11TH IAG
INTERNATIONAL
CONFERENCE ON
GEOMORPHOLOGY

FIELDTRIP GUIDE

RIVER GEOMORPHOLOGY AND MANAGEMENT IN A CANTERBURY BRAIDED RIVER: A TOUR OF THE WAIMAKARIRI CATCHMENT

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River geomorphology and management in a Canterbury braided river: A tour of the Waimakariri catchment

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This fieldtrip travels from Christchurch and tours through the Waimakariri catchment.

Figure 1 provides an overview of the sites we will visit followed by a schedule. Locations on this map are noted in bold in the text.

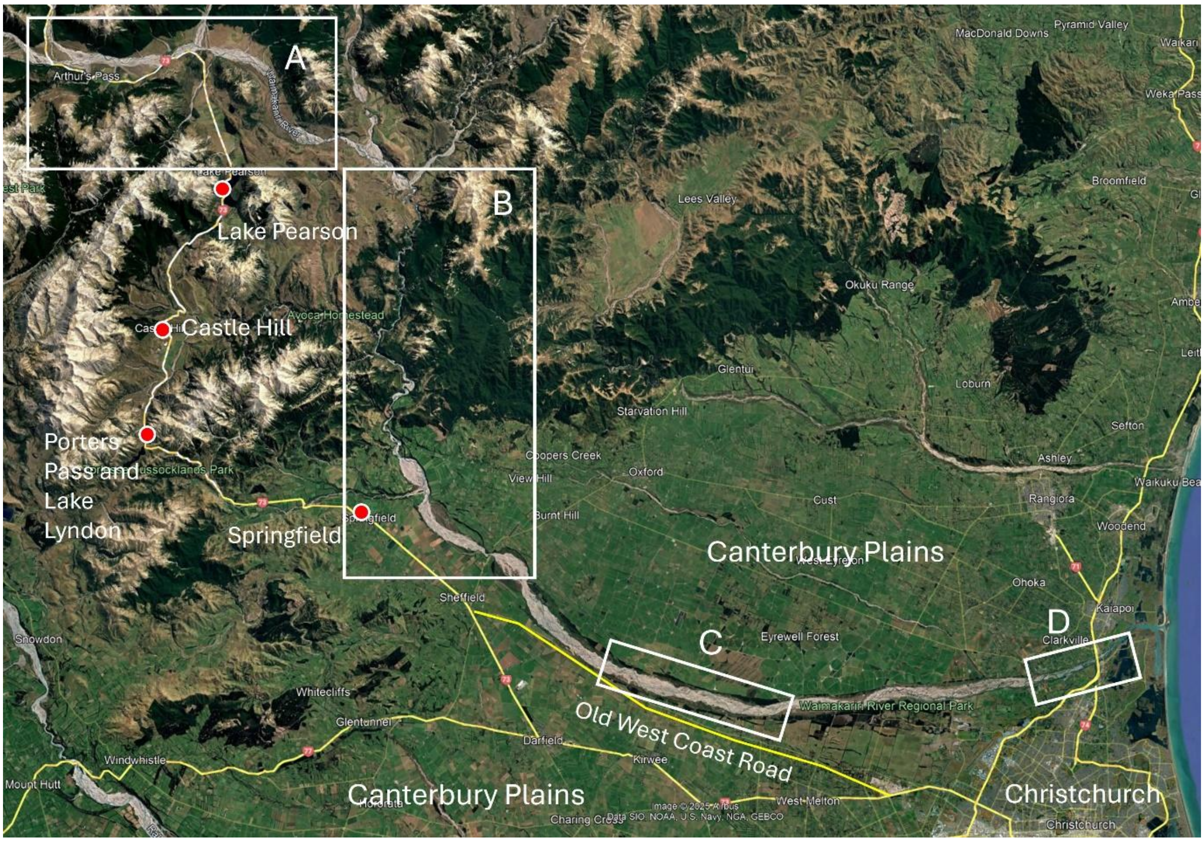

Figure 1. Field trip route overview (see following figures for key stops). See Figure 5 for A, Figure 10 for B, Figure 13 for C and Figure 22 for D.

Schedule

Time	Location	Speaker
9am	**Depart Te Pae, Christchurch**	
	Drive across Canterbury Plains via Old West Coast Road to Springfield (1 hr drive)	
10am	**Springfield (15 min toilet stop)**	
	Drive Springfield (via Porters Pass, Castle Hill, Lake Pearson) to Bealey Bridge (1 hr drive)	
11.15am	**Location A - Bealey Bridge (45 min)**	
	Braided river morphodynamics and ecology (15 min talk)	Jo Hoyle
	Wander in the river (30 mins)	
12.00pm	Depart – drive to Springfield (1 hr drive)	
1.00pm	**Springfield (15 min toilet stop)**	
	Drive to Waimakariri Gorge Bridge (15 min drive)	
1.30pm	**Location B - Gorge Bridge (30 mins)**	
	Braided river confinement – terraces, weeds, agricultural encroachment (15 min talk)	Jo Hoyle
	Flood prediction and hydrology (15 min talk)	Shaun McCracken
2.00pm	Depart – Drive to Haul Road (45 min drive)	
2.45pm	**Location C - Haul Road/Crossbank (45 min)**	
	Gravel extraction (15 min talk)	Richard Measures
	Flood management infrastructure (15 min talk)	Fred Brooks
	GW-SW connections and water quality (15 min talk)	Mohammad Arar
3.30pm	Depart – drive to Regional Park (30 min drive)	
4.00pm	**Location D - Regional Park, Kainga (30 min)**	
	Single thread - Gravel-sand transition zone, regional park values (30 min talk)	Karen Elliott and Shaun McCracken
4.00pm	Depart – drive to Te Pae (30 min drive)	
5.00pm	**Arrive Te Pae**	

1.1 Introduction to the Waimakariri

The Waimakariri is one of the largest rivers in North Canterbury. It flows in a generally south-easterly direction from Kā Tiritiri-o-te-moana (the Southern Alps). The name refers to the cold (makariri) mountain-fed water (wai). Not only has the river been a source of nourishment for local Māori (Ngāi Tūāhuriri), it is also a river which is referred to by Ngāi Tūāhuriri in identifying themselves. The river itself was a traditional travel route to Te Tai Poutini (the West Coast), and it was also frequently used to access the rich mahinga kai lakes (food sources) of the Canterbury high country. Originally an unconstrained braided river that divided into two main channels forming a number of islands in the lower reaches, the river flowed into an estuary that ran parallel to the sea before discharging into the ocean, south of the present-day mouth. The straightening of the lower reaches of the river in the early 20th century resulted in a much stronger flow, which formed the current river mouth (https://kahurumanu.co.nz/atlas).

1.2 Points of interest as we drive to our first stop

1.2.1 Canterbury Plains

We start by driving across the Canterbury Plains. Christchurch is underlain by marine and coastal sediments of Holocene age (Christchurch Formation) on its eastern side, while the west side of the city is built on gravels belonging to the Springston Formation (Figure 2). This is an interglacial gravel formation tied to the current profile/elevation of the Waimakariri River (Suggate, 1963).

We will travel up the **Old West Coast Road**. This road runs close to the modern Waimakariri River on a Holocene terrace surface. We will see source bordering dunes on the right hand side of the road between West Melton and Kirwee. These dunes are derived from the Waimakariri floodplains and are tied to lower terraces. They are undated but are believed to be Holocene in age. In the present day the large flat area formed by the Waimakariri and other braided rivers (including notably the Rakaia and Waitaki to the south) is one of the most intensive agricultural production areas in the country. In the last two decades the introduction of irrigation has catalysed a shift in Canterbury Plains agriculture from grains (e.g., wheat) to high intensity livestock grazing, particularly for dairy production.

We will have a brief toilet stop in **Springfield**.

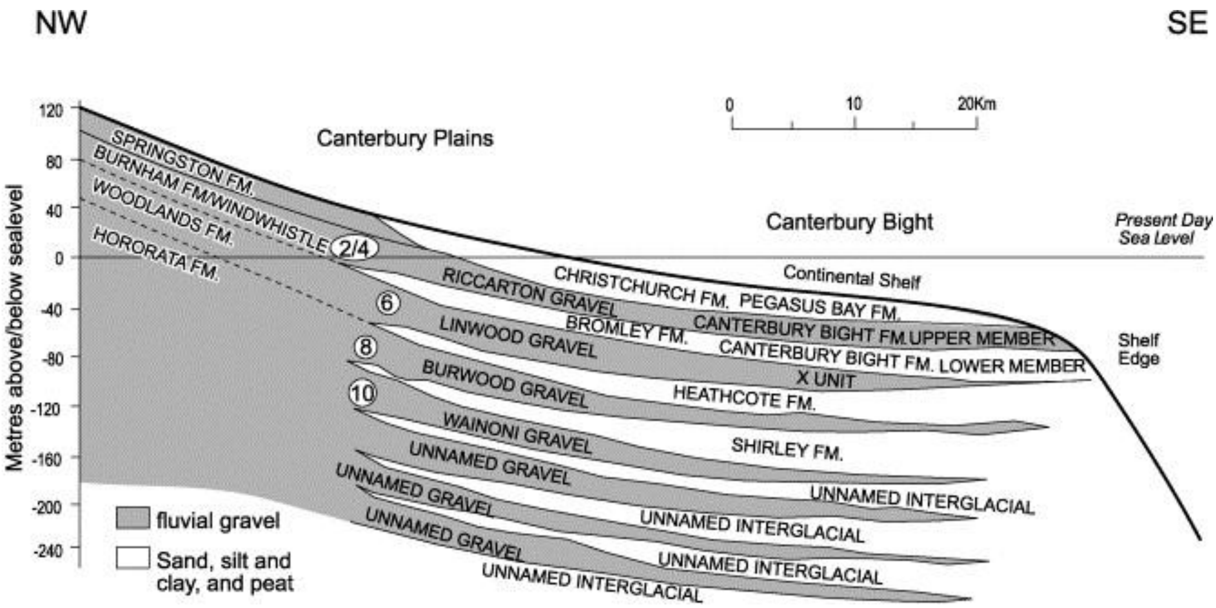

Figure 2. *Stratigraphic relationships between gravel sheets and coastal/marine sediments on the Canterbury Plains (from Brown and Weeber, 1992).*

1.2.2 Porters Pass to Cass Basin

After the stop at **Springfield**, we will go over **Porters Pass** where we will pass the trace of the Porters Pass Fault (Figure 3). It is believed to have last ruptured about 500-600 years ago with a likely recurrence interval of about 1500 years (Howard et al., 2005). Earthquakes on this fault are significant (estimated to be M > 7). The slip rate for the fault is estimated at 3.2-4.1 $mm.yr^{-1}$.

Travelling across the pass we enter the interior basins on the eastern side of the Alps. This part of the range was either never glaciated or the glaciations were so long ago that we cannot see any obvious evidence of their existence.

Figure 3. *Trace of the Porters Pass Fault from Porter's Pass. This fault has been trenched and its recurrence interval (c. 1500 years) and magnitude of ruptures (> M 7.0) determined (photo provided by Jamie Schulmeister).*

Lake Lyndon at the bottom of the hill beyond Porters Pass is a shallow alluvial fan constrained lake. The Lyndon valley was definitely glaciated at its western (Rakaia) end. The surrounding mountains are made of Torlesse rocks. These are heavily folded but only weakly metamorphosed meta-sediments of deep sea turbiditic origin. Structurally, the basins contain inliers of Cenozoic sediments including limestones and greensands in synclinal basins. While New Zealand currently lies on the plate boundary between the Australian and Pacific Plates, the period from 90 million years ago to about 22 million years ago the Zealandia continent occupied a gradually sinking passive margin setting. Repeated basin formation, associated with rifting events resulted in the formation of terrestrial swamps and fluvial deposits and of shallow marine siltstone, sandstones and limestones. Small scale basaltic volcanism is common. Up to about 5km of these shallow marine/marginal terrestrial rocks were laid down from Cretaceous to Oligocene times. The exposure of Torlesse Rocks at high elevations indicates that a minimum of 7-8 km of uplift has happened in this area during the Kaikoura Orogeny (22-0 MYA starting from the southern end of the island and propagating northward to be much more recent in this area).

As we continue towards the **Castle Hill** area we will observe numerous mass movement landforms. There are some excellent examples of debris flows with well developed levees (Figure 4).

The hard limestone beds visible at Kura Tawhiti | Castle Hill and near Cave Stream display a complex series of folds and faults and are a well known rock climbing/bouldering and recreational caving location.

We will swing north towards Castle Hill Village. The Craigieburn Range is visible on the left hand side. This range has been subject to frequent rock avalanches.

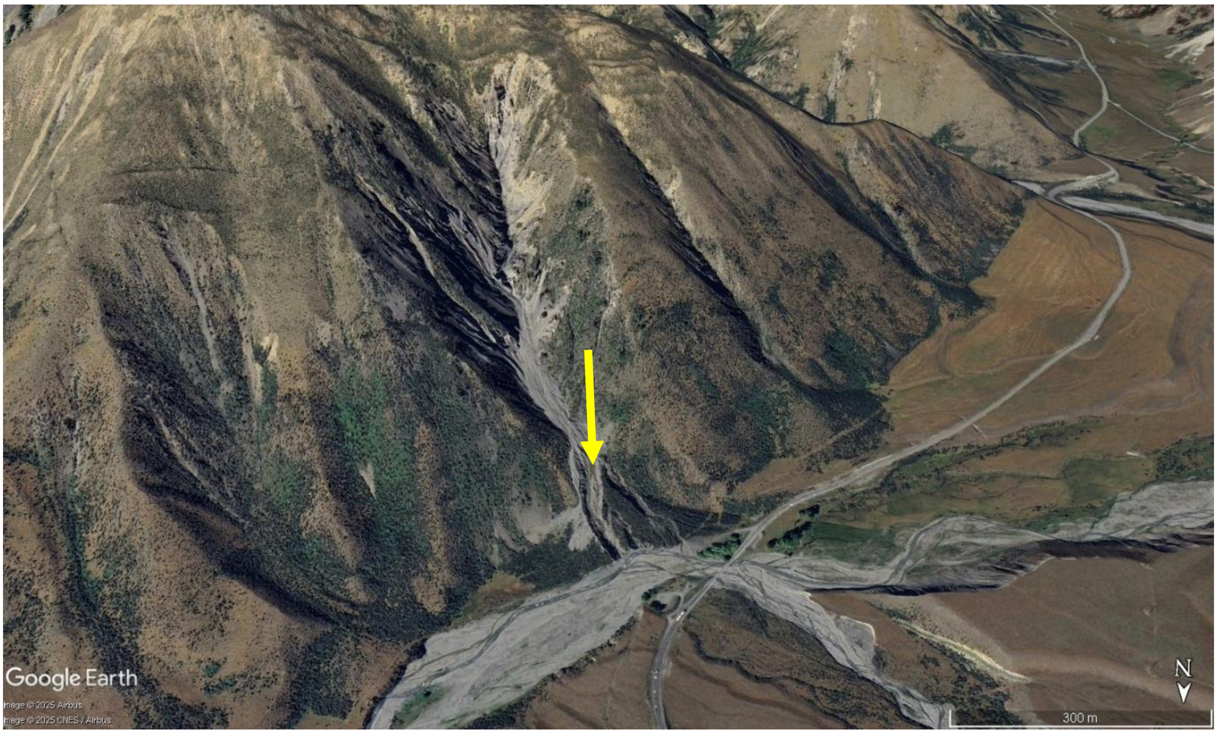

Figure 4. *Debris flow fan with well developed levees just off the road near Castle Hill. The yellow arrow highlights the levees. Google Earth.*

The Cass area was extensively glaciated during the last (Otiran; 74-14 ka) glaciation with the local higher peaks protruding above the ice as a series of nunataks. Since the end of the ice age and the retreat of the glaciers, over-steepened slopes have been exposed, creating the ideal conditions for a variety of mass movement processes to start. At the same time, the retreat of the ice also allowed a lake to form and then rivers to reoccupy the valley floors.

Three lobes of the Waimakariri Glacier worked their way through this area. The main road follows the 'Winding Creek' Lobe which extended through what is now **Lake Pearson**. Because the valley floor was cleared of sediments during glacial times this section of the valley has some of the best developed alluvial fans in New Zealand. Sediment trapped in the interior catchments of local hills spilled out onto the valley floor when the glaciers melted. Lake Pearson is almost dissected by alluvial fans and it is one of the most photogenic fans around.

1.3 Location A - Upper Waimakariri catchment

Next we enter the upper Waimakariri valley, with excellent views to the right of the Waimakariri braidplain. Figure 5 zooms in on area A in Figure 1.

Figure 5. *Upper Waimakariri braidplain (inset A on Figure 1).*

1.3.1 Braidplain morphodynamics

The Waimakariri is a classic braided river and the braidplain in the upper catchment is spectacular. Reinfelds and Nanson (1993) used the Waimakariri to describe the processes involved in the formation of braided river floodplain (now commonly referred to as braidplain). Only part of the braidplain is active at any given point in time. This ‘active braidplain’ area (occupied by bare gravel and flowing braids) is highly dynamic. The river reworks the broader/older parts of the braidplain by both avulsing (abandoning parts of the braidplain and re-occupying previously abandoned braidplain) and eroding laterally to rework bed material within the broader/older braidplain (Figure 6). Reinfelds and Nanson (1993) suggested that the Waimakariri is capable of reworking almost the entire valley floor over a period of approximately 250 years. This creates management challenges even here in the upper catchments where human populations are low. The mature flat areas created by the river (‘mature surfaces’, Figure 6) form the primary land area for low-intensity agriculture (typically grazing sheep, beef, and deer), as well as for transport routes like the one we’re driving on.

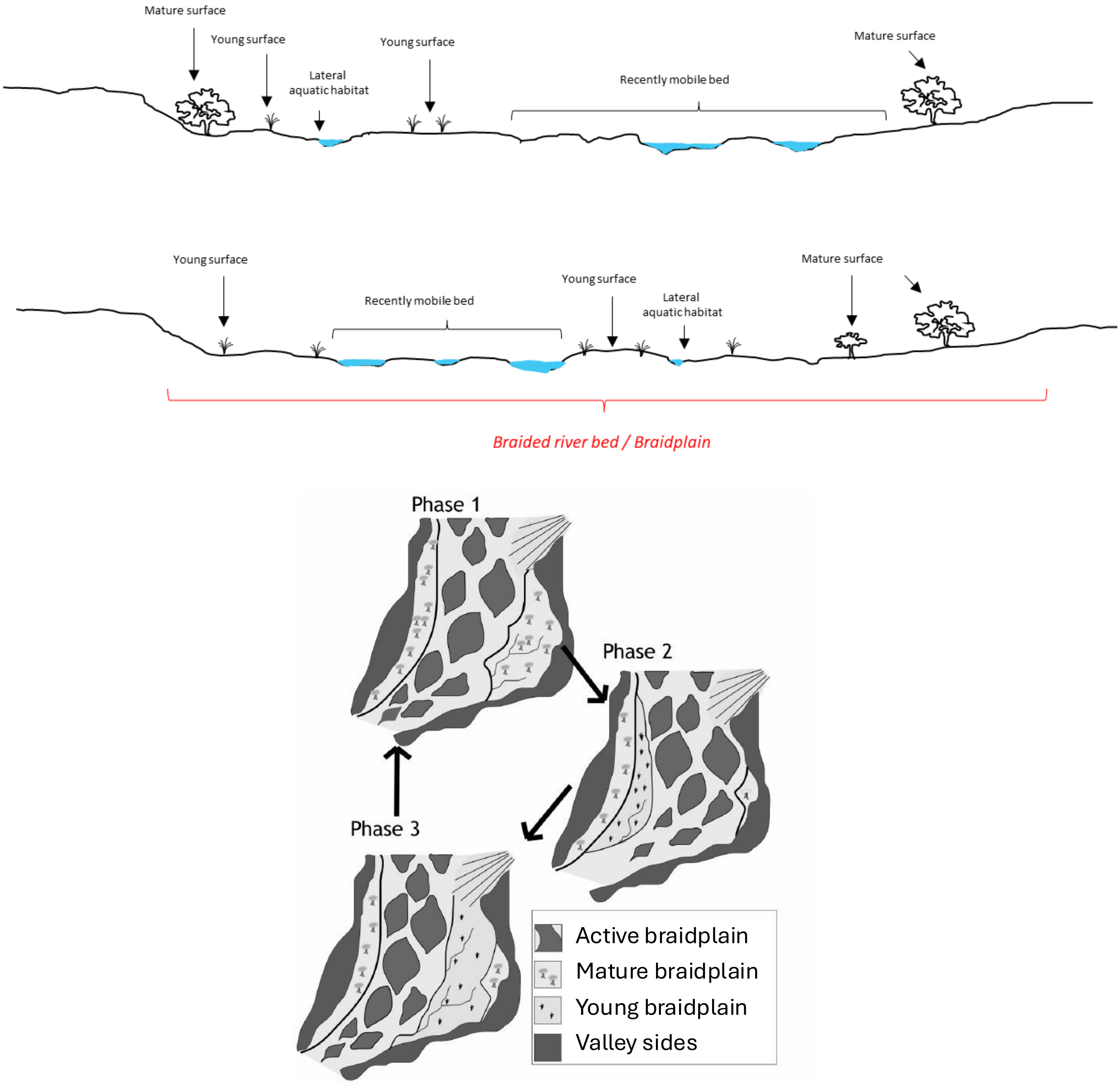

Figure 6. *Braided river morphodynamics – reworking of the braidplain. Top figure adapted from Brower et al. (2023), bottom figure adapted from Reinfelds and Nanson (1993).*

1.3.2 Braided river ecology

Braided river morphodynamics result in a patchwork of different surfaces of different ages, proximity to surface water and groundwater, and surface flow intensity. This patchwork results in a mosaic of different habitats (Figure 7). For aquatic species, braids of different sizes provide channels with a broad range of depths, velocities and bed material grain sizes. For terrestrial species, young gravel surfaces host early succession vegetation and associated fauna. Older surfaces host later succession vegetation and different types of fauna. You also have lateral disconnected aquatic habitat, such as springs, where the relatively stable conditions produce distinctive 'nursery' habitats that sustain the diversity of life found across the river (Figure 8). The diversity of surfaces is why braided rivers are biodiversity hot spots – even though if you were to view one of its channels or gravel bars in isolation it may appear depauperate. The mobility of braided rivers maintains the diversity of surfaces that in turn maintains the diversity of life (Harris et al., 2025).

Figure 7. *Braided river habitats within easy walk of the bus stop.*

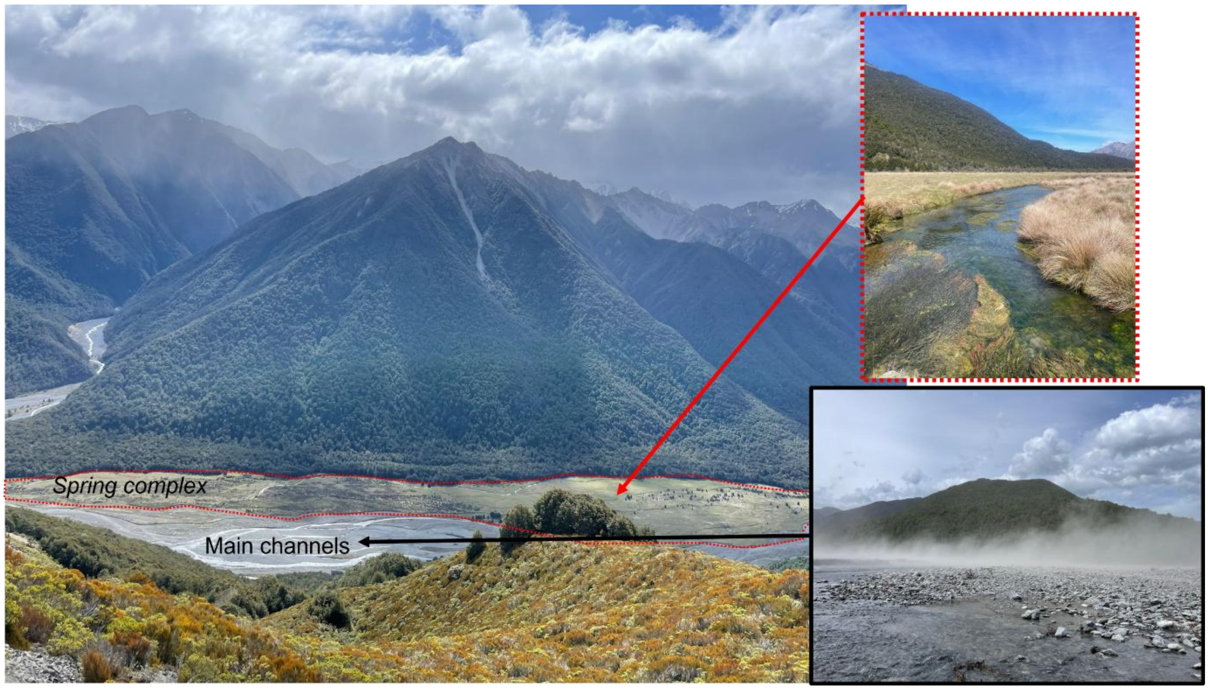

Figure 8. *A spring complex sits in the active braidplain of the Hawdon River (Waimakariri tributary). Water in these springs primarily comes from the subsurface, creating a more stable environment for aquatic life to thrive (see inset image, where the springs house extensive macrophyte beds that form the basis of the aquatic foodweb). In contrast, life in the main part of the river is frequently disturbed by high surface flows that transport scouring fine sediments and mobilise the gravel beds. Together the stability of the springs and fluctuations of the main channel support an incredible diversity of both terrestrial and aquatic organisms.*

New Zealand's braided rivers are home to many rare species, including varies species of bird that nest on bare gravels, various lichens, mosses, tiny cushion plants, and wispy native grasses, and the charismatic robust grasshopper (which don't live in grass and while they can hop, it's more like a leap of faith that ends in a crash-landing, hence the armour plating) (Figure 9).

Banded dotterel – nationally vulnerable

Black billed gull – nationally critical

Wrybill – nationally vulnerable

Robust grasshopper - nationally endangered

Endemic Forget-me-not

Raoulia sp.

Figure 9. *A few rare species to keep an eye out for.*

However, even in this beautiful alpine area life in braided rivers is under threat. Introduced plant species, from willow trees to gorse shrubs to lupine flowers, dominate much of what you'll see looking out across the braidplain. Although harder to spot, invasive mammals like rats and cats (note New Zealand's only native mammal is a bat!) also predate nesting braided river birds. The spread of these invasive species seems to be accelerating along with warming temperatures, which have been felt particularly acutely in the high country with diminishing snowpack and less intense winter cold spells. For instance, you might notice bright green patches in the river gravels – these are most likely invasive aquatic plants. Until very recently these plants only proliferated in the lower Canterbury Plains. But they are now found throughout spring systems in rivers like the Waimakariri.

There will be a stop at Springfield on the way to the next stop at the Waimakariri Gorge Bridge.

1.4 Location B - Waimakariri Gorge and terrace-confined reach

Our stop at location B is at the Waimakariri Gorge Bridge (Figure 10). Between the last stop and this one, the Waimakariri passes through an approx. 30 km long gorge, and then emerging from the gorge the braidplain remains confined by alluvial terraces for a further approx. 30 km.

Figure 10. *Waimakariri gorge and terrace-confined braidplain (inset B on Figure 1).*

1.4.1 Pressures on braided rivers

As the Waimakariri flows across the Canterbury Plains a number of anthropogenic factors influence it's geomorphology, including water abstraction to support irrigation of the plains, agricultural encroachment, introduced invasive exotic weeds and flood defenses (more on this at the next stop). These factors alter the natural dynamics of the river by reducing the ability for the river to adjust laterally. Braidplain narrowing is a common trend in New Zealand braided rivers, with the degree of narrowing varying depending on the energy of the river and degree of human intervention (Figure 11).

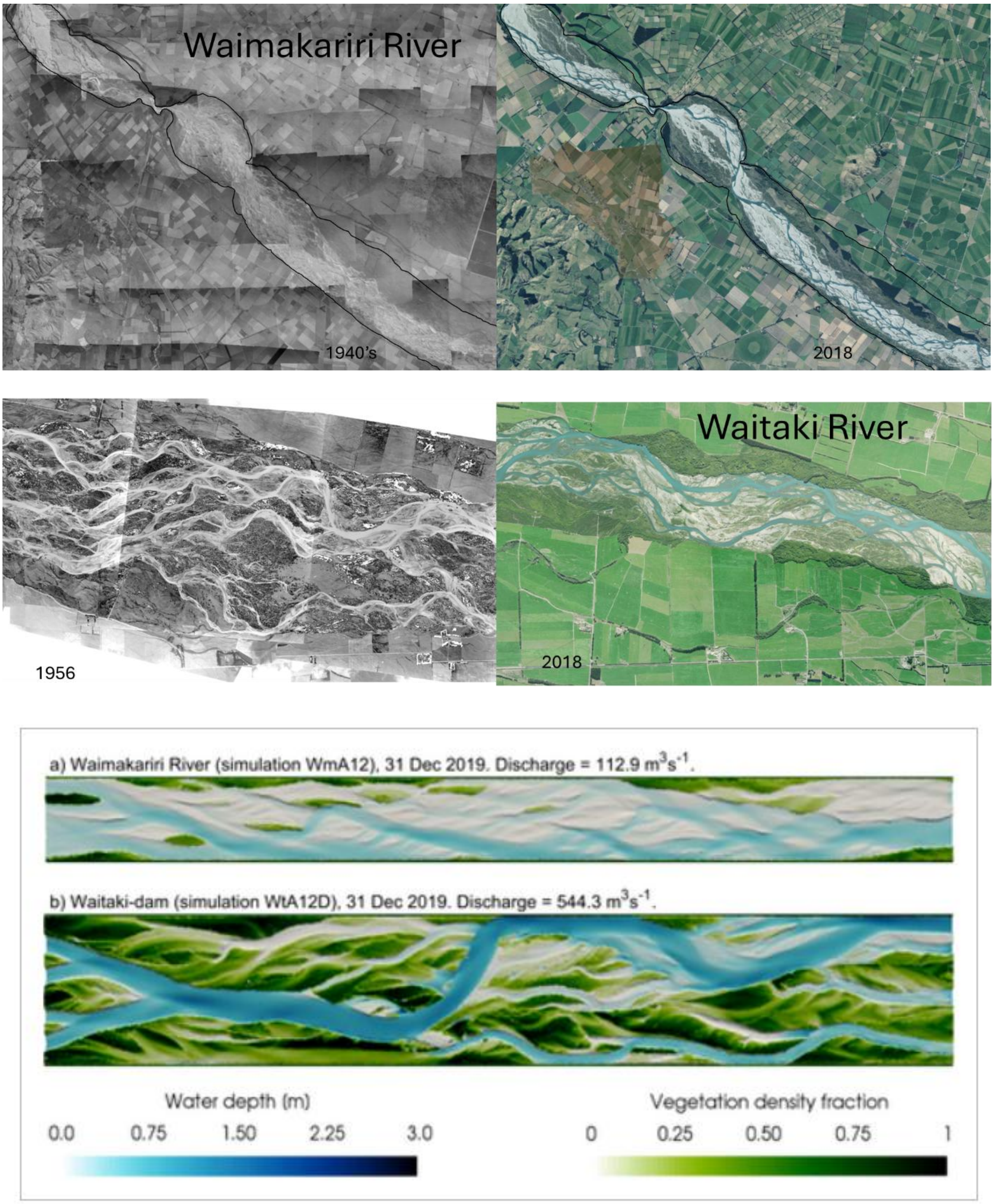

Figure 11. *Braidplain narrowing – Changes in active braidplain width in the Waimakariri (top) and Waitaki (middle) rivers over time. The black lines on the Waimakariri figures show the braidplain/terrace margins. The Waitaki has both natural lakes and hydropower lakes upstream which dampen the flow regime. The bottom figure shows morphodynamic modelling of these two rivers, comparing the relative effectiveness of their flow regimes at controlling vegetation growth on the braidplain (Stecca et al. 2023).*

1.4.2 Hydrology and flood prediction

The majority of the South Island's rainfall occurs on the West Coast. It is not uncommon to receive rainfall in excess of 50 mm/hr in the Southern Alps with 48 hr storm depths of 400-500 mm common. There are numerous rainfall and river flow gauges throughout the region, allowing prediction of flood flows in the rivers as they exit their gorges onto the Canterbury Plains.

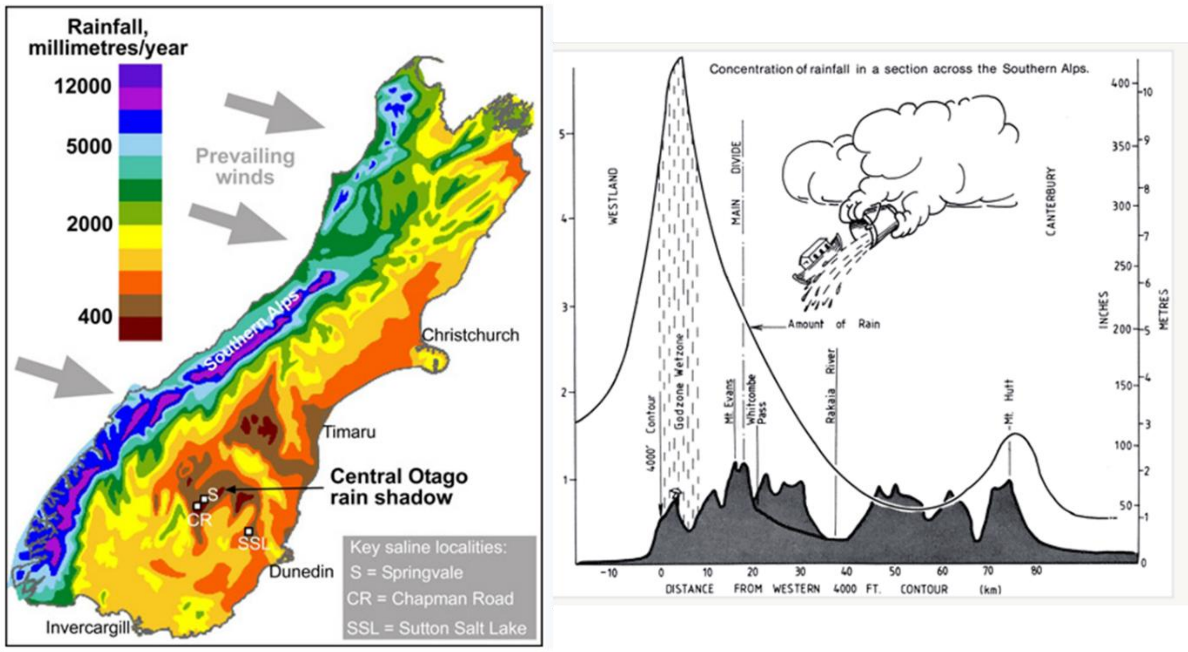

Figure 12. *New Zealand weather and rainfall.*

The mean annual flow of the Waimakariri River is 120 m^3/s. In 1957 the largest flood on record occurred, with an estimated peak discharge of 4,248 m^3/s (Griffiths 1979). This flood initially was estimated to have a 100-year return period (Griffiths 1979) but was later revised to an approximately 450-year return period (Ian Heslop, personal communication 2010) and essentially served as the design basis flood for the levee improvement scheme implemented in the 1960s.

More recently, the flood frequency analysis has been revised and an estimate made for future climate change effects. The results of this are presented in Table 1.

Table 1. *Waimakariri River Flood Frequency Estimates (Environment Canterbury).*

ARI	Flow (m3/s)	Plus 20% Climate change	Rounded (m3/s)
5	1870	2244	2500
10	2270	2724	3000
20	2695	3234	3500
50	3305	3966	4000
100	3815	4578	4500
200	4370	5244	5500
500	5190	6228	6500
1000	5870	7044	7000

1.5 Location C – The geomorphically unconfined Waimakariri braidplain (Haul Road / Crossbank

Figure 13. *Waimakariri River, unconfined reach (inset C on Figure 1).*

1.5.1 Flood management infrastructure

Settlements have been established on the Waimakariri floodplain and are therefore at risk from flooding (Figure 14). The early response to this threat was to construct stopbanks to contain the floodwaters within the river system. Encouraged by the protection provided, the level of development on the floodplain increased, providing stimulus to increase the capacity and strength of the protection works and renewing the cycle.

Emphasis in recent years has been towards an integrated programme of structural (e.g. stopbanks, erosion control works, river clearing) and non-structural (e.g. building controls, flood warnings, education) measures.

The Waimakariri river floodplain contains the Kaiapoi (which is the old north branch of the Waimakariri river), Eyre, Cam, and Cust rivers. The Eyre discharges into the Waimakariri river via the Eyre Diversion, and the Cam and Cust rivers discharge into the Kaiapoi which in turn discharges into the Waimakariri river. These rivers are maintained by the Waimakariri-Eyre-Cust Rating District.

Other rivers such as the Avon and Heathcote (which flow through the centre of Christchurch) are also located on the Waimakariri floodplain but are not tributaries of the Waimakariri River. They (and the Styx) are maintained by the Christchurch City Council and are not considered in this plan.

The South Waimakariri River District was set up by the Provincial Government in 1869. In 1880, the South Waimakariri River Board was elected and continued the work of the earlier body on the south bank. The Waimakariri River Improvement Act (1922) was passed as a result of pressure from people on the north side of the river, who were concerned that protection works on the south were making their land more vulnerable to flooding. The Waimakariri River Trust was set up in 1923, giving it the responsibility of dealing with both the north and south banks of the river from the mouth to the lower gorge. The Trust built the Hays No 2 Scheme and continued with maintenance. The Waimakariri River Trust merged with the North Canterbury Catchment Board in 1946, which strengthened and maintained the river control system until 1989, when the Board was abolished and its functions and powers assumed by the Canterbury Regional Council.

The Council administers approximately 1660 ha of reserve land in the Eyre river system, and approximately 14,370 ha in the Waimakariri River downstream of the gorge bridge. Much of the reserve land originated as a Crown grant of Endowment Lands to the South Waimakariri River Board in 1880 for the purpose of earning funds for river control works. Other areas of land had their origin in the Waimakariri River Improvement Act 1922 and its amendments, whereby control of further areas was vested in the Waimakariri River Trust. Over the years, further freehold title to some land associated with the river has been acquired. All Council land in the catchment not required for river works and suitable for leasing is used as endowment land to supplement rates in the Waimakariri-Eyre-Cust Rating Area.

As the existing scheme was complete the Draft Waimakariri River Floodplain Management Plan (DWRFMP) was prepared in 1991 to determine what degree of protection was desirable and justified for the future. The plan aimed to minimise damage to the Christchurch and Kaiapoi communities for a 30 year period. Five options incorporating floodplain management measures ranging from dams to relief funds were assessed for their ability to minimise social disruption and damage to life, limb, community and private assets, and the environment from all conceivable breakouts of floodwaters into Christchurch and Kaiapoi. Twenty-seven protection measures (structural and non-structural) were selected as practicable and acceptable. They were used in different combinations to form five options for the DWRFMP. Each option was evaluated as a whole using physical, economic, social, and environmental criteria. A Community Advisory Committee unanimously agreed on a preferred option (Option 3) which had 18 measures involving river control, land use management, community preparedness, emergency actions, and civil defence.

In October 1996 the DWRFMP was withdrawn by the Canterbury Regional Council for reasons based on submissions on the plan that included:

- Lack of support by the Christchurch City and Waimakariri District councils in particular, for proposed rules in the plan controlling land use for building purposes
- Public perception that the proposed flood protection measures were too restrictive, and
- Imposition of land use controls on rural ratepayers within the floodplain but not on urban ratepayers is discriminatory.

Although the plan was withdrawn structural measures described in Option 3 of the DWRFMP were adopted by the Waimakariri-Eyre-Cust Liaison Committee in 1996.

Additional funding (approximately $600,000 per year) was provided to enable the construction of these measures. The work was scheduled to be carried out over 20 years.

The final stage of these measures is to construct a secondary bank on the south side of the Waimakariri to cater for floods up to 6500 cumecs. These works and the associated mitigation are known as the Waimakariri Flood Protection Project (WFPP). Resource consents were granted for the WFPP works in June 2009. The WFPP has a 10 year, $34m works programme. A separate rating district was set up to fund the capital works for this project.

Flood protection now includes approximately 144 km of levees, 145 groynes, 220 km of trees and 600,000 tonnes of rock for scour protection (Figure 15).

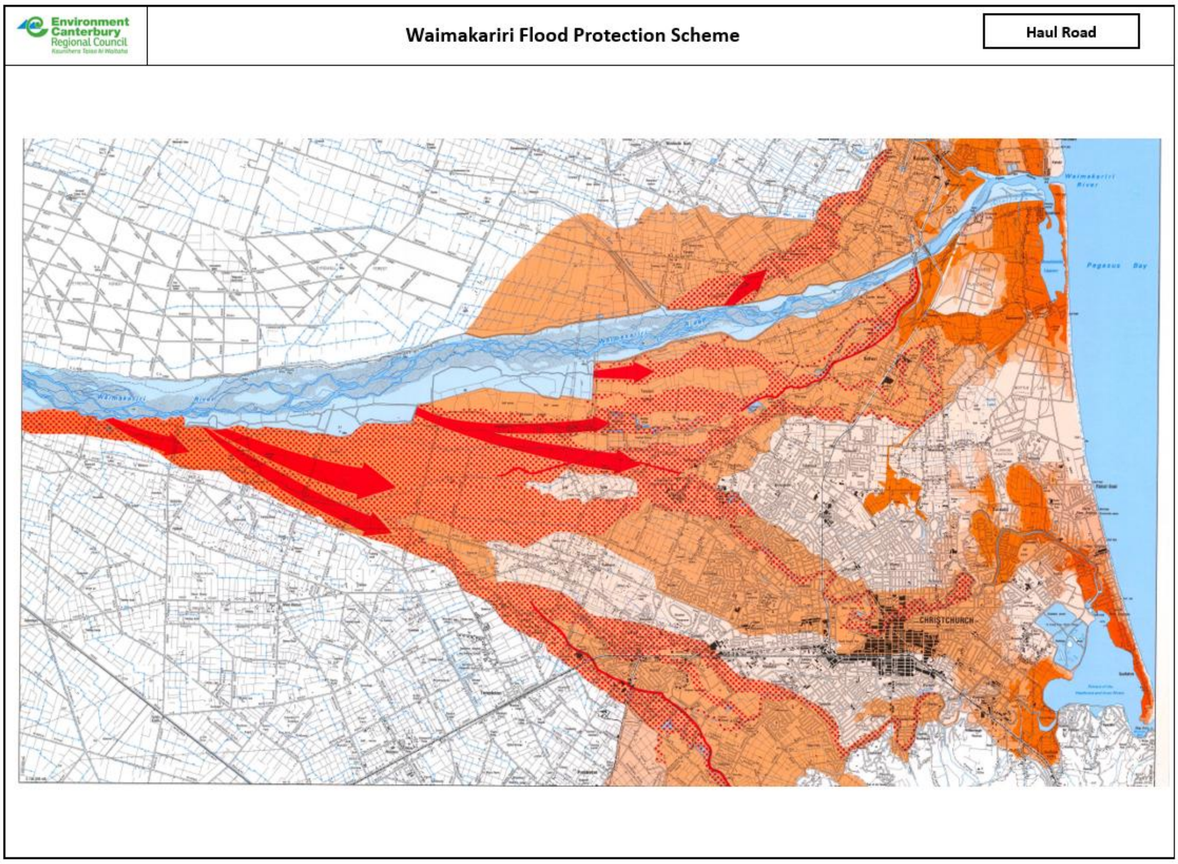

Figure 14. *Waimakariri flood modelling (Environment Canterbury).*

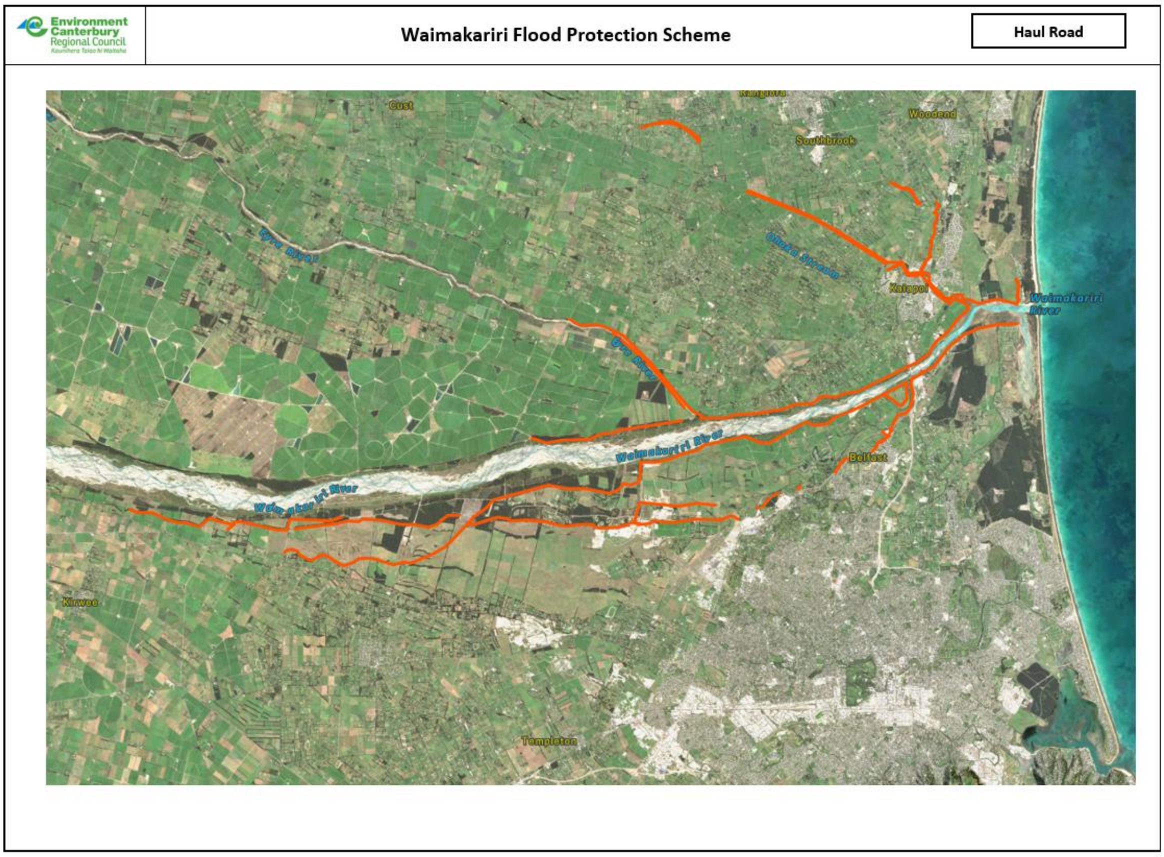

Figure 15. *Waimakariri flood protection infrastructure (Environment Canterbury).*

1.5.2 Gravel extraction

Gravel extraction forms an important part of both the flood management regime for the Waimakariri River and for aggregate supply to the greater Christchurch area. Approximately 300,000 m^3 of gravel is extracted from the river annually through a tightly monitored permissions system (Figure 16). This is necessary because all of the gravel bedload is deposited before it reaches the coast (Figure 17) resulting in high rates of aggradation in the absence of gravel extraction (Figure 18).

Bed level and geomorphic change is monitored through a combination of cross section and LiDAR analysis. All permissions to extract from the Waimakariri River have a condition specifying a 'minimum bed level' where if the measured bed level drops below this elevation, extraction must cease.

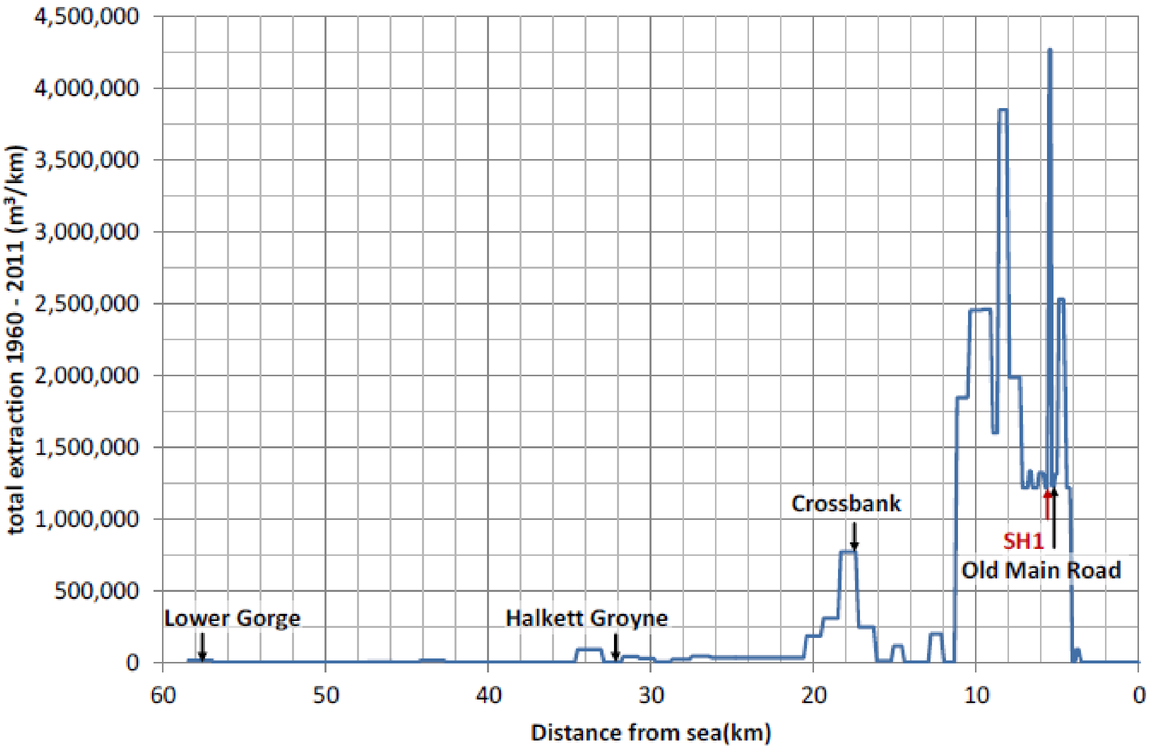

Figure 16. *Total gravel extraction per kilometre from the Waimakariri River 1960-2011 (Measures, 2012).*

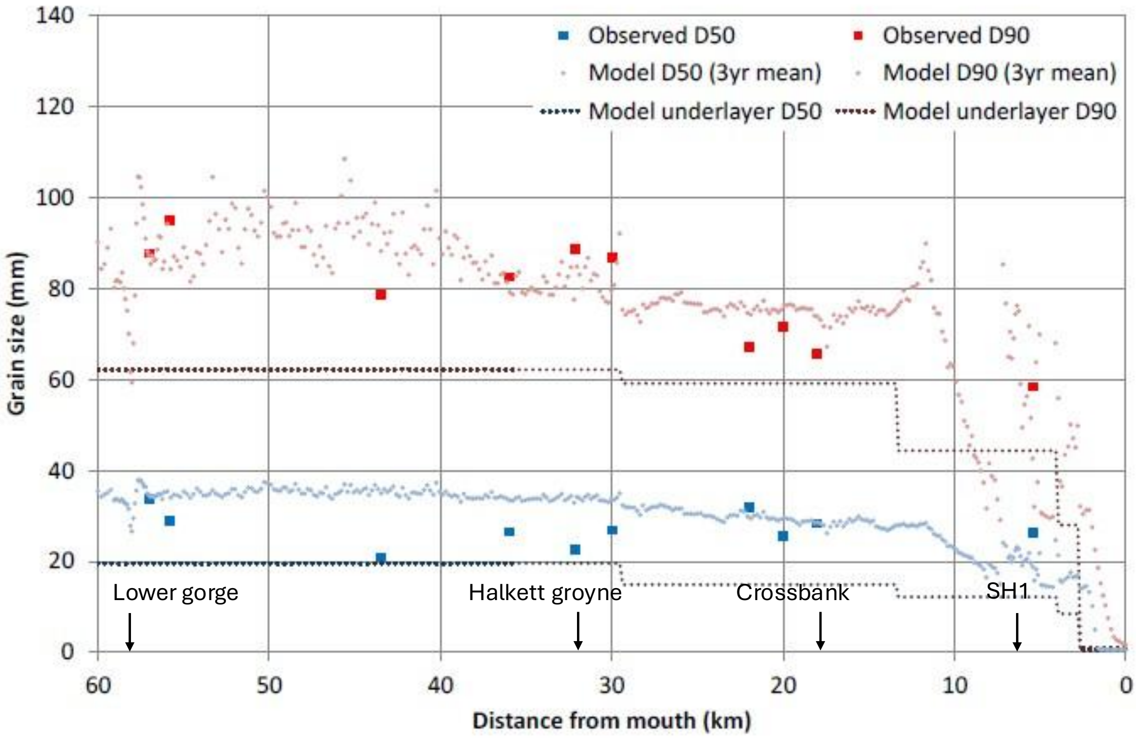

Figure 17. *Long profile of surface sediment D50 and D90 down the Waimakariri River (Measures, 2012).*

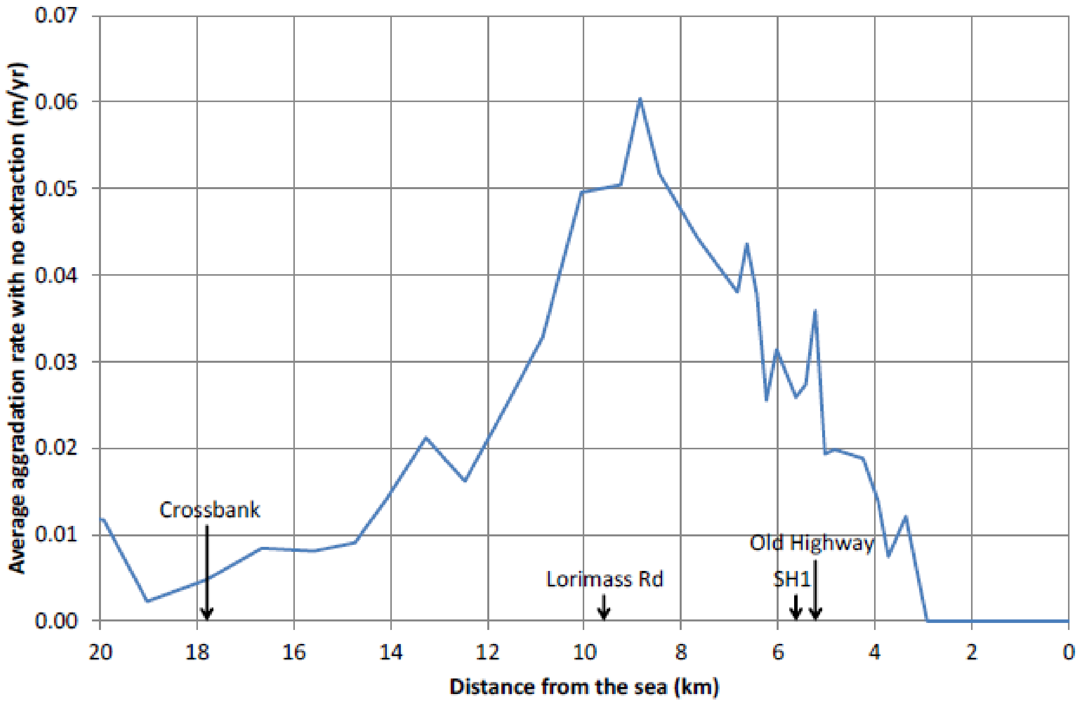

Figure 18. *Aggradation rates in the reach downstream of Crossbank if there was no gravel extraction (Measures, 2012).*

1.5.3 Water quality

There are significant concerns about water quality on the Canterbury Plains. This is primarily focused around extremely high levels of reactive nitrogen (nitrate, NO_3^-) found in groundwater. High groundwater nitrate levels here primarily are caused by the combination of intensive food production and the loose gravels that underlie the plains – without clays or organic matter the nutrients applied to farm fields is easily leached away from the plant roots and into the water. Nitrate is not toxic (unless at extreme concentrations). Rather the problem is just the opposite: when excess nitrate reaches a waterbody it accelerates the growth of all sorts of lifeforms. The net result of this nitrate-enhanced growth is algal blooms and the 'take over' of fast growing weed species, which can then lead to the overconsumption of oxygen that triggers biological catastrophes like fish kills.

Increasing nitrate levels and algal growth have been observed in some of Canterbury's smaller, non-alpine braided rivers. But it was hoped that large alpine-fed rivers like the Waimakariri River would be largely insulated from the water quality problems of the Canterbury Plains. First, the Waimakariri River receives its water in the alpine part of the catchment (low nitrate), then slowly loses this water to the groundwater (high nitrate) as it moves across the plains (Stewart 2012; White et al. 2012). So, the river should be helping to dilute the high groundwater nitrate pollution rather than itself becoming full of nitrate. Second, large volumes of water move very quickly through the river, meaning that any parcel of nitrate-bearing water would only be in the system for hours, rather than days. This would not be enough time for it to influence river biology. However, in reality the amount of nitrate moving through the Waimakariri River is increasing (Figure 19).

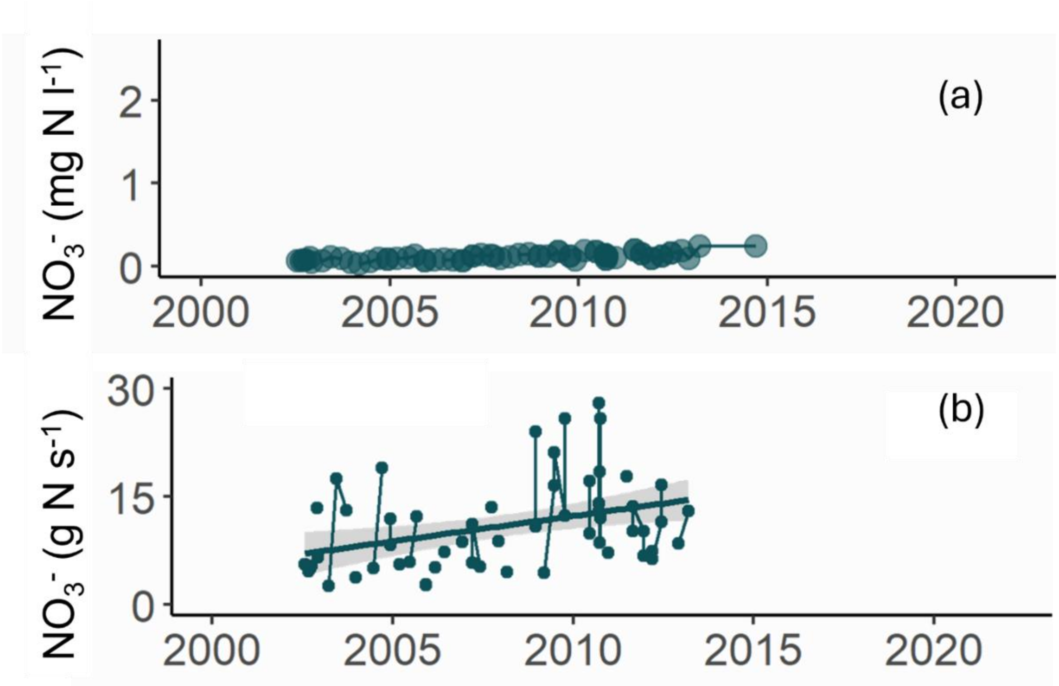

Figure 19. *While it is hard to detect changes in the concentration of nitrate in Waimakariri surface water over the past decade (a), when the concentration is combined with discharge data to calculate the total load of nitrate moving through the river (b) there is a clear increasing trend over time. Data from Environment Canterbury.*

The structure of braided rivers makes monitoring and mitigating these types of water quality issues particularly difficult. Water quality monitoring assumes that you are observing changes from the same point over time – but how is this possible when the river's channels continuously shift? Water quality monitoring also assumes that the sampled point represents a well-mixed and accurate signal for the whole stretch of river – but can this be true when the river has many parallel channels, each with distinct biological communities and gravel composition? Fortunately, we have found that nitrate levels tend to be pretty consistent across most parallel channels in the Waimakariri River. But, throughout the river, 'springs' emerge into the braidplain and carry with them wildly diverging chemical signatures - including nitrate levels. Based on their chemical signatures these springs seem to bring water from the regional aquifer, rather than the shallow 'braidplain' aquifer that constantly mixes with the surface water (Wilson et al 2024). This fits with what we have come to understand about the ecology of braided river systems. But it also suggests a vector for how high nitrate from Canterbury groundwater may be getting into the surface water of the river. We have been working to figure out how prevalent surface water mixing with deeper groundwater might be, and what this means for braided river water quality (Figure 20).

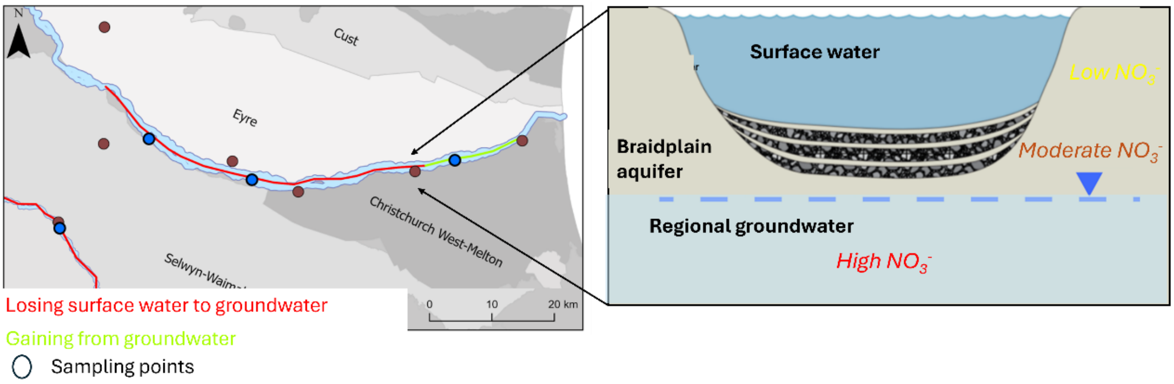

Figure 20. *The high nitrate (NO3-) levels in regional groundwater don't correspond to high nitrate levels in Waimakariri surface water. But moderately elevated levels in the braidplain aquifer underlying the river, and evidence for braidplain springs feeding regional groundwater into the river, indicate that the river is not totally isolated from the pollution problems facing the Canterbury Plains.*

Observations of increased algal growth have come along with concerns about nitrate pollution. Ponds created by gravel extraction can 'bloom' with green filamentous algae (Figure 21), and black mats of toxic cyanobacteria can form along the gravel beds. To some extent the 'boom and bust' cycles of life in a braided river mean that sudden proliferations of algae are part of the river's natural ecological rhythm. Life in the river is primed to take off as soon as there's enough sunlight and nutrients, the flow slows down enough, and the temperatures are warm enough. The combined pressures of water extraction (decreased flows), gravel extraction (creating 'no flow' ponds), and climate change (warming water and intermittently decreased flows) could be enough on their own to make algae growth increase across the lower reaches of the Waimakariri River. Adding some nitrate to the mix accelerates this even more.

Figure 21. *Filamentous green algae dominates in the scours left behind from gravel extraction. Unlike most of the braidplain features, these 'ponds' often have very fine sediment bottoms.*

1.6 Location D - The lower Waimakariri River (Regional park - Kainga)

Our last stop is in the Lower Waimakariri in a reach where the river transitions from braided to single thread river and from a gravel bed river to a sand bed river (Figure 22).

Figure 22. *Lower Waimakariri - transition from braided to single thread, and gravel bed to sand bed.*

As the river is so close to Christchurch, the riverbed and open bermland, (which contain the flood protection works including stopbanks, groynes, and protection plantings of willow, poplar and pine plantations), has a high usage for passive and active recreation. This places demands on the rating district to limit and repair public damage to flood protection works, maintain tracks to a standard suitable for private vehicles, and remove indiscriminately dumped rubbish and vehicles (stolen or dumped).

The Waimakariri River Regional Park covers 15,000 hectares of river and river's edge land so we've broken it down into several park areas that cater to activities ranging from mountain biking, picnicking, horse riding, walking, game bird hunting, fishing and more (Figure 23).

Prior to European settlement, the Waimakariri River was a vast and unconstrained braided river that frequently overflowed surrounding land, including through the site of present-day Christchurch. The Waimakariri River Regional Park was originally created as a way of managing the Environment Canterbury-owned river protection land along the length of the Waimakariri River.

__Figure 23.__ Waimakariri River Regional Park.

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