

TECHNICAL REPORT Science Group

Braided rivers: natural
characteristics, threats
and approaches to more
effective management

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Summary

This report is intended to provide context for the debate on the ongoing management of braided rivers in Canterbury. The report begins by describing the physical form and process that occur within braided rivers before reviewing the ecological values and natural character of these river systems. The report proceeds to discuss the major threats to ecological values and natural character, and discusses potential future options for management.

Braided rivers are iconic features of the Canterbury landscape that are also nationally (and globally) threatened ecosystems. Intact they are complex and dynamic habitats with very high natural character and biodiversity values. Change in current management practices are necessary in order to deliver on outcomes for the protection of biodiversity, ecosystem health and natural character of braided rivers, as required by the Canterbury Water Management Strategy and Regional Policy Statement. The purpose of this report is to provide an ecological context for the management of braided rivers.

Given an adequate supply of sediment, unmodified flows and room to move laterally the active channels migrate back and forth over an area termed the braidplain, renewing habitats as they move. This is the essential characteristic that determines the natural character of these river systems. The highest biodiversity values are often found in the lateral habitats left behind by the migrations of the recently active surfaces.

However, in order to protect land and assets from flooding and channel migration these rivers are constrained, in places, by flood defence works particularly when infrastructure and settlements are vulnerable. Historically engineering techniques have been applied with limited regard for impacts upon ecosystem and natural character values. However, over recent years there has been a greater appreciation of the ecological implications of flood management interventions on braided rivers and the future of flood defence management is an area of potential collaboration between river engineers, geomorphologists and ecologists.

Braided rivers are also under pressure from a combination of invasive weeds, agricultural land use change and *ad hoc* flood defences. Exotic weeds are present in the majority of rivers with often only the headwaters remaining weed free. In the absence of active intervention weeds, such as willow and lupin, will reduce the natural character of braided rivers with commensurate effects on ecological values.

Land use change and *ad hoc* flood defences on braidplains have occurred at a rapid rate over the last 15 years despite policy to restrict such activities. This appears to be partially the result of confusion over the extent of 'river bed' being referred to by policy and associated rules. The bed of a river is defined by the Resource Management Act 1991 as 'the space of land which the waters of the river cover at its fullest flow without overtopping its bank'. However, in most cases this definition will not incorporate the full width of the braidplain.

The preservation of the extant natural character and ecological values of Canterbury braided rivers is a significant challenge. A critical first step is a clear definition of the spatial extent of a braided river in order to give effect to current policy and rules. Also important is an understanding of the various elements that constitute, or influence, 'natural character'. How the braidplain is subsequently managed must take into account impacts upon land use, livelihoods, cultural uses and the economy as well as biodiversity and natural character. A braided river strategy, whose development will incorporate all of these considerations, provides an opportunity to preserve the values of Canterbury's braided rivers into the future.

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Glossary

Aggradation - increase in land elevation, typically in a river system, due to the deposition of sediment.

Alluvial plain - largely flat landform built via the deposition of gravels by one or more rivers.

Braidplain - the area of land covered potentially, currently and historically by the active river surfaces within a given hydrological and geomorphological context or period of time.

Catchment - the area of land which contributes water to any river.

CWMS - Canterbury Water Management Strategy.

Diadromous - typically refers to fish: migrates to and from the sea to complete its life cycle.

Degradation - decrease in land elevation, typically in a river system due to the erosion of sediment.

Extant - Currently existing, not having disappeared. That which remains.

Floodplain - the area of land that may be inundated by a flood (i.e. a river flow that overtops its banks).

Impoundment - damming of a river or stream.

LWRP – Canterbury Land and Water Regional Plan.

NRRP – Canterbury Natural Resources Regional Plan. Superseded by the LWRP.

Rating District - area in which the regional council collects targeted rates to fund flood and/or erosion management, e.g. stop bank maintenance or strategic planting.

Reach - a length of river with relatively uniform characteristics.

Recently active surface - area recently impacted by flood waters and channel migration, typified by early successional state vegetation or bare gravels.

RPS - Canterbury Regional Policy Statement.

RMA - Resource Management Act (1991).

RMA riverbed - [except for the purposes of esplanade reserves, esplanade strips and subdivision], the space of land which the waters of the river cover at its fullest flow without overtopping its banks.

Stopbank - constructed bank or levee designed to contain floodwater.

1 Introduction

Braided rivers are an iconic feature of the Canterbury landscape. In their natural state they encompass a complex and dynamic range of aquatic, wetland and terrestrial habitats with very high values for biodiversity (Gray & Harding, 2007). Some critical factors that determine the state of Canterbury braided rivers are well understood and regulated, such as flow and sediment supply. However, there are a number of outstanding threats and pressures with high potential to reduce the natural character and consequently the biodiversity values of these rivers. This report is intended to provide context for the debate on the ongoing management of braided rivers in Canterbury. The report begins by describing the physical form and process that occur within braided rivers before reviewing the ecological values and natural character of these river systems. The report proceeds to discuss the major threats to the ecological values and natural character of braided rivers and discusses potential future options for management.

1.1 Notes on terminology

1.1.1 Natural character

Much of the following discussion refers to 'natural character'. The term 'natural character' is referred to in the RMA and throughout Environment Canterbury policies, plans and strategies. For the purposes of this report natural character is considered in accordance with the Canterbury Regional Policy Statement (RPS) and incorporates:

- Water quality
- Water quantity
- Bed substrate
- Natural processes (movement of sediment, water and biota)
- Natural life-supporting capacity
- Ecosystems and biodiversity
- Landscapes and landforms
- Characteristics of special spiritual, historical or cultural significance to Māori
- Significant places or areas of historic or cultural significance

In many resource management situations we already assess some of the component factors of natural character, but don't consider them in terms of natural character, i.e. water quality and quantity, cultural values, biodiversity, etc. However, consideration of the overall naturalness of a braided river has not been undertaken to date and we have not amalgamated all these factors into an overall assessment of natural character. The application of natural character assessments to braided rivers could be particularly helpful because these systems are so complex and dynamic.

1.1.2 RMA definition of river bed

Much of the legislation invoked to manage rivers and their environs (including the protection of braided rivers) is centred on the RMA definition of a riverbed. A regional council can control certain activities that affect the bed of a river, such as structures, excavations, introduction or disturbance of plants, deposition of substances, reclamation or draining of the bed. The RMA defines the bed of a river as 'the space of land which the waters of the river cover at its fullest flow without overtopping its banks'¹. However, a braided river has many banks and in its natural state these banks are highly mobile over time. Also, a flood may inundate some of these banks, but still not occupy the full extent of a braided river.

¹ Section 2 RMA 1991

1.1.3 Definition of a 'braidplain'

A central thesis of this report is that in order to effectively manage braided rivers it is critical to preserve the lateral migration of these rivers over time. This requires a new definition and delineation of the extent of the 'river' which allows for lateral migration. The extent of a braided river includes the full area that may be occupied by the river channels (i.e. currently, historically and potentially in the future). We refer to this area as the 'braidplain'. Accordingly, because this report relates to braided rivers, we refer to the braidplain or braided river rather than 'river bed' unless specifically in reference to the RMA defined term.

1.2 Historical context

Historically, flood defence has been the dominant priority for river managers. While early settlers were apparently unaware of the flood risk from braided rivers (Logan, 2008), a number of serious floods, notably in 1859 and 1868 when the Waimakariri River flooded Kaiapoi and Christchurch City, spurred various attempts at containment. Flood defence schemes were subsequently built throughout the region and many schemes came under the control of catchment boards from the 1940s (Logan, 2008). Latterly these schemes are now managed by the Canterbury Regional Council. There are also numerous private flood defence schemes that are subject to ongoing development and maintenance as active channels migrate within their braidplains and the value of developed flat land increases.

Land ownership upon and adjacent to braided rivers in Canterbury is split between a variety of agencies (Department of Conservation, Environment Canterbury, Land Information New Zealand and Territorial Authorities), freehold (private) land, and significant areas of unknown ownership. The legal and legislative context is also complex. The edge of the RMA defined riverbed is an important statutory boundary between Section 13 (use of the beds of rivers and lakes) and Section 9 (use of land) of the RMA and between regional and district council responsibilities. However, as noted by the (now withdrawn) Canterbury Natural Resources Regional Plan (NRRP) 'the definition of the bed provided in the RMA is not always straightforward to apply in the context of braided Canterbury rivers'. As a result there is uncertainty about the application of policies, rules and definitions in the context of braided rivers and no definitive boundary of the river to demarcate areas of responsibility for management. Consequently, there is an ongoing loss of the natural character and biodiversity values of Canterbury braided rivers.

Braided rivers are considered to be one of the globe's most critically threatened ecosystems (Tockner *et al.*, 2008). Yet despite the global and regional importance of these rivers there is no unified strategy for the management of braided rivers in Canterbury. A clear understanding of braided river geomorphology, the physical context for the debate, needs to form the basis of such a strategy.

2 Braided rivers and braidplain geomorphology

Braided rivers are physically characterised by having multiple channels separated by bars and islands that look from the air to have the intertwining effect of a braid (Lane, 1957) (Figure 2-1). While this description alludes to the recently active surfaces of the river, an additional characteristic of these rivers is their tendency to migrate across a wider braidplain. The formal definition of a braidplain is the area of land covered currently, historically and potentially in the future by the recently active river surface within the current hydrological and geomorphic context. This is quite distinct from the area of land that may be inundated by a single flood event. A braidplain incorporates the area inundated, but also wider breadth of land across which river channels may migrate over tens to hundreds of years. The braidplain may not therefore, be inundated in its entirety, even during large floods. A braidplain may be constrained within the terraces of an older alluvial plain, such as the terraces at Windwhistle and Te Pirita adjacent to the Rakaia River within the Canterbury Plains, or by the bedrock flanks of a confining valley (Shumm, 2005). The migration of the active channels within the braidplain, which results in the creation of a mosaic of surfaces of varying age (defined by time since mobile) is fundamental to the natural character of braided rivers. The concept is presented in the schematic in Figure 2-2.

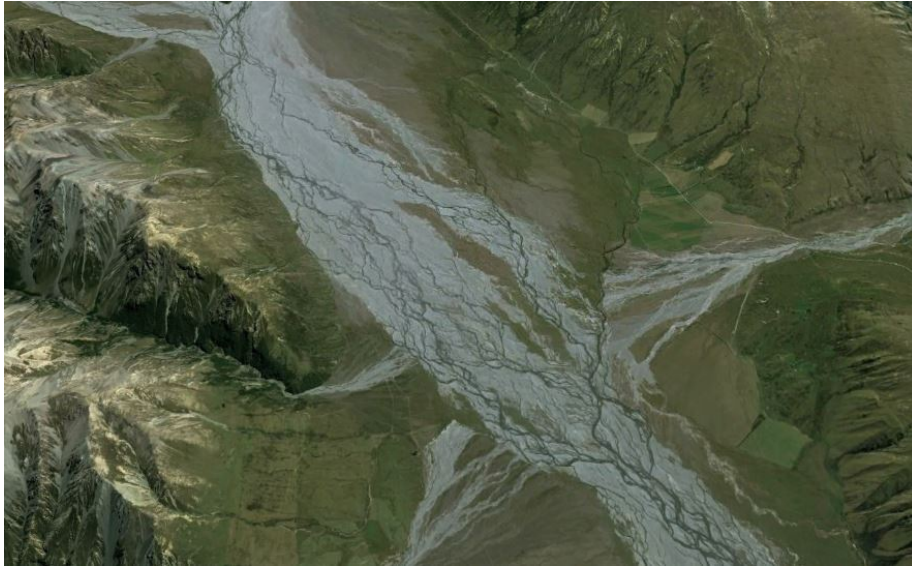


Figure 2-1: An inland basin, braided reach of the Rangitata River showing multiple intertwined channels, bars and islands

River braiding is primarily controlled at two spatial scales; the catchment and the reach. At the catchment scale, braiding is regulated by the magnitude and frequency of high energy flooding and an adequate supply of sediment. High rainfall in the mountains and the erodible nature of the Southern Alps provides these conditions in Canterbury (Griffiths, 1979 a, b; Duncan & Woods, 1992; Mosely, 2004). At the reach scale braiding is regulated by the available width of the flat valley floor. Braiding cannot occur within a confined river channel incised into bedrock or narrow, high terraces; the banks must be erodible and there must be room for the river to braid. Other reach scale conditions such as the valley slope and vegetation communities also combine to determine the precise character of any braidplain (Gray *et al.*, 2016).

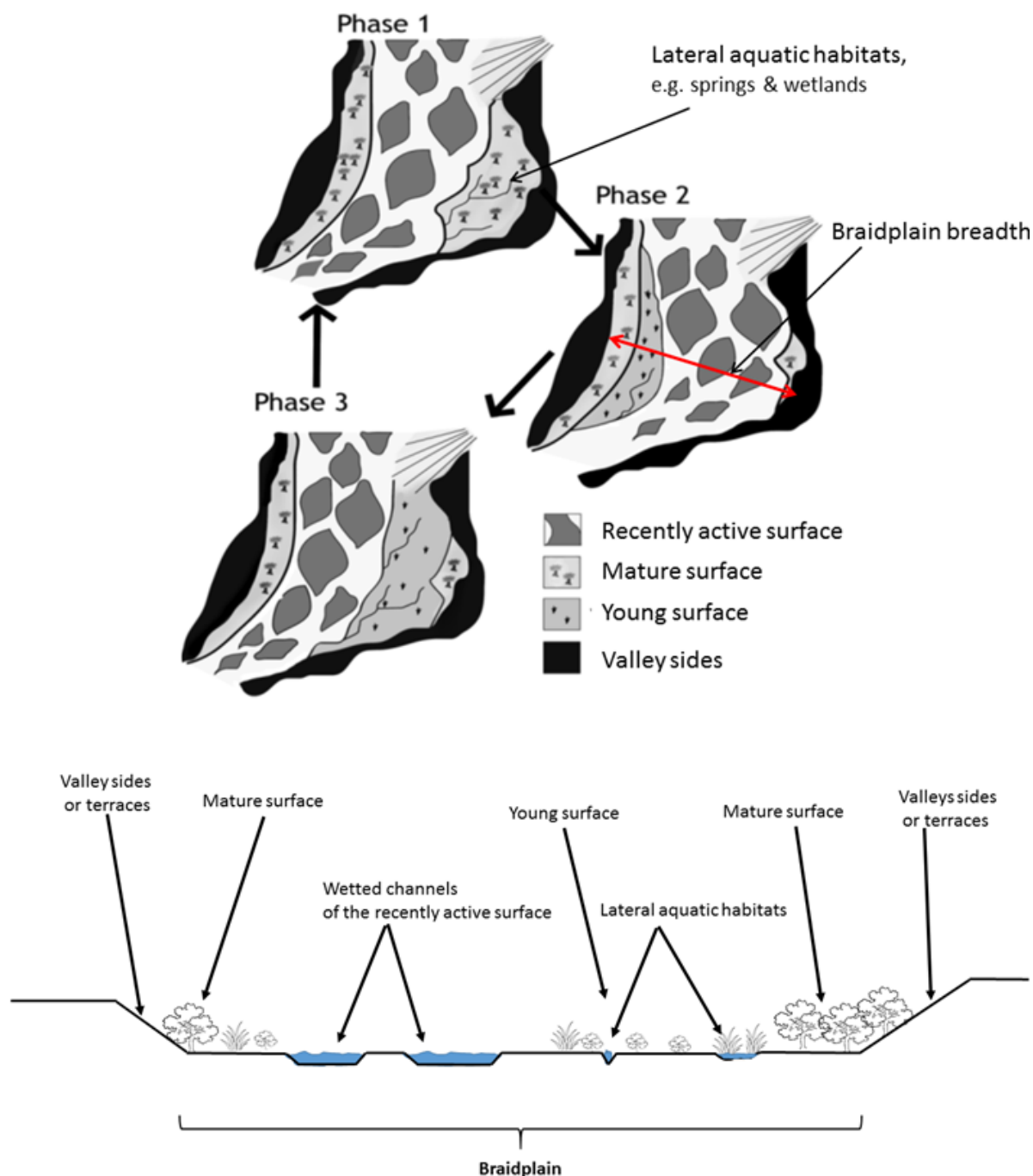


Figure 2-2: Top. Schematic of a braided river showing the full extent of the braidplain and migration of the recently active surface over time. Adapted from Reinfelds & Nanson (1993). Bottom. Transverse view of a braided river showing the recently, active, mature and young braidplain surfaces of phase 3 as a component of the entire braidplain over which the recently active surface may travel

3 Biodiversity and ecosystem values

The recently active surface of the braided river migrates across the braidplain causing a turnover of aquatic and terrestrial habitats. As a result across the entire braidplain there are many different types of ecological habitat: from stable spring streams to flood prone main channels; from mature forested islands to bare gravels (Gray & Harding, 2007). All of the habitat types found across the braidplain have their own distinct character and together contribute to the very high biodiversity values associated with braided rivers.

Braided rivers and their habitat mosaics support diverse communities of plants, invertebrates, fish and birds, both introduced and native (e.g. O'Donnell, 2000; Peat and Patrick, 2001; Gray & Harding, 2010). While the importance of the recently active surface for a range of specialised indigenous plants and animals is now well understood, more recent studies of the wider braidplain have demonstrated their potential as biodiversity hotspots for native plants and terrestrial insects (e.g. Patrick and Grove, 2014).

Lateral aquatic habitats provide safe refugia from floods. Although small in comparison to the wetted surface area of the main river channels, ponds and springs are common in braidplains (Figure 3-1). They may be connected to the main river by groundwater, surface water (temporary or permanent) or a combination of both. Springs, wetlands, ponds, and lower reaches of tributary streams have distinct physical, hydrological and chemical characteristics compared to the main channels of the braided rivers although they are all part of the same body of water (Gray and Harding, 2007). These lateral braidplain habitats have been shown to support the greater proportion of aquatic macroinvertebrate life found within the braided river (Gray and Harding, 2010).

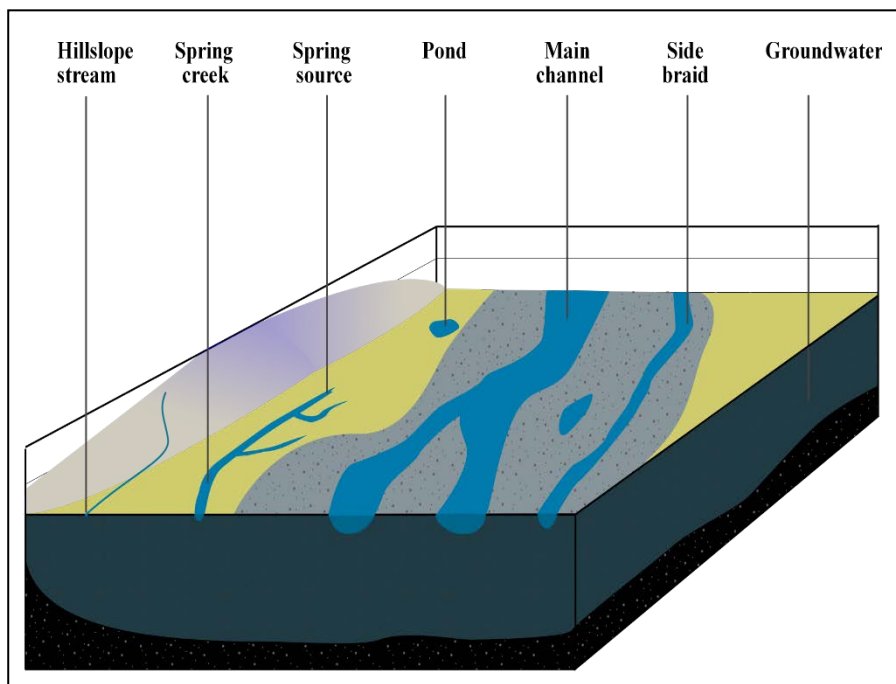


Figure 3-1: Aquatic habitats nested with the wider braidplain may be distinguished by the time since turnover by recently active surface migration and the source of flow; groundwater, precipitation or both

Fish communities in braided rivers are as diverse as the habitats which occur across the braidplain. Of particular note are threatened non-migratory galaxiid populations in South Island rivers and introduced salmonids which support important sports fisheries (Deans *et al.*, 2004). Salmonids inhabit the full length of many braided rivers, but tend to use spring-fed streams in the headwaters for spawning and juvenile rearing. While many diadromous galaxids (or whitebait) inhabit the lower reaches of braided rivers, the headwaters are home to regionally restricted and threatened non migratory species, primarily from the 'pencil-galaxias' group (Goodman *et al.*, 2014; McDowall, 2010).

Braided rivers support feeding and breeding populations of over 80 species of birds, many of which are unique to New Zealand (O'Donnell and Moore, 1983). A number of these birds have specialist adaptations for living on braided rivers including migratory patterns, morphological features, specialised foraging behaviours, narrowly defined ranges of preferred habitats (e.g. bare, unvegetated gravels) and the ability to breed in an unstable river environment (O'Donnell and Moore, 1983).

Braidplains along Canterbury rivers also provide habitat for indigenous lizards, and function as corridors to connect remnant lizard populations (Whitaker, 2008; Department of Conservation Bioweb Herpetofauna) and other unique fauna such as spiders and other invertebrates.

Vegetation of the braided rivers of the Canterbury Plains has been described by Meurk (2008). Exotic plant species generally dominate the vegetation cover of the recently active surfaces and their margins in this part of the region. However, undeveloped or uncultivated area of the braidplain continue to provide habitats for a range of native plant species and their associated fauna that are otherwise scarce in lowland Canterbury (Peat and Patrick, 2001). Undeveloped riparian and wetland habitats on braidplains frequently contain a range of native plants, e.g. sedges, rushes, raupō, flax, cabbage tree under or amongst the surrounding exotic vegetation (e.g. Blakely and Todd, 2005).

Native and 'semi-native' vegetation types are more extensive along the undeveloped braidplains of inland Canterbury than on the low plains, with 'naturalness' of the vegetation generally increasing further inland. On the recently active surfaces, open gravels with a naturally-sparse vegetation cover of native herbs and mat plants become the typical, rather than unusual, feature. Wetland and riparian habitats of inland braidplains typically support native tussock, sedge and rush vegetation. Terrestrial habitats of undeveloped young and mature braidplains are mostly covered in native or semi-native scrub, shrubland and tussock grassland vegetation. However, invasive leguminous shrub weeds (e.g. gorse, Scotch broom, tree lupin, Russell lupin) remain common, and in many places active weed management is required to maintain these 'natural state' habitats. River protection plantings in inland Canterbury are of far more limited extent than in lowland Canterbury. Naturalised willows trees are generally less common than on the Canterbury Plains river margins, although they are locally abundant in some areas. Other introduced shrub and tree weeds include false tamarisk and wilding conifers.

It is important to note that the majority of ecological values and ecosystem functions are dependent upon the natural character of braided rivers. The high degree of braidplain turnover by flooding and patchy mosaic nature of the braidplain habitats are essential for the co-existence of the many species associated with braided rivers. Factors that alter the natural character of these rivers will inevitably impact upon ecological functions and populations of indigenous species.

4 Character change in braided rivers - threats

4.1 Introduction

The character of braided rivers and their braidplains, and consequently their ecological values, are dependent upon factors operating at two spatial scales; catchment and reach (Section 2). Activities which alter the hydrology, sediment supply, braidplain breadth and erodibility will all change the character of a river. Demand for both water and gravel outside of the river network, engineered or land use constraints on the movement of channels within the braidplain and the spread of invasive exotic plants are the primary drivers of change in braided river character.

4.2 Catchment scale

4.2.1 Impoundment and abstraction

At the catchment scale impoundment may result in a fundamental change in the flow regime and sediment supply to a river. A dampening of flood peaks and reduction in supply of mobile sediments can result in a braided, multichannel river changing towards a more stable, single channel system. This is because, typically, it is the large to medium flows of a river that transport the most sediment and promote channel migration thereby influencing the rivers geomorphology.

There is the potential for large flood harvesting water abstraction to have a similar effect on braidplain morphology, although the abstraction would have to represent a large proportion of the flood to have an appreciable effect.

Although it is predominantly large to medium flows that drive geomorphic change, alterations to base flows also impact upon ecological values through, for example, change in area of wetted habitat, fish passage and the opening of river mouths to the sea.

The effects of impoundment have been well documented in the Waitaki and Opuha rivers in Canterbury (Lessard *et al.*, 2013; Hicks, 2011; Hicks *et al.*, 2006; Hicks *et al.*, 2003). Both of these rivers now require active intervention such as large scale vegetation control (see Hicks, 2003) to maintain the vestiges of their natural character. While further impoundment of the main stems of some braided rivers is now prohibited through the LWRP or Water Conservation Orders, there remains considerable demand to harvest flood waters and abstract base flows for irrigation.

4.2.2 Land use change

Land use change outside of the braidplain has the potential to impact upon water quality, sediment supply and flow characteristics of some braided rivers. Large alpine sourced rivers, such as the Rakaia and Waimakariri rivers derive the majority of their flow from the main divide and have few significant tributaries outside of alpine areas. As such water quality is typically good and in the absence of impoundment or large flood harvesting abstractions, natural flow regimes and sediment supply are retained. However, smaller rivers draining the foothills, such as the Waipara or Pareora rivers show clear declines in water quality due to adjacent land use (Hayward *et al.*, 2003).

4.3 Reach scale – within the braidplain

4.3.1 Introduction

At the reach scale, braidplain narrowing and land use are the most influential factors driving change. As the braidplain becomes constrained by invasive exotic vegetation, flood defence works, agricultural encroachment, or a combination of these, the balance of habitats is altered and natural character reduced. Land use change within the braidplain alters natural patterns and impacts upon quality and extent of aquatic, wetland and terrestrial habitats. Activities such as gravel extraction and recreational use impact upon ecological values for example by disturbing nesting birds and facilitating weed invasions. However, gravel extractors have also contributed to braided river bird habitat creation projects for example on the Waitaki River. Finally, mammalian and avian predators have a considerable impact upon nesting bird, lizard and presumably terrestrial invertebrate populations.

4.3.2 Flood protection management

The Soil Conservation and Rivers Control Act 1941 s126(1) states that “It shall be a function of every Catchment Board [now Regional Council] to minimise and prevent damage within its district by floods and erosion”. Subsequently, the RMA stipulated that flood management must be carried out in a sustainable manner with respect to the ongoing use of natural and physical resources while maintaining the life supporting capacity of ecosystems. There are various legislative tools to manage the economic, social, environmental and cultural values of the natural character of braided rivers, including the recognition in the RMA that the natural character of rivers and their margins are a matter of national importance. However, to date, flood defence activities have generally continued more or less in the same form as prior to the introduction of the RMA. Flood and erosion control activities have typically taken precedence over effects on the natural character of rivers. This is justified by the natural tendency of these rivers to laterally migrate through the locations of settlements, infrastructure and agricultural land.

A number of methods are used to prevent migration of braided river channels beyond a desired lateral extent. Permanent structures such as stopbanks and groynes may form the final line of defence. Between these structures and the desired recently active surface or fairway, vegetation is planted or allowed to establish, in order to “train” or “stabilise” the river. Planting fast growing, flood resistant tree species, such as varieties of Matsudana Willow prevents active river surface migration, although the use of especially weedy tree species, such as the crack willow is now prohibited. Additionally, gravel

ripping may be undertaken, which involves cutting deep furrows, akin to ploughing, in the braidplain which loosen gravel and guide flood flows back towards the desired channel location. Within the desired channel location vegetation may be removed to improve flood capacity. Gravel extraction is undertaken in aggrading reaches (where gravel is accumulating) to encourage the river to stay within the existing recently active surface.

The Canterbury Regional Council is responsible for managing 60 River and Drainage Ratings Districts covering 2,000 km of the 78,000 km of river in the region (Oldman & Surman, 2015). Targeted rates are collected within the districts to fund the maintenance of flood defences, supplemented by limited general rate funding. The focus of the majority of these ratings districts is on clearing vegetation from the desired recently active surface and protecting and /or enhancing flood and erosion protection vegetation on the margins or “berms” of the recently active surface.

Outside of the river ratings districts, Canterbury Regional Council is less involved in flood defence although it does provide advice to land holders and manage gravel extraction (Oldman & Surman, 2015). Within a rating district, if a river should breach defences, there is generally an expectation that defences will be re-instated. Outside of the rating districts, there is neither general rate funding nor an obligation to manage the flood risks from the river. Works in these areas are generally undertaken by individual land holders or groups (typically requiring resource consent).

The CWMS put a “line in the gravel” with a target “From 2010, maintain the braided character of all Canterbury’s braided rivers by ...maintaining the extent of active floodplains, flow variability and sediment flow processes including when undertaking river protection works, land use change or deliberate vegetation stabilisation”. It remains a challenge for targets such as this to become embedded into policy, plans, actions and organisational culture and for them to be reconciled with the existing flood and erosion protection function of the Council.

4.3.3 Land use change in the braidplain

A major current issue for both flood defence and ecosystem management is one of land use change on the braidplain (Grove *et al.*, 2015). Both within and outside of ratings districts vegetation has been cleared and *ad hoc*² flood defences have been constructed to allow agricultural intensification of previously undeveloped braidplain (Figure 4-1). This can have implications for existing flood protection works due to the loss of lateral vegetation which helps control the location of the recently active surface of the river. It also further constrains the available extent of the braidplain impacting upon ecosystem and natural character values. Intensification of land use surrounding lateral braidplain aquatic habitats, i.e. ponds, streams and wetlands, can also result in a degradation of water and habitat quality from agricultural runoff, and direct stock access.

Grove *et al.* (2015) showed that between 1990 and 2012, a total of 11,630 ha of formerly undeveloped or forested river margin land on the lowland Canterbury Plains was converted to intensive agricultural use. Approximately 60 % of this area was freehold land, 24 % was public and the remaining 16 % was unallocated or previously unoccupied crown land. Given the already constrained state of braidplains due to flood defences, this further encroachment is significant from the braidplain ecosystem and natural character perspective. The same process of braidplain vegetation clearance and agricultural intensification is also underway in the high country, but with a greater potential impact due to current higher natural character and ecosystem values in these areas.

² Unconsented flood defences may take the form of vegetation clearance or planting, groynes, mini stopbanks or channel diversion.

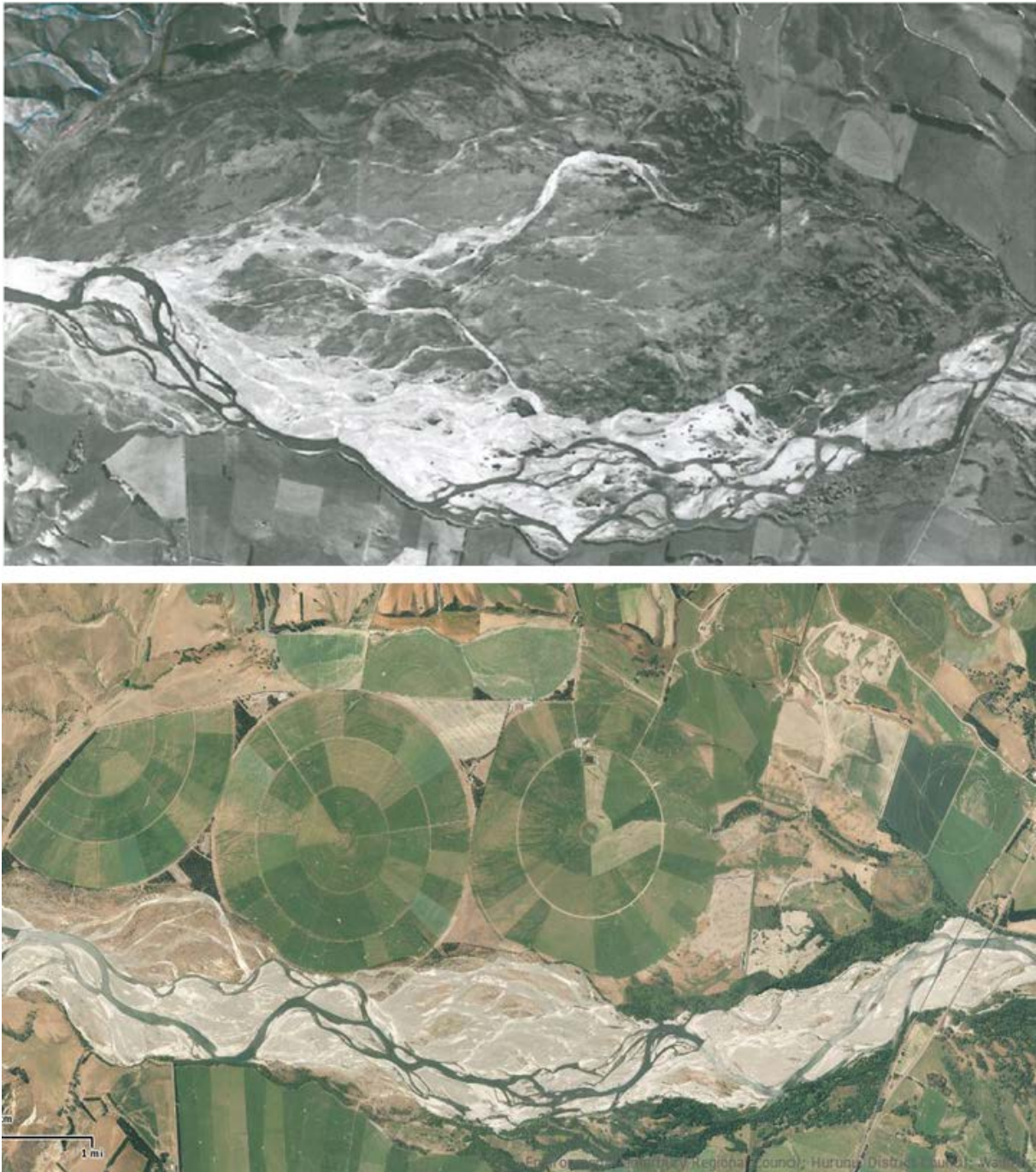


Figure 4-1: An example of agricultural encroachment of the braidplain of the Waiau River between 1966 (top) and 2014 (bottom)

4.3.4 Invasive weeds

The impact of invasive weeds on braidplains is altering their natural character irrespective of the effects of engineering and agricultural encroachment. Willow and poplar trees have been used for many years by river engineers and land owners to prevent lateral migration of recently active channels. However, willows in particular, spread rapidly by vegetative propagation and have invaded large areas of braidplain, such as parts of the Waipara and Rakahuri/Ashley rivers. In addition to reducing migration of the recently active channels, willows choke lateral aquatic habitats such as spring creeks and wetlands. In the Upper Waitaki Basin, Russell Lupins have spread onto the braidplains of several rivers. The lupins degrade habitat for endangered birds by reducing clear space on gravel bars, providing cover

for predators and altering the morphology of the river by encouraging island and bar accretion through trapping fine sediment (DoC, 2007). Although flood events in braided rivers can clear vegetation to expose clean gravels, Caruso *et al.* (2013) and Javernick (2013) observed that even large floods only removed 25 % of the lupins from the Ahuriri river and that the plants quickly re-established. They concluded that the natural flood regime would not be able to remove lupins permanently from the river and as a result without active intervention Russell Lupins would result in a permanent impact upon the ecological values. Gorse, broom and a range of other pest plant species also have the potential to impact upon natural character and ecosystem values through the invasion of braidplains (Kowai River for example).

Weed and pest management is carried out on some reaches of some rivers by Land Information New Zealand and the Department of Conservation, and has been the focus of some actions in Environment Canterbury Zone Implementation Plans. The Ō Tū Wharekai (Ashburton Lakes/upper Rangitata River) partnership project has cleared significant areas of weeds from the Rangitata and Hakatere/Ashburton rivers. However, regionally invasive weeds remain a significant threat to natural character.

4.3.5 Gravel extraction

The impacts of gravel extraction on river morphology were studied by Kelly *et al.* (2005) who found that rates of extraction in excess of supply had significant effects on channel morphology. The extraction caused a narrowing and incision of the channel and reduction in the likelihood of channel migration and braiding. This effect was less pronounced when extraction matched supply, but would have resulted in a lesser degree of braiding than if no gravel was extracted. Gravel extraction is one technique used to guide active river channels and prevent flood defences being breached in aggrading river reaches.

In Canterbury gravel extraction is a primary tool in the management of flood defence and is a significant commercial enterprise. Sustainable gravel extraction is managed through the Land and Water Regional Plan via the Canterbury Regional River Gravel Management Strategy (Environment Canterbury, 2012) and the Canterbury Regional River Gravel Extraction Code of Practice (2017). These documents acknowledge the importance of flood defence, while providing for cultural values and the protection and where appropriate enhancement of environmental values.

4.3.6 Recreation

Human access, on foot or by motorised vehicles, is a significant value of braided rivers but, is also implicated in a number of concerns for the biodiversity values and natural character of braided rivers. Invasive terrestrial and aquatic plants can be spread over large distances by recreational traffic. Recreational use, particularly 4WD vehicles, may result in the crushing of bird eggs, lizards, invertebrates and fragile plant communities (O'Donnell *et al.*, 2016). Birds may also vacate nesting sites due to regular disturbance from traffic, humans or their pets. Bow waves from jet boats disturb nesting birds.

The favoured current mechanisms to reduce the impact of recreational use on ecological values and natural character are through educational programs and the restriction of access to vulnerable areas of the recently active surface. However, it is currently unknown to what extent these activities impact upon ecological values and pest plant incursions nor how effective are control measures (O'Donnell *et al.*, 2016).

4.3.7 Predators

Mammalian predators have an enormous impact on threatened native birds that breed on braided rivers (O'Donnell *et al.*, 2016; O'Donnell & Moore, 1983). Lizards and terrestrial invertebrates are also likely to be adversely affected by predation (Reardon *et al.*, 2012). Cats, possums, hedgehogs and mustelids all prey upon nesting birds and chicks and their ability to do so is likely to be enhanced by the impacts of character change described above. A reduction in the area of clean gravels, gravels surrounded by water or available breadth of braidplain concentrates the remaining nesting birds and makes them more vulnerable to predation.

Any braided river management plan intending to address the decline in specialised bird species would need to consider the interaction of character change and mammalian predators. Numerous predator trapping and poisoning operations have occurred over the last 30 years. However, only a limited number

have resulted in measurable benefits to bird populations (O'Donnell *et al.*, 2016). Equivocal results from predator control are assumed to be due to programs not being implemented at a great enough scale and intensity or failing to target the predator species responsible for native fauna mortality.

Effective predator control or mitigation programs (such as island creation) are an area of active research by the Department of Conservation. Environment Canterbury and community groups are also involved in such projects. Predator control programs that are undertaken jointly between organisations have the potential to suitably prioritise and maximise effectiveness. In some situations, native avian predators have equal or greater impact. For example the proliferation of southern black-backed gulls (*Larus dominicus*) since European settlement (see O'Donnell *et al.*, 2016).

4.4 Summary

The primary threats to natural character and ecological values of braided rivers are summarised in Figure 4-2. Natural character of braided rivers, in this context, is multifaceted and incorporates the full spectrum of natural character values associated with braided rivers under a single umbrella. There are a number of activities, such as engineering works, that are considered as a threat to natural character despite their considerable value to society. Including engineering works as a threat does not diminish the overall importance of this activity as detailed in section 4.3.2, rather it highlights there is a conflict between the value and the impact that needs to be balanced. As such engineering works are considered to be a significant and ongoing threat to natural character, but that there is an effective management pathway/infrastructure in the form of Rating Districts and the Regional Council river engineers. Other threats, such as abstraction and flow modification, are considered to be adequately managed via established pathways to preserve natural character and ecological values. Finally, there are a number of issues that are significant and ongoing and that lack an adequate management pathway or mechanism to protect natural character. Activities in the braidplain, particularly encroachment by agricultural development, *ad hoc* erosion protection by individuals, exotic weed invasion and control of predators lack a cohesive management strategy between stakeholders and have the potential to drastically alter the natural character and ecological values of Canterbury braided rivers as well as others around the country.

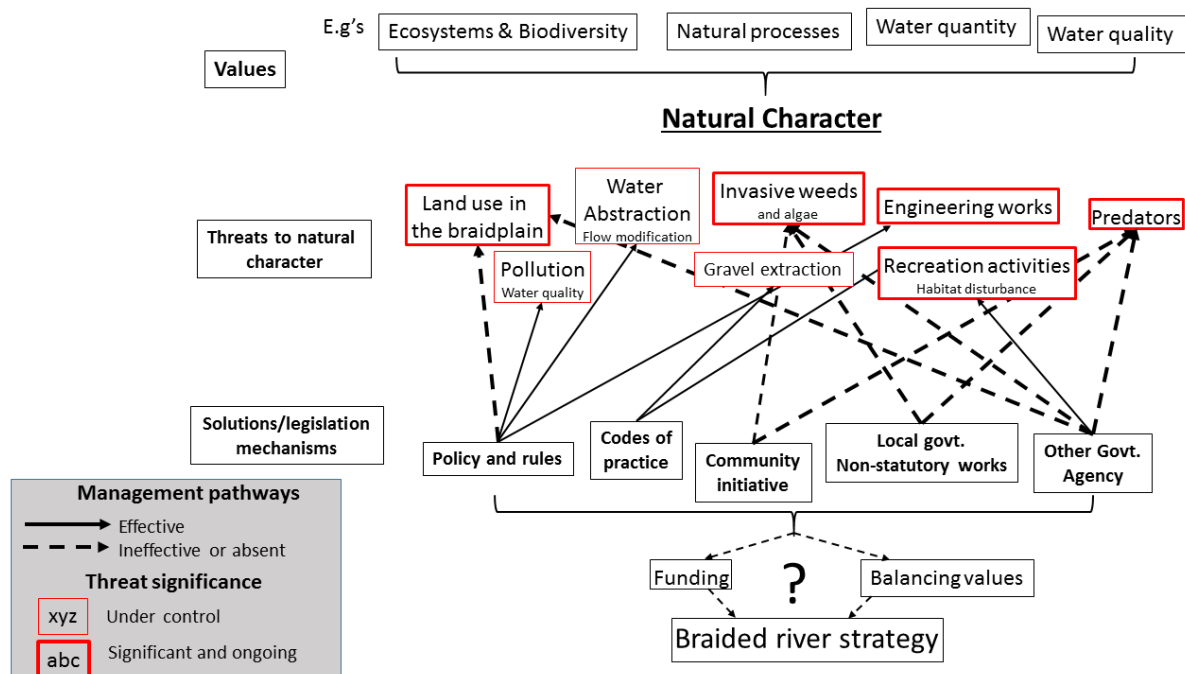


Figure 4-2: Summary diagram of values, threats to natural character and management mechanisms currently available for braided river. Arrows indicate major management pathways and the degree (dashed versus solid) to which they are considered adequate to manage threats to natural character

5 Options for more effective management

5.1 Introduction

There appear to be two main groupings of braided river issues that are having an ongoing significant impact upon natural character; those that constrain the movement of the recently active channels, narrowing the braidplain and activities which impact directly upon specific ecological values.

5.2 Braidplain narrowing

The braidplain of a river may be constrained, legally or illegally, by flood defence engineering, agricultural development and/or invasive weeds. While rarely mutually exclusive we discuss the implications and potential solutions to each issue below.

5.2.1 Flood defence engineering

River engineering within Rating Districts or performed under a consent is regulated by policy, rules and codes of practice, which increasingly seek to balance the competing interests of natural character and biodiversity with the protection of assets and infrastructure. Historically engineering techniques have been applied with limited regard for impacts upon ecosystem and natural character values. Consented works outside Rating Districts tend to be piecemeal and uncoordinated, with the individual and cumulative impact on natural character downplayed and often underestimated. However, this is an area with potential for improvement through collaboration between river engineers, geomorphologists and ecologists and others, particularly where opportunities for braidplain restoration exist.

Ad hoc and unconsented (where a consent ought to be gained) flood defences, typically associated with agricultural development, are a greater concern for natural character and biodiversity because these works are planned and implemented without due process, or consideration and mitigation of impacts.

Given the clear conflict between the management of braidplains purely for flood defence and the sensitivities of ecosystems, this topic is deserving of further investigation and collaboration between river engineers, planners and ecologists. Guidelines and planning rules that clearly define viable areas of compromise between outcomes would be beneficial.

However, both legal and illegal flood defence activities are difficult to manage, in part, due to the uncertainty about the spatial extent of RMA riverbed and jurisdiction of the various planning frameworks. Clear guidance on planning frameworks and their spatial jurisdiction needs to be provided to land owners, tenants and contractors.

5.2.2 Agricultural development

Agricultural development of braidplains typically begins with the clearance of any vegetation present. Accordingly, the planting or clearance of vegetation associated with braided rivers is managed by the LWRP with acknowledgment of its value for biodiversity. However, although the Canterbury Water Management Strategy, Regional Policy Statement and objectives and policies within the Land and Water Regional Plan (LWRP) outline the ecosystem values and natural character values associated with braided rivers, it is only recently that these values have been explicitly protected in the vegetation clearance rules of the LWRP. Plan Change 4 of the LWRP prevents (in the absence of a resource consent) 'the clearance of vegetation and earthworks in the beds of Canterbury's seven big braided rivers'. Plan Change 4 sends a strong message that further development within the bed is to be prevented so as to preserve the natural character, biodiversity and habitat of these rivers. However, Plan Change 4 does not provide definitive guidance on the lateral extent of the braided river or its bed outside of the flood bylaw lines within river ratings districts.

Consequently, it remains difficult to apply vegetation clearance rules within the seven big braided rivers and policies in all other braided systems because the actual extent of the braided river has not been defined or delineated outside of the flood bylaw line. The LWRP defines a braided river as 'any river with multiple successively divergent and re-joining channels separated by gravel islands'. However, this

definition provides no indication of the lateral extent of a braided river and its margins. Although an area of land may obviously be adjacent (or “immediately adjacent”) to a braided river it is often not clear if rules and policies pertaining to braided rivers are applicable or not.

5.2.3 Invasive weeds

Invasive weeds, as distinct from vegetation planted or managed to control flooding and river migration, have the potential to drastically alter the natural character and ecological values of braided rivers. Although there are localised programs to control or eradicate weeds there is a lack of a strategic plan to address the issue region wide. Weeds with the potential to impact upon braided rivers are present in the majority of catchments, particularly across the plains reaches. Any attempt to control weeds on braidplains will require careful prioritisation and collaboration between agencies, land owners and community groups. The specific impacts of particular weeds on braided river morphology is the topic of ongoing research by NIWA.

5.2.4 Combined effects

There is often overlap with invasive weeds and planned or reactive flood defences combining to constrain rivers, reinforced by agricultural development behind these constraints, leading to increased desire from landowners to protect their investments by further narrowing of the river. Timeframes for river movement across the braidplain can be very long (decades to centuries) so an expectation of river stability reinforces agricultural development at the expense of the diverse ecosystem functions and habitats exhibited by a fully functioning braided river.

5.2.5 The primary issue

The continued narrowing of braided rivers, resulting loss of natural character and absence of a cohesive management strategy appears to be partly the result of an absence of an accepted definition and delineation of the physical and jurisdictional boundaries of these rivers.

This situation appears to derive from the incompatibility between the definition of river bed in the RMA and the physical form of braided rivers (Figure 5-1). The RMA defines a riverbed as ‘the space of land which the waters of the river cover at its fullest flow without overtopping its banks’. However, braided rivers have many ‘banks’ and do not necessarily inundate their entire braidplain, rather they migrate across it over time.

Figure 5-1 shows one of many potential interpretations of the jurisdictional extents across a braidplain. In this example only the recently active bed is considered ‘riverbed’ and the wider braidplain is considered land with considerable ramifications for the natural character and ecological values of the river. The RMA riverbed definition is very difficult to apply to a braided river, but typically does not incorporate the entirety of the braidplain. In addition there is a resulting requirement to determine the boundary of the river bed on a case by case basis. Therefore, the restrictions in Section 13 of the RMA cannot currently be relied upon to support biodiversity and natural character outcomes in braided rivers.

Alternatively, it could be acknowledged that managing the RMA riverbed is only one part of achieving natural character and biodiversity outcomes, but that the values extend beyond the RMA riverbed and other planning provisions may be necessary. One possible option would be to define and delineate the ‘braidplain’ which incorporates the full physical extent of these rivers and provide policies and rules to suit. Irrespective of potential future terms of reference and planning frameworks the current situation is confused and has resulted in a loss of braidplain, natural character and ecological values as well as considerable uncertainty for adjacent communities.

The effective regulation of land use upon braided rivers and the establishment of a management strategy to deal with invasive weeds, mammalian pests and recreational impacts cannot meaningfully proceed until the extent of the braided river is determined.

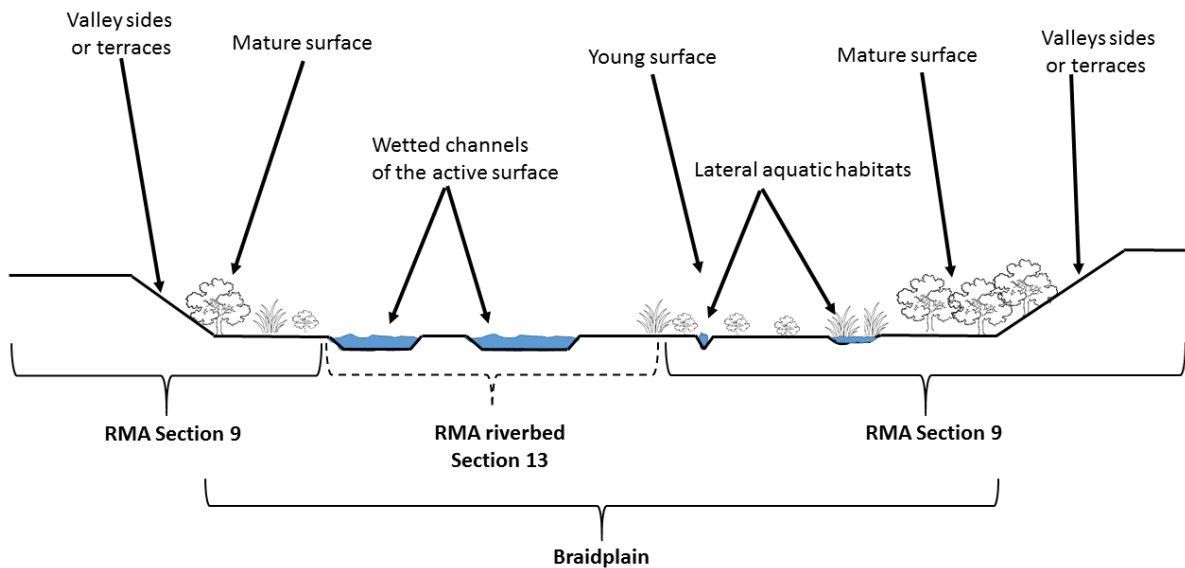


Figure 5-1: Transverse view of a braided river showing (at bottom) one of many potential interpretations of the components of the system defined by the RMA and jurisdictional functions used to manage natural resources

5.3 Direct impacts on ecological values

Predation on native fauna, damage caused by recreational users and the introduction and movement of pest species to rivers require a coordinated response between statutory agencies, land holders and community groups. Due to the vast size and complexity of the issue careful prioritisation is required to focus resources and achieve tangible outcomes. The Department of Conservation is active in managing many of these issues and recently published its management and research priorities for braided rivers (O'Donnell *et al.*, 2016).

5.4 Summary of management options

The preservation of the extant natural character and ecological values of Canterbury braided rivers requires the creation of a broad ranging and cohesive braided river strategy. The strategy will require interdisciplinary input from river engineering, science, biosecurity, land management, planning groups, other agencies, industry and the Canterbury community.

A critical first step would appear to be a clear definition of the physical extent of a braided river. A subsequent clarification of the permitted activities within a clearly defined area of land would remove uncertainty for land owners and resource managers allowing a conversation about the future of braided rivers to occur. How the braided river is subsequently managed must take into account impacts upon land use, livelihoods, cultural values and the economy as well as biodiversity and natural character.

5.5 Recommendations

- Define and delineate the physical and jurisdictional components of braided rivers to permit the implementation of existing policy and rules and provide a spatial extent for a braided river management strategy.
- Undertake community consultation to inform the management strategy.
- Collaboration between river engineers, land managers and scientists to achieve more holistic management of braided rivers within river Rating Districts.
- Collaboration (including external agencies) and coordination to implement the braided river management strategy regionally.

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