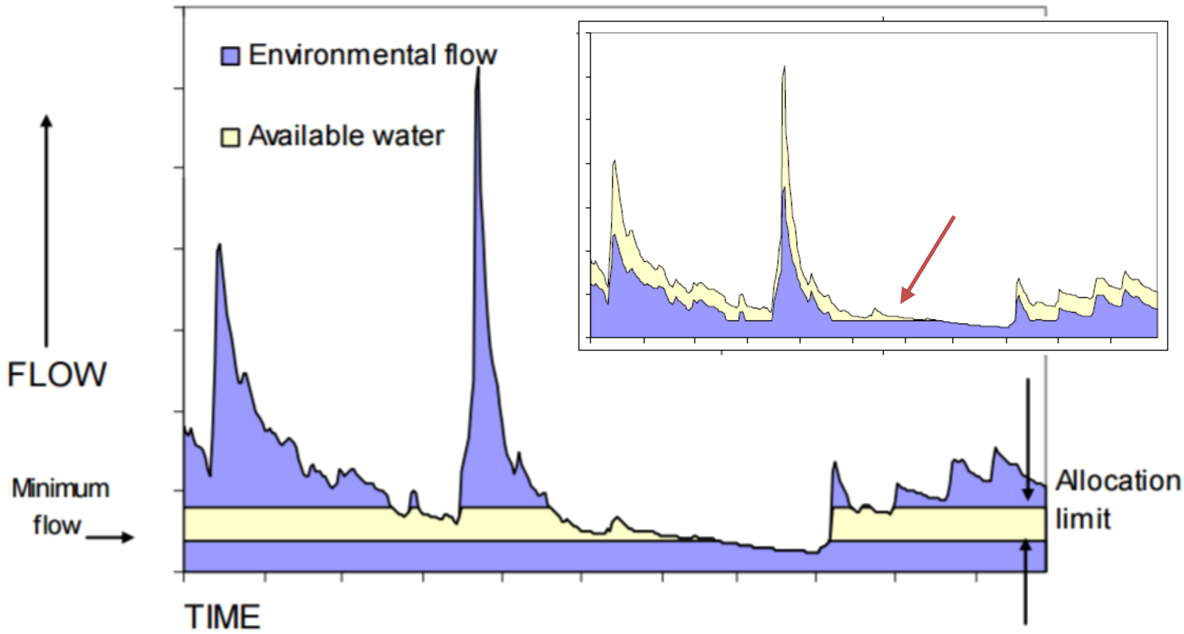


**Figure 1.** Example of how an allocation limit can affect a stream's flow regime (adapted from MfE, 2008). Red arrow indicates how a stream's flow can 'flat line' under allocation.

## Ecological minimum flow reporting

A key component for assessing an EMF is the naturalised 7-day mean annual low flow ($7dMALF^{natural}$) of a stream. That is, the 7dMALF once the anthropogenic effects of groundwater and surface water abstractions or recharge are removed. In the WWZ this includes the effects of consented water takes for irrigation, stock water, and drinking water, and the influence of water losses to ground via unlined Waimakariri Irrigation Limited (WIL) races and Waimakariri District Council (WDC) stockwater races. In 2009, Environment Canterbury contracted Golder Associates to conduct habitat and desktop assessments to evaluate the ecological flow requirements of lowland Waimakariri River tributaries (Golder Associates 2009). A shortfall of these EMF assessments is that suitable hydrological data did not exist to adequately quantify anthropogenic effects on stream flows. Instead EMF estimates were calculated using 7dMALF as measured in the environment regardless of abstraction and 'new water' ($7dMALF^{measured}$). This resulted in a discrepancy between EMF recommendations, as they are currently presented in Golder Associates (2009), and those that are actually suitable for protecting aquatic species under the scenario of a natural flow regime.

A recently developed groundwater model has provided a means to approximate the effects of groundwater abstraction and anthropogenic land surface recharge on spring-fed streams in WWZ. As a result, $7dMALF^{natural}$ values have been estimated for streams and rivers, which account for both surface water and groundwater anthropogenic effects. In light of these new findings, and considering the shortcomings of reported EMF recommendations, there is justification to reassess existing EMF values based on newly available $7dMALF^{natural}$ data.

## Ecological minimum flow reassessment methods

River Hydraulics and Habitat Simulation (RHYHABSIM) methods were used for determining stream- and species-specific weighted usable area (WUA) curves (i.e. habitat availability). This memo does not go into detail to describe these methods, but they are detailed in the report by Golder Associates (2009). Revised EMFs were calculated by applying newly modelled $7dMALF^{natural}$ values to the reported WUA curves in Golder Associates (2009). Aquatic species presence/absence at each stream was then used to calculate ecologically appropriate flows.

EMF preferences for northern Waimakariri River tributaries (as detailed in this memo) were based on the fish community significance criteria outlined in Golder Associates (2009) (

Table 1). These criteria select the minimum flow necessary to retain a percentage of habitat area that an individual species has available at or below 7dMALF$^{natural}$ conditions. The precise percentage of habitat retained is usually, but not always, determined by the flow preference of the most threatened species present in a stream. The more significant or threatened a fish population or community is, the higher the recommended percentage of habitat retention. For example, the presence of "chronically threatened" longfin eel requires the retention of flows that provide at least 95 percent of usable longfin eel habitat in a stream. In other cases, percentage habitat retention may be assigned to protect fish spawning or rearing (e.g. salmonids).

The use of the RHYHABSIM method for calculating ecological flow requirements was not feasible or appropriate for all spring-fed tributaries assessed in the WWZ. In some cases, it was difficult to establish habitat versus flow relationships because water levels in spring-fed streams are strongly influenced by abundant aquatic macrophyte beds. In these circumstances, the method for developing EMF preferences were based on a.) generalised flow versus depth relationships of fish species (particularly adult and juvenile brown trout) (Golder Associates 2009), or b.) a proportion of 7dMALF$^{natural}$ whilst weighing the validity of the recommendation of Golder Associates (2009).

**Table 1** Fish community significance criteria for determining percentage of maximum habitat retained when setting minimum flows. Adapted from Golder Associates (2009).

| Significance criteria | | Habitat retention (% of max. habitat) |
|---|---|---|
| 1 | Acutely threatened species<br>e.g. Canterbury mudfish, lowland longjaw galaxias | 100% |
| 2 | Chronically threatened and regionally threatened species<br>e.g. longfin eel, banded kokopu | 95% |
| 3 | Locally or regionally significant brown trout fisheries, plus habitat on which these fisheries depend for spawning and rearing. | 90% |
| 4 | Diverse and abundant native fish communities<br>Includes those with high recreational (e.g., whitebaiting) or cultural/mahinga kai values (e.g., eels). | 85% |
| 5 | Non-diadromous species of native fish | 80% |
| 6 | Sparse and unfished trout populations | 60% |
| 7 | Streams with few fish or aquatic fauna present | 50% |
| 8 | Other fish communities | 70% |

## Revised ecological minimum flow results

Table 2 details the previously reported and newly revised EMF preferred options for minimum flow sites in the northern lowland tributaries of the Waimakariri River. All revised EMF values are calculated from the 7dMALF$^{natural}$, however one anomaly exists. The Cust River contains reaches that dry intermittently and flow for extended periods of time. Because of this, it is difficult to hydrologically model the river and naturalise it’s 7dMALF (i.e. remove anthropogenic effects of water abstraction and leaky water races). As a result, the EMF preference is conservative for the Cust River and calculated from the measured 7dMALF value (Table 2).

**Table 2.** Ecological minimum flow preferred options for the northern lowland tributaries of the Waimakariri River, as revised from Golder Associates (2009) using naturalised 7dMALFs.

| Stream | Site | Current minimum flow (L/s) | Previous assessment | | Revised assessment | | | Justification |
|---|---|---|---|---|---|---|---|---|
| | | | 7dMALF$^{meas.}$ (L/s) | Recommended ecological min flow (L/s) | 7dMALF$^{meas.}$ (L/s) | 7dMALF$^{nat.}$ (L/s) | Preferred ecological min flow option (L/s) | |
| North Brook | Marshes Rd | 530 | 622 | 530 | 598 | 611 | 530-560 | 530 L/s is unchanged from Golder Associates (2009) recommendation based on providing habitat for longfin eel, shortfin eel, brown trout adults and fry, and bully species. 7dMALF$^{nat.}$ less than 7dMALF$^{meas.}$. Assessed previously. 95% habitat provided for longfin eel at a flow of 560 L/s as per "chronically threatened" significance criteria. However, 91% of longfin habitat provided for at 530 L/s. A flow of 545 L/s required to provide 90% habitat for brown trout adults. |
| Middle Brook | Marshes Rd | 60 | 31 | 30 | 28 | 28 | 28 | Retain recommendation of Golder Associates (2009) which recommends a minimum flow set at 7dMALF$^{nat.}$ or a large proportion of it. 7dMALF$^{nat.}$ less than 7dMALF$^{meas.}$. RHYHABSIM modelling results not available due to poor flow versus stage relationship. Middle Brook characterised by shallow water depths limiting available large eel and trout habitat. Does have capacity to support juvenile trout and trout spawning habitat. Further lowering of minimum flow below 7dMALF$^{nat.}$ is not recommended given shallow depths. |
| South Brook | Marshes Rd | 140 | 171 | 120-140 | 178 | 155 | 120-140 | Retain the Golder Associates (2009) recommendation of 120-140 L/s. RHYHABSIM modelling results not available due to poor flow versus stage relationship. Recommendation based on generalised relationship between flow and habitat availability for juvenile trout in Waimakariri tributaries. Existing minimum flow of 140 L/s would retain 97% of juvenile trout habitat. 90% of juvenile trout habitat at 7dMALF$^{nat.}$ would occur at approx. 100 L/s. A flow between 60-100 L/s would retain a minimum depth of 0.15m past shallow riffles and provide for upstream passage and spawning of brown trout. 140 L/s only expected to drop water levels approx. 1 cm from 7dMALF$^{nat.}$ and would retain high amount of available habitat for trout, bullies and eels. |
| Cam River | Young Rd | 1000 | 1022 | 890 | 1021 | 1035 | 890 | 7dMALF$^{nat.}$ is marginally higher than the 7dMALF$^{meas.}$ previously assessed. Retain Golder Associates (2009) recommendation of 890 L/s as it retains approx. 90% of brown trout habitat as available at 7dMALF. WUA curves for most indigenous fish species shows declining or stable habitat availability with increasing flow around 7dMALF$^{nat.}$. This means that a very high proportion of habitat will be retained for indigenous fish at 890 L/s. Main (2001) recommended a flow of 670 L/s would provide adequate upstream passage for spawning salmon. |
| Cust River | Rangiora-Oxford Bridge | 20 | 140 | 120 | 179 | 0 | [a]150 | 7dMALF$^{nat.}$ greater than 7dMALF$^{meas.}$ assessed previously. 150 L/s retains 90% of juvenile trout habitat as available at 7dMALF$^{nat.}$ (based on RHYHABSIM WUA curve). Golder Associates (2009) recommendation of 120 L/s only provides 77% of juvenile trout habitat. Current minimum flow of 20 L/s only provides about 18% of habitat for juvenile trout. Cust River's size and channel shape provides little habitat for larger adult salmonids. Moderate depths also provide poor quality habitat for longfin eel and adult shortfin eel (Golder Associates 2009). 95% habitat availability for longfin eels occurs at 144 L/s as per "chronically threatened" significance criteria. Available shortfin eel habitat changes little with flow. 80% of common bully habitat occurs at approx. 140 L/s, while other native fish species habitat availability changes little or decreases with increasing flow. |
| Cust Main Drain | Threlkelds Rd | 230 | 325 | 230 | 358 | 301 | 230-270 | 7dMALF$^{nat.}$ is slightly lower than the 7dMALF$^{meas.}$ previously assessed. Retain Golder Associates (2009) recommendation of 230 L/s as it retains at least 85% of all native fish species present as available at 7dMALF$^{nat.}$ (based on RHYHABSIM WUA curve). The broad and shallow nature of the Cust Main Drain limits habitat for adult salmonids and eels, but provides good habitat for smaller natives and salmonid spawning. Greater than 90% of juvenile brown trout habitat is retained at a flow of 230 L/s, while approx. 75% and 72% of trout and salmon spawning habitat is retained respectively. Alternatively, a flow of 270 L/s would retain 90% salmon and trout spawning habitat. Golder Associates (2009) suggests that a flow of 280 L/s required for upstream passage of adult brown trout (Main, 2001) could be used as part of an autumn/winter minimum flow if necessary. |
| No. 7 Drain | Main Drain Rd culvert | 60 | 67 | 60 | 66 | 148 | 130 | 7dMALF$^{nat.}$ is much greater than the 7dMALF$^{meas.}$ previously assessed. No. 7 drain is very shallow and narrow providing poor quality habitat for adult salmonids, but provides some habitat for smaller native fish and juvenile salmonids (Golder Associates 2009). RHYHABSIM data is available, but only at flows less than the revised 7dMALF$^{nat.}$ flow. Based on forecasting of the WUA slope (assuming the continuing near-linear |

| Stream | Site | Current minimum flow (L/s) | Previous assessment | | Revised assessment | | | Justification |
|---|---|---|---|---|---|---|---|---|
| | | | 7dMALF$^{meas.}$ (L/s) | Recommended ecological min flow (L/s) | 7dMALF$^{meas.}$ (L/s) | 7dMALF$^{nat.}$ (L/s) | Preferred ecological min flow option (L/s) | |
| | | | | | | | | relationship with flow) 90% of juvenile brown trout habitat as available at 7dMALF$^{nat.}$ occurs at approx. 130 L/s. The existing minimum flow of 60 L/s provides approx. 30% of available juvenile trout habitat. A minimum flow of 130 L/s should provide ample protection for shortfin eels, upland bullies, common bullies, and black flounder, which Golder Associates (2009) notes as the native species recorded in the stream. |
| Kaiapoi River | Neeves Rd | 600 | 1273 | 1000 | 1499 | 1595 | [b]1150 | A combination of good depths, gravel substrate and macrophyte cover provide good habitat and cover for salmonids and native fish (Golder Associates 2009). RHYHABSIM data not available due to poor flow vs stage relationship and 7dMALF$^{nat.}$ greater than 7dMALF$^{meas.}$ previously assessed. Based on generalised flow versus depth relationship, 7dMALF$^{nat.}$ flows of 1595 L/s would provide average depths of slightly over 0.6 m. Existing minimum flow of 600 L/s provides average depths of 0.46 m (Golder Associates 2009). 90% retention of habitat suitability (HIS) at 7dMALF$^{nat.}$ occurs at 1,150 L/s for adult brown trout, and 870 L/s for juvenile brown trout. The existing minimum flow provides 70% HIS for adult brown trout. Given the greater depth requirements of large eels, habitat is likely to follow a pattern of declining habitat availability with declining flow, similar to that of adult brown trout. Therefore, protection of adult brown trout habitat would likely also protect large eel habitat (Golder Associates 2009). Main (2001) indicates that a minimum flow of 900 L/s in the Kaiapoi River is necessary to protect salmon passage. Given the significance of the Kaiapoi River as a salmon fishery and the presence of Silverstream hatchery upstream, protection of salmon passage is considered a high priority. |
| Ohoka Stream | Kaiapoi River confl. | 300 | 526 | 365 | 564 | 662 | 470 | Retain the recommendation of Golder Associates (2009) to raise the minimum flow. Ohoka Stream contains moderate depths and stony bed sediments that provide good instream habitat for juvenile and spawning salmonids, and eels and other native fish species. 7dMALF$^{nat.}$ greater than 7dMALF$^{meas.}$ previously assessed. 90% of juvenile brown trout habitat occurs at 370 L/s, whereas the existing minimum flow of 300 L/s provides 81% of available habitat based on WUA curve. 90% of spawning habitat for salmon and trout occurs at 335 L/s. Main (2001) suggests a minimum flow of 415 L/s to allow passage of spawning salmon past shallow riffles. WUA curves show that available habitat changes little with flow for most native species present (upland and common bully, and shortfin eel), however 95% of longfin eel habitat as at 7dMALF$^{nat.}$ (as per "chronically threatened" criteria) occurs at approx. 470 L/s. The current minimum flow of 300 L/s would retain 85% longfin eel habitat. Golder Associates (2009) recommends a minimum flow consistent with retaining salmonid spawning habitat and most native fish habitat. Consistent with this recommendation, this memo suggests a flow of 470 L/s to retain longfin eel habitat as per "chronically threatened" criteria (95% available habitat at 7dMALF$^{nat.}$). An alternative flow of 370 L/s would protect salmonid spawning and achieve 90% availability of longfin eel habitat. |
| Griegs Drain | Griegs Drain Rd | 150 | 302 | 230 | 260 | 278 | 230 | Retain 230 L/s recommendation of Golder Associates (2009). Grieg's Drain is deep and narrow with high macrophyte cover and silty bed sediments. There is little habitat diversity with slow runs dominating. Good depths and cover provide good habitat for juvenile and adult brown trout, and large eels. Lack of swift and stony habitat means there is little spawning habitat. 7dMALF$^{nat.}$ is less than 7dMALF$^{meas.}$ previously assessed. Based on WUA curves, 90% of available habitat for juvenile and adult brown trout occurs at 230 L/s and 215 L/s respectively. The current minimum flow of 150 L/s provides 75% habitat for juvenile trout, and 81% for adults. Main (2001) suggests a minimum flow of 195 L/s to allow upstream passage of adult brown trout. Available eel habitat changes little with increasing flow due to the streams narrow channel and depth. This is the same for other native species. Therefore, a flow for protecting salmonids will also protect native fish species. |
| Courtenay Stream | Opposite Ashley Meats Ltd. | 260 | 393 | 350 | 335 | 360 | [b]330 | 7dMALF$^{nat.}$ is less than 7dMALF$^{meas.}$ previously assessed. Courtenay Stream is narrow and deep, with high macrophyte cover and a predominantly silty bed. Based on RHYHABSIM data and WUA curves in Golder Associates (2009), 90% retention of available juvenile brown trout occurs at 215 L/s. 90% of available habitat for adult brown trout occurs at 310 L/s. Good habitat is provided for eel species in Courtenay Stream. 95% available longfin eel habitat (as per "chronically threatened" criteria) occurs at a flow of 330 L/s. The current minimum flow of 260 L/s provides lower protection for |

| Stream | Site | Current minimum flow (L/s) | Previous assessment | | Revised assessment | | | Justification |
|---|---|---|---|---|---|---|---|---|
| | | | 7dMALF[meas.] (L/s) | Recommended ecological min flow (L/s) | 7dMALF[meas.] (L/s) | 7dMALF[nat.] (L/s) | Preferred ecological min flow option (L/s) | |
| | | | | | | | | longfin eels by only providing 83% available habitat. 85% shortfin eel habitat is provided for at the current minimum flow. Most other native species habitat availability changes little with increasing flow. This memo suggests a minimum flow of 330 L/s to protect eel species, other native fish, and juvenile and adult brown trout. |

[a] The Cust River contains reaches that dry intermittently and flow for extended periods of time. Because of this, it is difficult to hydrologically model the river and naturalise it's 7dMALF (i.e. remove anthropogenic effects of water abstraction and leaky water races). As a result, the EMF preference is conservative for the Cust River and calculated from the measured 7dMALF value.

[b] The extent of saltwater intrusion in the tidal reaches of the Kaiapoi River and Courtenay Stream is somewhat flow dependent. Decisions on environmental flow setting needs to acknowledge low flow and saltwater intrusion effects on stream ecology. Ecological minimum flow assessments, as detailed in this memo, accounts for effect of low flows on habitat availability excluding the influence of saltwater intrusion.

## Allocation limit options for protecting instream values

The draft proposed NES (MfE, 2008) suggests a default allocation limit of 30 percent of 7dMALF$^{natural}$ for streams and rivers with a mean flow less than 5 $m^3/s$. This is applicable to all northern lowland tributaries of the Waimakariri River (Megaughin and Hayward, 2016). In the absence of better information, this memo uses the MfE (2008) guidelines to set out the preferred allocation limits for northern Waimakariri tributaries as set out in Table 3 below.

**Table 3.** Ecological allocation preferences for the northern lowland tributaries of the Waimakariri River.

| Stream | 7dMALF$^{natural}$ (L/s) | Current allocation limit (L/s) | Preferred allocation limit (L/s) | Justification |
|---|---|---|---|---|
| North Brook | 611 | 200 | 183 | Draft NES default value of 30% of 7dMALF$^{nat.}$ for streams with mean flows less than 5 $m^3/s$. |
| Middle Brook | 28 | 30 | 8 | |
| South Brook | 155 | 100 | 47 | |
| Cam River | 1035 | 700 | 311 | |
| Cust River | 0 | 290 | 0 | |
| Cust Main Drain | 301 | 690 | 90 | |
| No. 7 Drain | 148 | 130 | 44 | |
| Kaiapoi River | 1595 | 1000 | 479 | |
| Ohoka Stream | 662 | 500 | 199 | |
| Griegs Drain | 278 | 70 | 83 | |
| Courtenay Stream | 360 | 140 | 108 | |

## Other waterways

Not all waterbodies in the WWZ are well monitored and some have very poor hydrological datasets. Therefore, it is difficult to quantify EMF or allocation preferences. The following section characterises those key waterbodies in the zone that have high values and are affected to some extent by water abstraction, but do not had ecological flow regimes quantified.

### *Upper Eyre River SWAZ catchment and View Hill Stream*

The upper Eyre River drains the majority of the foothill area to the west of the Eyre plains. The upper catchments of this surface water allocation zone (SWAZ) (Coopers Creek, Mounseys Stream, Washpen Creek) are comprised of broad networks of small gravel streams and remnants of extensive wetlands and spring systems. Most of the time flows from the upper Eyre River catchment are lost into the plains gravels. These flows form part of the water balance of the Eyre groundwater allocation zone (GAZ).

Water quality monitoring is not currently undertaken for the upper Eyre River tributaries, but data collected between 2009-2011 in Coopers Creek indicates that water quality was, and probably still is, good. Streams contain high dissolved oxygen levels and low nutrients, faecal contaminants and sediment. Washpen Creek is particularly valued due to its populations of critically endangered Canterbury mudfish. Coopers Creek is also likely to support mudfish habitat, while both creeks support a variety of other native invertebrate and fish species. Native bush dominates the upper to middle reaches of each catchment and supports recreation and amenity values associated with walking and swimming. It is important that decisions around water allocation affecting surface flows in these streams allows for the protection of ecological, cultural, recreational and amenity values.

### *Eyre River SWAZ*

The Eyre River is generally dry but can sometimes flow the length of the plains, particularly in winter after high or sustained rainfall. With the exception of the upper reaches, View Hill Stream (which is part of the Eyre River SWAZ) is also generally dry. High rainfall and flow events are important for providing opportunities for the recruitment of fish (particularly native fish like eels) into the perennial headwater streams and wetlands (e.g. Washpen Creek, Mounseys Stream and Coopers Creek). The Eyre River was historically a tributary of the North Branch of the Waimakariri River (now the Silverstream / Kaiapoi River), but to address flooding issues it was diverted in a straight cut directly to the Waimakariri River.

### *Coastal Streams SWAZ*

Kairaki Creek and McIntosh Drain flow into the lower Waimakariri River. Their waters are tidal, but saltwater intrusion and water level fluctuations are controlled to some extent by tide gates in the lower reaches. Extensive wetland habitat dominates each catchment and stream flows are sluggish. Water quality and ecological data is extremely limited for both streams, however the information that does exist indicates relatively good water quality with low-to-moderate phosphorus and low nitrogen levels. Each stream contains extensive ecological, cultural, recreational and amenity values. Both contain potential whitebait spawning areas and are likely to support diverse coastal fish and bird populations (although tide gates act as barriers to fish passage). Kairaki Creek is extensively fished by whitebaiters, and its connection to Tūtaepatu Lagoon likely offers it immense cultural value.

Small water takes do exist for each stream, but it is impractical to set a minimum flow for either stream due to their tidal nature and fluctuating water levels. Despite this, an allocation limit should be set to protect their significant value. An adequate allocation limit for each waterway will ensure that stream and "wetland" protection is maintained and that waters do not dry or stagnate. Ample water movement is also important to ensure proper tide gate function, which is important for flushing and fish passage. No data exists to quantify what allocation limits should be, so this memo merely suggests that a mechanism should be in place to control water abstraction.

## Ecological effect of groundwater use scenarios

The memo entitled '*Groundwater allocation modelling results for northern Waimakariri tributaries catchment'* examines changes in stream flow resulting from different groundwater use scenarios. These scenarios are as follows:

- Good management practise (GMP):
  - irrigation efficiency increases by 20%.
- Full abstraction (**full_abs**):
  - all consented wells use 100% of consented volume (excludes permitted activity wells).
- Full abstraction and full allocation (**full_abs_allo**):
  - all consented wells use 100% of consented volume in Groundwater Allocation Zones (GAZs) (except in Loburn and Lees Valley) and groundwater is fully allocated up to current Land and Water Regional Plan (LWRP) limits.
- Full allocation and current usage (**full_allo_cur_use**):
  - groundwater is fully allocated up to current LWRP limits, but assumes consent holders use the same percentage of water as currently used (55% based on metering data).

Under each scenario, a change in mean stream flow is modelled for each of the northern lowland tributaries of the Waimakariri River (

Table 4). Flow reductions greater than or equal to 10 percent are deemed to be significant, whereas flow reductions less than 10 percent are within the groundwater model margin of error. For this memo, all stream reductions less than 10 percent are considered negligible and are therefore not assessed for their impact to instream values. All percentage reductions displayed in Table 4 are assumed to apply to all flow types including low flows (e.g., 7dMALF), which are when stream communities are typically under the greatest amount of environmental stress.

Table 5 summarises the low flow (7dMALF value) estimation for streams with significant modelled flow reductions (≥ 10%) under each groundwater use scenario. The following sections highlight the impact to ecological, cultural, recreational and amenity values likely to result from modelled low flow reductions.

**Table 4.** Modelled changes in stream flows as a result of different groundwater use scenarios (adapted from memo entitled '*Groundwater allocation modelling results for northern Waimakariri tributaries*'). Red highlights significant flow decreases.

| Scenario name | Stream | [a]Median flow decline |
|---|---|---|
| GMP | Cam River at Youngs Rd | 1% |
| | CourtenayStream at Neeves Rd | 0% |
| | Greigs Drain | 0% |
| | Northbrook at Marsh Rd | 0% |
| | Ohoka Stream at Island Rd | 0% |
| | Silverstream at Island Rd | 0% |
| | Southbrook at Marsh Rd | 1% |
| | **Cust River at Oxford** | **16%** |
| | **Cust Main Drain at Threlkelds Rd** | **12%** |
| | No. 7 Drain | 1% |
| full_abs | Cam River at Youngs Rd | 4% |
| | CourtenayStream at Neeves Rd | 4% |
| | Greigs Drain | 3% |
| | Northbrook at Marsh Rd | 3% |
| | **Ohoka Stream at Island Rd** | **17%** |
| | Silverstream at Island Rd | 5% |
| | Southbrook at Marsh Rd | 8% |
| | **Cust River at Oxford** | **11%** |
| | **Cust Main Drain at Threlkelds Rd** | **16%** |
| | No. 7 Drain | 5% |
| full_abs_allo | **Cam River at Youngs Rd** | **10%** |
| | CourtenayStream at Neeves Rd | 6% |
| | Greigs Drain | 5% |
| | Northbrook at Marsh Rd | 8% |
| | **Ohoka Stream at Island Rd** | **30%** |
| | Silverstream at Island Rd | 7% |
| | **Southbrook at Marsh Rd** | **21%** |
| | **Cust River at Oxford** | **27%** |
| | **Cust Main Drain at Threlkelds Rd** | **54%** |
| | **No. 7 Drain** | **14%** |
| full_allo_cur_use | Cam River at Youngs Rd | 3% |
| | CourtenayStream at Neeves Rd | 1% |
| | Greigs Drain | 1% |
| | Northbrook at Marsh Rd | 2% |
| | **Ohoka Stream at Island Rd** | **11%** |
| | Silverstream at Island Rd | 1% |
| | Southbrook at Marsh Rd | 6% |
| | **Cust River at Oxford** | **11%** |
| | **Cust Main Drain at Threlkelds Rd** | **23%** |
| | No. 7 Drain | 5% |

[a] An assumption is made that the modelled percentage decline in mean flow is proportional to the decrease in all flow types (e.g., median and low flows) at each stream under each scenario.

**Table 5.** Effect of groundwater use scenarios and modelled flow reductions on low flow values in significantly affected (≥ 10% change in flow) northern lowland tributaries of the Waimakariri River. Values in bold represent scenarios below ecological minimum flow preferences.

| Stream | Current 7dMALF$^{meas.}$ (L/s) | Ecological minimum flow (L/s) | Scenario name | Predicted 7dMALF (L/s) |
|---|---|---|---|---|
| South Brook at Marsh Rd | 178 | 120-140 | Full_abs_allo | 141 |
| Cam River at Youngs Rd | 1021 | 890 | Full_abs_allo | 919 |
| Cust River at Oxford | 179 | 150 | GMP<br>Full_abs<br>**Full_abs_allo**<br>Full_allo_cur_use | 150<br>159<br>**131**<br>159 |
| Cust Main Drain at Threlkelds Rd | 358 | 230 | GMP<br>Full_abs<br>**Full_abs_allo**<br>Full_allo_cur_use | 315<br>301<br>**165**<br>276 |
| No. 7 Drain | 66 | 130 | **Full_abs_allo** | **57** |
| Ohoka Stream at Island Rd | 564 | 470 | **Full_abs**<br>**Full_abs_allo**<br>Full_allo_cur_use | **468**<br>**395**<br>502 |

The following sections detail the effect of groundwater use scenarios on instream habitat and water quality at sites with significant flow reductions (Table 5). It also explains briefly how these may impact other stream values.

***South Brook***

Full groundwater abstraction and allocation (full_abs_allo) would significantly reduce stream flows in the South Brook (

Table 5). Despite this, a modelled 7dMALF of 141 L/s would be greater than the preferred EMF of 140 L/s. Therefore, a good level of brown trout rearing and spawning habitat would be maintained as well as passage for spawning salmonids. Golder Associates (2009) notes that a flow above 140 L/s would also maintain habitat for the indigenous fish species present in the South Brook, such as longfin and shortfin eel, and upland bully. Te Ngāi Tūāhuriri and Tipa & Associates (2016) recommends a whanau flow preference of 170 L/s, which would not be met during low flow periods under a scenario of full groundwater abstraction and allocation. This may have significant cultural outcomes as the South Brook is a major tributary of the Cam River, which is part of a significant cultural landscape.

Any decrease in stream flows will likely have outcomes for water quality in the South Brook. The stream currently suffers from degraded habitat in the form of excess deposited sediment, excess nutrients, and prolific instream plant growth. Decreased flows instream will potentially reduce the capacity for sediment and nutrients to flush downstream, increase water temperatures, deplete dissolved oxygen levels in water, and decrease the dilution of nutrients and other contaminants (e.g. *E. coli*). Little impact on recreational values would be expected as sports fish habitat would continue to be supported and the stream is not well-used for swimming or other water sports. The amenity value of the South Brook is considered to be very high (Appendix 1) but may be affected by shifts in water and habitat quality, which affects stream appearance, odour etc.

***Cam River***

Cam River flows would change significantly under a scenario of full groundwater abstraction and allocation (full_abs_allo) (

Table 5). The Cam River catchment has high ecological values due to its high diversity of indigenous fish species, and is regarded as part of a significant cultural landscape (Appendix 1). However, the Cam River generally consists of a deep and wide channel and therefore available habitat for indigenous fish (e.g., longfin and shortfin eel, common bully, black flounder, inanga and yelloweye mullet) and brown trout would be minimally impacted. Flows under a scenario of full groundwater abstraction and allocation would not be sufficient to meet the whanau minimum flow recommendation of 1200 L/s (Te Ngāi Tūāhuriri and Tipa & Associates, 2016).

Like that of many spring-fed lowland streams in the WWZ, the Cam River contains degraded water and habitat quality. Any reductions in flow provisions to the river will affect its capacity to support healthy instream communities (see reasons for South Brook above). The Cam River catchment is particularly special as it contains remnant populations of koura (freshwater crayfish) and kakahi (freshwater mussels). Recreational and urban amenity values are considered high (Appendix 1) and require sufficient flows to ensure adequate protection.

***Cust River and Cust Main Drain***

The Cust River catchment has two distinct hydrological parts. Cust River, a natural waterway, drains a small area of foothill slopes around Mt Oxford, and the agricultural lands along its banks. The river has low baseflows, which are interspersed by high flows from the hill-catchment. Because of the free-draining gravels over which the river flows, it often goes dry in sections. The water lost from the river recharges groundwater, which in turn contributes to flow in the spring-fed streams near the coast. The lower part of the Cust River catchment is the Cust Main Drain. The upper Cust River used to flow into a swamp and had no outlet to the sea. Around the turn of last the century, the swamp area to the west of Rangiora was deemed necessary for farming and so the Cust Main Drain and its herringbone laterals were dug to drain the swamp. Cust Main Drain therefore has a high baseflow with most of this water coming from groundwater.

Changes to groundwater use will affect the occurrence of lower flows in the Cust River (Table 4) and may increase the incidence of dry reaches. Higher flows are unlikely to be significantly affected in this part of the catchment. By contrast, Cust Main Drain baseflows are more sensitive to changes to groundwater levels (Table 4) and these changes will be increasingly detrimental to water quality, habitat quality and fish passage in the river.

It is difficult to hydrologically model the Cust River and therefore naturalise it's 7dMALF (i.e. remove anthropogenic effects of water abstraction and leaky water races). As a result, the EMF preference for the Cust River is 150 L/s, as calculated from the measured 7dMALF value (not the naturalised 7dMALF as is typical for such calculations) (see Table 2). The full abstraction and full allocation (full_abs_allo) scenario would reduce summer low flows in the Cust River below the EMF to 131 L/s (

Table 5). Although the Cust River's size and shape provides limited habitat for adult salmonids or large eels, it does support juvenile trout and smaller indigenous fish such as bullies and smaller eels. A flow of 131 L/s would reduce the available juvenile trout habitat to 80 percent of what it would be at 7dMALF, while only a minimal change in habitat availability would be expected for smaller native fish species. Full groundwater abstraction and allocation (as well as other groundwater use scenarios) would increase drying extent and time in the Cust River and therefore increase the prevention of migratory fish passage.

Despite its modified nature, the Cust Main Drain is considered to have very high ecological values (Appendix 1) with the most diverse record of fish species for any of the northern Waimakariri tributaries in the zone. A shift to full groundwater abstraction and allocation would result in a 7dMALF of 165 L/s (Table 5). This would have a large impact on resident fish populations. Brown trout and salmon spawning habitat would likely halve, while smaller natives (such as bullies and smaller eels) would experience approximately 25-30% reductions in available habitat (based on WUA curves in Golder Associates (2009)). Large salmonid and adult eel habitat is generally limited due to the river's shallow nature, but passage for these larger individuals would be inhibited by flow reductions.

The Cust Main Drain was originally dug as a separate system from the upper Cust River. During a large flood the Cust River broke through into the No1 Drain (a lateral for Cust Main Drain) and connected the two systems. This means that Cust Main Drain now receives fresh and flood flows from Cust River. Freshes and floods are important for maintaining bed turnover and flushing the river, however it is unlikely that changes in groundwater use will have any significant impact on the high flows in Cust Main Drain.

***No. 7 Drain***

Full groundwater abstraction and allocation (full_abs_allo) would result in a 30 percent reduction in flows in No. 7 Drain (Table 4). As a result, the 7dMALF would be expected to drop to 57 L/s, well below the EMF preference of 130 L/s (Table 5). No. 7 Drain's shallow and narrow channel provides poor habitat for larger fish, but does support juvenile salmonids and smaller native fish. Low flow conditions under a scenario of full abstraction and allocation would greater than halve the amount of juvenile brown trout and salmonid spawning habitat available. Available shortfin eel habitat would reduce by approximately 25 percent, while common bully habitat availability would decrease by up to 40 percent (based on WUA curves in Golder Associates (2009)). Other native species recorded in No. 7 Drain (upland bully and black flounder) would likely experience minimal reductions in habitat availability.

No. 7 Drain has limited value in terms of recreation and amenity, but a significant flow reduction would adversely impact mahinga kai and taonga values as well as the flow in spring heads, which are tapu to iwi (Appendix 1). The stream already suffers poor habitat quality due primarily to excessive bed sediment, however further reductions in stream flow would exacerbate such habitat and water quality issues by reducing flushing and dilution.

***Ohoka Stream***

A scenario of full groundwater abstraction (full_abs) would reduce summer low flows to approximately the same level as the EMF preference (Table 5). This would provide ample habitat protection for instream fauna, including longfin and shortfin eels, bullies and trout. In contrast, full groundwater abstraction and full allocation (full_abs_allo) would reduce 7dMALF to only 395 L/s, below the EMF of 470 L/s. Under this scenario, juvenile brown trout and salmonid spawning habitat would still receive good protection with greater than 90 percent habitat availability. However, adult brown trout habitat would decrease by approximately 40 percent (compared to that available at naturalised 7dMALF). Low flows would not sustain salmon passage, which Main (2001) suggests requires a flow of at least 415 L/s to maintain.

Indigenous fish habitat availability changes little with changing flow, but habitat quality (not quantity) and water quality effects are likely to result from reductions in stream flow. In particular, the stream would have a reduced capacity to flush contaminants including nutrients and sediment. Both excess nutrients and deposited sediment are currently issues in Ohoka Stream. Habitat and water quality effects will have a detrimental outcome for the cultural, recreational and amenity values of the river. The river supports mahinga kai and taonga species, its springheads are tapu, fly fisherman commonly use its waters, and amenity values are considered high due to the proximity of local properties and areas of esplanade (Appendix 1).



## References

Golder Associates, 2000. Minimum flows and aquatic values of lower Waimakariri River tributaries. Technical report no. 07813138 prepared for Environment Canterbury.

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Ministry for the Environment (MfE), 2008. Proposed National Environmental Standard on ecological flows and water levels: discussion document. Report no. ME 868 published by Ministry for the Environment, Wellington.

Te Ngāi Tūāhuriri and Tipa & Associates (2016). Cultural health assessments and water management for the Rakahuri – Waimakariri Zone. Draft report supplied to Environment Canterbury.

## Appendix 1

Summary of preliminary ecological, cultural, recreational and amenity value assessment results for the northern lowland tributaries of the Waimakariri River. Values have been established based on an evaluation of community feedback, current state and trend data, the Cultural Opportunity Mapping Assessment and Response (COMAR) report (Te Ngāi Tūāhuriri and Tipa & Associates, 2016), technical reports, and anecdotal evidence. **These are preliminary findings only and intended solely for the purpose to aid WWZ Committee environmental flow setting discussions. They need to be revised and agreed upon, particularly by iwi representatives.**

| Stream | Value | | | | Justification |
|---|---|---|---|---|---|
| | Ecological | Cultural | Recreation | Amenity | |
| North Brook | High | Very high | Moderate | Very high | Part of highly valued Cam River catchment. Significant flow contribution (largest of the three brooks). Degraded habitat state with excessive sedimentation (but still some areas where deposited sediment is minimal) and aquatic plant growth. However, extensive ecological values including presence of indigenous bankside vegetation and fish populations (e.g. threatened longfin eel and koura). Part of significant cultural landscape. Presence of mahinga kai and taonga species including eels and bullies. Waipuna (springs) are tapu. Limited recreation values, but does support brown trout juveniles and adults. High amenity values as spring arises in, and stream passes through, Rangiora township. North Brook waters have significant recreation and heritage values. |
| Middle Brook | High | Very high | Moderate | Moderate | Contributes to overall health of Cam River catchment. Degraded habitat state with excessive sedimentation, however a range of indigenous fish populations present including threatened longfin eel populations. Part of significant cultural landscape. Presence of mahinga kai and taonga species including eels and bullies. Waipuna (springs) are tapu. Limited recreation values, but likely supports juvenile trout and potentially trout spawning habitat. Urban amenity values associated with Rangiora township such as Matawai Park. |
| South Brook | High | Very high | Moderate | Very high | Large tributary of the highly valued and culturally significant Cam River contributing to its water quality and habitat state. Receiving environment for Rangiora stormwater ponds and degraded habitat state with excessive sedimentation, but extensive areas where bed sediment is minimal and gravels dominate. Indigenous bankside vegetation and replanting. Presence of indigenous fish communities including threatened longfin eel. Part of significant cultural landscape. Mahinga kai gathering site (e.g., watercress) and |

| Stream | Value | | | | Justification |
|---|---|---|---|---|---|
| | Ecological | Cultural | Recreation | Amenity | |
| | | | | | presence of taonga species including eels and bullies. Waipuna (springs) are tapu. Limited recreation values but supports juvenile trout and potentially trout spawning habitat. Urban amenity values associated with south end of Rangiora township. |
| Cam River | High | Very high | High | High | Tidal river in the lower reaches. Degraded habitat state and excessive sedimentation, and extensive channel straightening and modification in the tributary Tuahiwi Stream. However, presence of diverse indigenous fish community including inanga and threatened longfin eel. Historic records of Canterbury mudfish (1946) and more recently Giant kokopu (1994). Regarded as part of a significant cultural landscape to Te Ngāi Tūāhuriri. Presence of mahinga kai and taonga species including eels, flounder, mullet and common bully. Contains koura, kakahi and shrimp. Waipuna (springs) are tapu. Recreationally important for trout fishing, whitebaiting, kayaking and boating. “Priority river” for esplanade under Waimakariri District Plan. Extensive efforts currently invested into rehabilitating ecological values. |
| Cust River | High | High | High | Moderate | Intermittently flowing in some reaches but good opportunities for fish passage in higher connected flows. Good cobble and gravel habitat for invertebrate and fish species. Highly diverse and abundant aquatic communities in lower ‘Cust Main Drain’ reaches. Recorded indigenous fish species above Cust Main Drain include upland bully, and longfin and shortfin eels. Hill-fed headwater tributaries provide good native fish habitat, including that potentially supporting Canterbury mudfish (nationally critical). Supports a mahinga kai and taonga species including eels and bullies. Waipuna (springs) are tapu. Seasonal brown trout fishery although flows and channel morphology generally more suited to support juvenile trout. Locally important areas for swimming. “Priority river” for esplanade under Waimakariri District Plan. |
| Cust Main Drain | Very high | High | High | High | A permanently flowing, modified reach of the lower Cust River. Good cobble and gravel habitat for invertebrate and fish species. Highly diverse fish communities with at least 16 species recorded. Threatened fish species recorded include longfin eel, redfin bully, torrentfish, inanga (all ‘at risk – declining’) and lamprey (nationally vulnerable). Supports a large variety of mahinga kai and taonga species including flounder, koura, kakahi, mullet, eels and bullies. Waipuna (springs) are tapu. Important recreationally for trout fishing, whitebaiting, walking and other activities. Generous grassed areas present on either side |

| Stream | Value | | | | Justification |
|---|---|---|---|---|---|
| | Ecological | Cultural | Recreation | Amenity | |
| | | | | | and beside these shingle roads with low traffic volumes. These areas are popular with walking groups and for people to exercise their dogs. |
| No. 7 Drain | Moderate | Moderate | Low | Low | Modified waterways acting as agricultural drains, and stormwater ponds and network. Contributes flow to highly valued Cust Main Drain. Poor habitat quality with excessive bed sediment, and incised and straightened channels. Provides habitat for smaller fish including shortfin eel, juvenile brown trout, upland and common bullies, and black flounder. Supports limited mahinga kai and taonga species such as shortfin eel, bullies and flounder. Drains areas of historic wetland (upper reaches were historically part of culturally significant Cam River catchment) and flows stem from waipuna (springs) which are tapu. Little recreational value but supports juvenile trout. Amenity value limited to that for adjacent landowners. |
| Kaiapoi River | High | Very high | High | Very high | Extent of waterway includes both the tidal Kaiapoi River in the lower reach and Silverstream in the middle and upper reaches. Degraded water quality and habitat in most areas with excessive sediment, instream plant and algal growth, nutrients and faecal contamination. Some areas of Silverstream with higher quality gravel substrates suitable for trout and salmon spawning. Inanga spawning habitat in the tidal reaches of the Kaiapoi River. Supports indigenous fish species including longfin (at risk – declining) and shortfin eels; giant, common and upland bullies; black flounder and common smelt. Presence of kakahi population. Presence of Silverstream salmon hatchery. Recognised by iwi as culturally significant. Supports a variety of mahinga kai and taonga fish and bird (e.g., gulls and terns) species. The Kaiapoi River was historically a popular mahinga kai gathering site and was used as a navigation channel. Presence of waipuna (springs) which are tapu. River used extensively for fishing (trout and salmon), dragon boat racing and waka ama paddling, rowing and walking. Very popular and productive whitebait fishery. Urban amenity values include those associated with Kaiapoi township, Silverstream Reserve, stream plantings and restorative work, and lifestyle blocks. |
| Ohoka Stream | Moderate | Moderate | Moderate | High | Contribution of significant flow to the highly valued Kaiapoi River. Heavily modified in upper reaches with extensive straightening. Degraded water and habitat quality with excessive bed sediment, instream plant growth, nutrients and faecal contaminants. However, deep habitat supports longfin and shortfin eel, and trout populations, while |

| Stream | Value | | | | Justification |
|---|---|---|---|---|---|
| | Ecological | Cultural | Recreation | Amenity | |
| | | | | | some gravel bedded areas support small native bullies. Potential inanga spawning in very lowest reaches. Supports limited mahinga kai and taonga species including eels and bullies. Drains historic wetlands and flows stem from waipuna (springs) which are tapu. A variety of recreational uses including fly fishing and walking. Ohoka Reserve on south side of ‘middle branch’. Esplanade reserve and walkway present on north bank of north branch. Other local amenity values including those associated with community planting efforts. |
| Griegs Drain | Moderate | Moderate | Low | Low | Small, channelised waterway used primarily for agricultural drainage. Poor benthic habitat quality with excessive bed sediment and instream plant growth. Supports good depths and cover for adult and juvenile trout, and large eels. Fish passage issues at motorway culvert. Supports limited mahinga kai and taonga species such as shortfin eel. Flows stem from waipuna (springs) which are tapu. Little recreational value and amenity value limited to that for adjacent landowners. |
| Courtenay Stream | Moderate | Very high | High | High | Contains numerous water and habitat quality issues including excessive and anoxic bed sediment, imponding, barriers to fish passage (e.g., tide gate), and stormwater discharges. However, does contain a short swift flowing reach with gravel beds. Supports habitat for inanga spawning, and depth provides good habitat for trout and eel species. Significant cultural landscape area that includes Kaikanui Pā. Kaikanui is an old Ngāi Tahu kainga nohoanga (established village area of occupation) and traditionally an outpost of Kaiapoi Pā. Courtenay Stream was an important mahinga kai area (Te Whakatau Kaupapa) although it currently supports limited mahinga kai or taonga species. Waipuna (springs) are tapu. Recreationally valued for trout fishing, coarse fishing in Courtenay Lakes, kayaking, walking and model boat sailing. Urban amenity values associated with proximity to Kaiapoi township, and potential to improve currently degraded state. |