Taieri River Morphology and Riparian Management Strategy (Strath Taieri)

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Overview

The Taieri River morphology and riparian management strategy has been prepared by the Otago Regional Council (ORC), with input from the local community, to help protect the recreational, cultural and ecological values of the Taieri riverbed and to enable long-term sustainable use of the land which borders the river. The strategy, as summarised in the two diagrams overleaf, is intended to help achieve this by guiding work programs, decision making, and activities, for the community, stakeholders, and ORC. It is therefore recommended that people who live, work or play within the Taieri River catchment consider, and give effect to the principals, objectives, and actions listed in this strategy.

The strategy is not a statutory document; rather it is intended to present the aspirations of the community and the various stakeholder agencies. However, the statutory processes which do influence river management activities[1] are more likely to be used effectively and efficiently if there is a general consensus on what is valued about the river, and commonly understood objectives.

The strategy is intended to be a living document, which will evolve in response to new information, changes in the environment, the needs of the community and the work of the ORC and other stakeholders. The strategy will be reviewed regularly, and this process will involve landowners with property alongside the river, other stakeholders and ORC,[2] and will help to set priorities and work programmes for all of these groups. The strategy document will also record progress made towards achieving the stated objectives, It is intended that version 2 of the strategy will include further guidance and plans for undertaking planting on riparian margins, for river management purposes and for habitat enhancement.

[1] Including the Local Government Act (in regards to funding considerations), and the Resource Management Act (in regards to environmental effects)

[2] In particular, staff with responsibilities for river ad waterway management and natural hazards

Taieri river morphology and riparian management strategy - overview

Purpose

- To provide guidance to landowners, stakeholders, and the community for good decision-making and appropriate activities within the riverbed and on the riparian margins of the Taieri river.

Vision

- The long-term sustainable use and enjoyment of the Taieri River and its riparian margins.

Functions

Appropriate guidance and active engagement to empower good decision-making and to ensure that activities are undertaken in a sustainable and appropriate manner

Understand natural river processes and morphological characteristics, and the potential effects of those on the river and its margins.

The wise use of resources to:
- manage the risk to property and assets
- enable sustainable gravel extraction
- protect and enhance community values
- improve community resilience.

A shared vision of the rivers values and features to be utilised, preserved and enhanced.

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Taieri river morphology and riparian management strategy - overview

Objectives & associated activities (these are further refined in Section 8 - implementation)

Objective 1.
To recognise and characterise natural river processes.

- collect information about flood and erosion processes
- report on changes in channel morphology
- provide information to the community
- identify the location of river corridors, within which the river will naturally meander.

Objective 2.
To equip the community to live with the effects of changes in river morphology.

- promote land-use practices and the placement of assets which reduce the risk associated with changes in riverbed morphology
- consider all available options to manage the effects of bank erosion, including structural and non-structural options
- enable works that will, where necessary, improve the conveyance of floodwater and 'train' the river within its natural corridor, without compromising the features which are of high value to the community and iwi.

Objective 3.
To enable sustainable gravel extraction.

- identify areas where gravel accumulation can naturally occur
- identify areas where permanent removal of gravel may have a detrimental effect on assets, riverbed morphology or community values
- identify minimum bed levels/profiles, below which extraction will not occur.

Objective 4.
To promote activities that enhance the natural character and enjoyment of the river.

- provide maps showing the location and characteristics of features which are of high value to the community
- encourage the establishment of riparian plantings that are practical and appealing
- provide access and habitat for fishing and white-baiting activities
- support pest and weed control activities.
- discourage dumping, and arrange the regular collection of rubbish.

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1. Introduction

Changes in the morphology (physical form) of riverbeds occur as a result of natural processes that are often uncontrollable, and also from human intervention. The Taieri River bed is an integral part of the wider Taieri River catchment (Figure 1). The Taieri riverbed is part of a dynamic river system, and has experienced changes in morphology in recent decades. These changes will have occurred in response to naturally occurring flood events, as well as gravel extraction activities and historic river management decisions. Changes to riverbed morphology have included degradation[3] and sedimentation within the main channel and significant bank erosion in places (Figure 2). In some cases these changes have negatively affected the values placed upon the river by the community and stakeholders (landowners, iwi, Fish & Game New Zealand, Department of conservation (DoC), Dunedin District Council (DCC), and residents).

Land alongside the river channel is often referred to as the 'riparian margin'. More intensive use of the land that borders the river has occurred in recent decades, with valuable farmland replacing what was previously rough vegetation. As a result, changes in the position and form of the riverbed can cause issues for landowners and other river users.

The Otago Regional Council (ORC) has proposed the Taieri River morphology and riparian management strategy ('the strategy') to help provide guidance (for all users of the rivers) for good decision-making and appropriate activities on the riverbed and riparian margins of the Taieri River. The strategy has a vision of long term sustainable use and enjoyment of the Taieri riverbed and its riparian margins. It is also important when undertaking activities within the riverbed and on the riparian margins of the Taieri River that people recognise, and allow for, the traditional, spiritual, and cultural values of the local iwi.

- The strategies key objectives are to:
- Recognise and characterise the natural river and catchment processes that occur in the Taieri River.
- Equip the community to understand, and live with, the effects of changes in river morphology
- Enable sustainable gravel extraction
- Promote activities that enhance the natural character and enjoyment of the river.

The strategy is also intended to guide the natural and extent of land use, so that the negative effects of morphological changes in the riverbed do not increase, and where possible, are progressively reduced. It provides a framework for decision-making, so that activities undertaken by people occur in such a way that results in:

- A visually appealing river system
- A habitat that supports existing wildlife, fish, and preferred plant species

[3] The term 'degradation' in this case refers to the wearing down of the channel by the erosive action of water

- Limited effects on assets as a result of flood events
- Resilient infrastructure (roads, bridges, water supply)

Many of the actions listed in this strategy are voluntary and will rely on interactions between the key stakeholders and the community to be successful. It is therefore recommended that people who live, work, or play in the Taieri River catchment consider, and give effect to, the principles, objectives, and actions listed in the strategy.

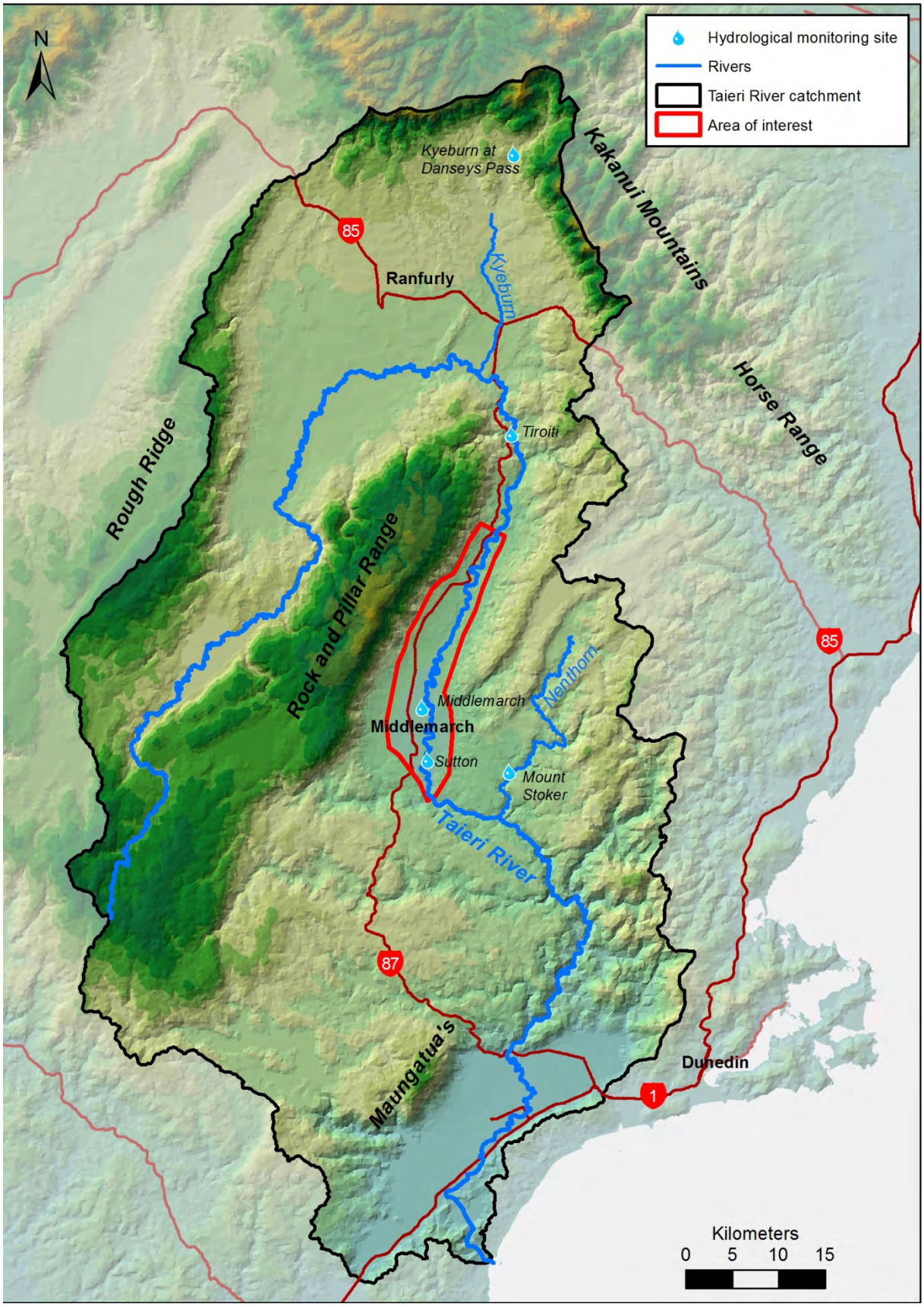

Figure 1. **Taieri River catchment boundary, showing main tributaries and the area of interest**

Figure 2. **Examples of changes in channel morphology. Top: Bank erosion at 0.8 km downstream of the Moonlight Road bridge (November 2015), bottom: bank erosion and channel migration 5 km upstream of Ngapuna (November 2015)**

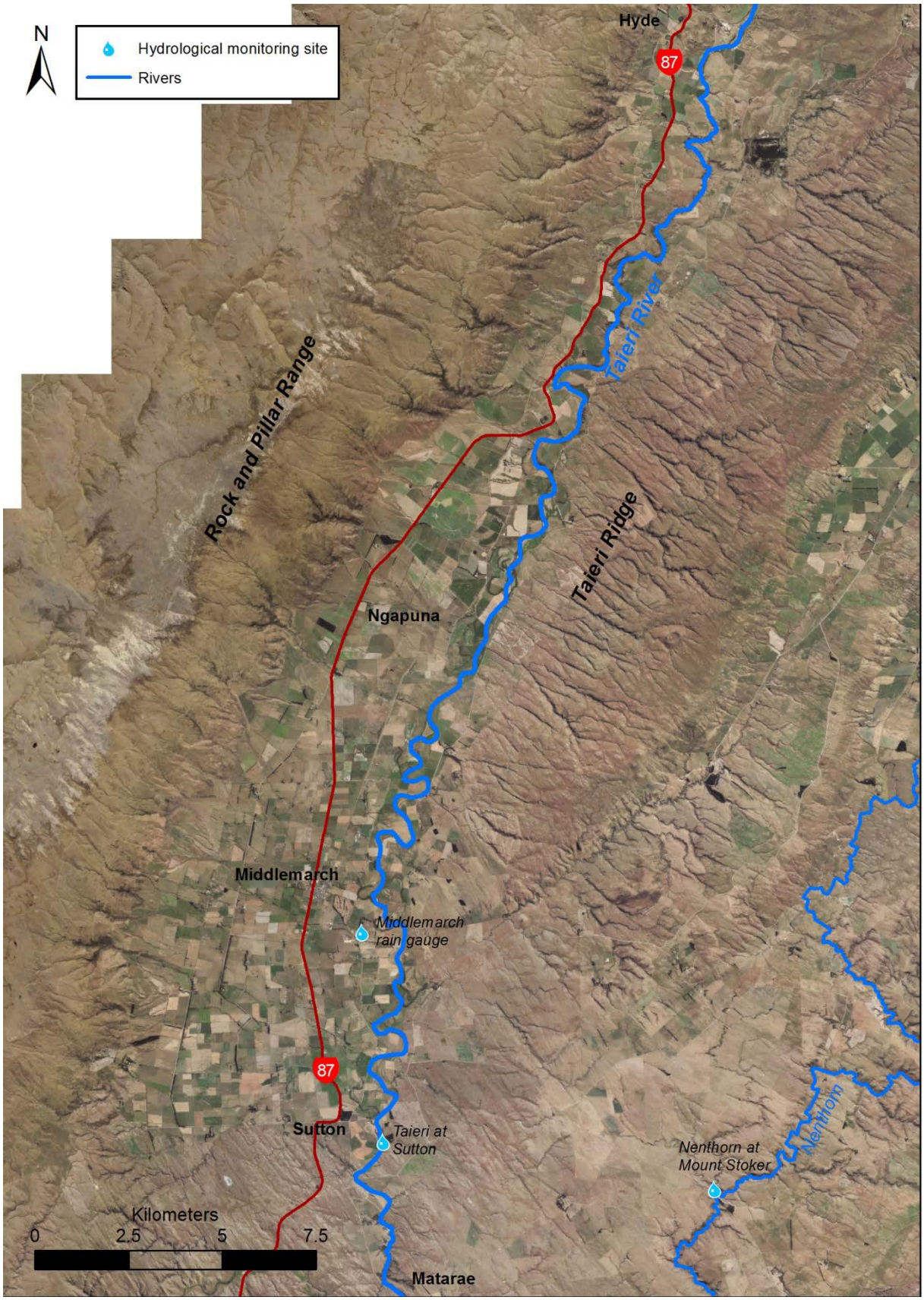

Figure 3. **Map showing the reach of the Taieri River to which this strategy applies, and other main tributaries of the Taieri River**

2. Scope

2.1. Study reach

The geographical scope of the strategy is the reach of the Taieri River between the gorge downstream of Hyde (Hyde Gorge) to Matarae (Figure 3). Activities that occur in the upper catchment of the Taieri River and in other tributary streams may have an effect on the study reach. The Strath Taieri area (study area) slopes from about 300 m (above sea level (asl) in the the north to 150 m asl in the south. Numerous short watercourses join the Taieri River in this reach and are sourced from the Rock and Pillar Range. The upper reaches and tributary streams were not investigated, because most concerns previously raised by the community concerned the study reach. The focus was therefore on this location. Other areas in the Taieri River catchment may also experience problems and issues associated with river processes; however these are not examined here.

2.2. Risk

The strategy has a focus on the risks and effects associated with changes in riverbed morphology (including channel degradation and bank erosion, sedimentation, and flooding) in the study reach of the Taieri River. However, it is acknowledged that heavy rainfall events may lead to a range of other risks, including widespread flooding and surface runoff.

There are several other environmental issues and hazards in the Taieri River catchment. These include natural hazards such as seismic activity, as well as water quality and quantity issues. While numerous other issues do exist, this strategy is primarily concerned with the negative effects of changes in river form on the values associated with the Taieri River. Guidance and regulations relating to other issues can be obtained from the ORC. [4]

2.3. Strategy development

The strategy is intended to be a living document, which will evolve in response to new information and changes in river morphology,[5] the needs of the community and the work of the ORC and other stakeholders. It will be reviewed regularly as part of council's annual and long term planning process, or in response to large flood events. The review process will involve landowners with property alongside the river, other stakeholders, and ORC staff with responsibilities for rivers and waterway management and natural hazards. The review is proposed to monitor the effectiveness of the strategy, the workability of its stated objectives and to note progress towards achieving those objectives. It will also help ORC to set priorities when considering funding and undertaking river-maintenance work in the rivers concerned.

[4] For example. The Otago Natural Hazards Database, the Water Info website and the Regional Plan: Water, all available from www.orc.govt.nz

[5] Including additional understanding gathered during future flood events

Before the review process, ORC will arrange and facilitate a workshop with the local community and invited stakeholder groups. This will consist of two parts:

- An opportunity for participants to present to the group any issues they face as to changes in channel morphology or riparian management; work they have undertaken or would like to see undertaken; or to discuss, question or suggest changes to the strategy itself.
- A facilitated process to coordinate activity and work towards achieving the principals and objectives outlined in the strategy

3. Environmental setting

The natural and social settings of the Taieri River catchment are described in this section with a particular focus on the special characteristics that give rise to the risks associated with changes in riverbed morphology.

3.1. Geological setting

The reach of the Taieri River to which this study applies is located on the floodplain between the Hyde Gorge and Matarae. Sediment has subsequently been eroded from the hill catchments upstream and at the study area to create the wide, flat floodplain within which the river sits. The geology of the floodplain and adjacent fans are described as Quaternary age (2.5 million years before present) gravels (Forsyth, 2001). The hills surrounding the study area are made up of schist of Permian age (299 to 252 million years before present) with some volcanic intrusions of Miocene age (23 to 5.3 million years before present) (Forsyth, 2001).

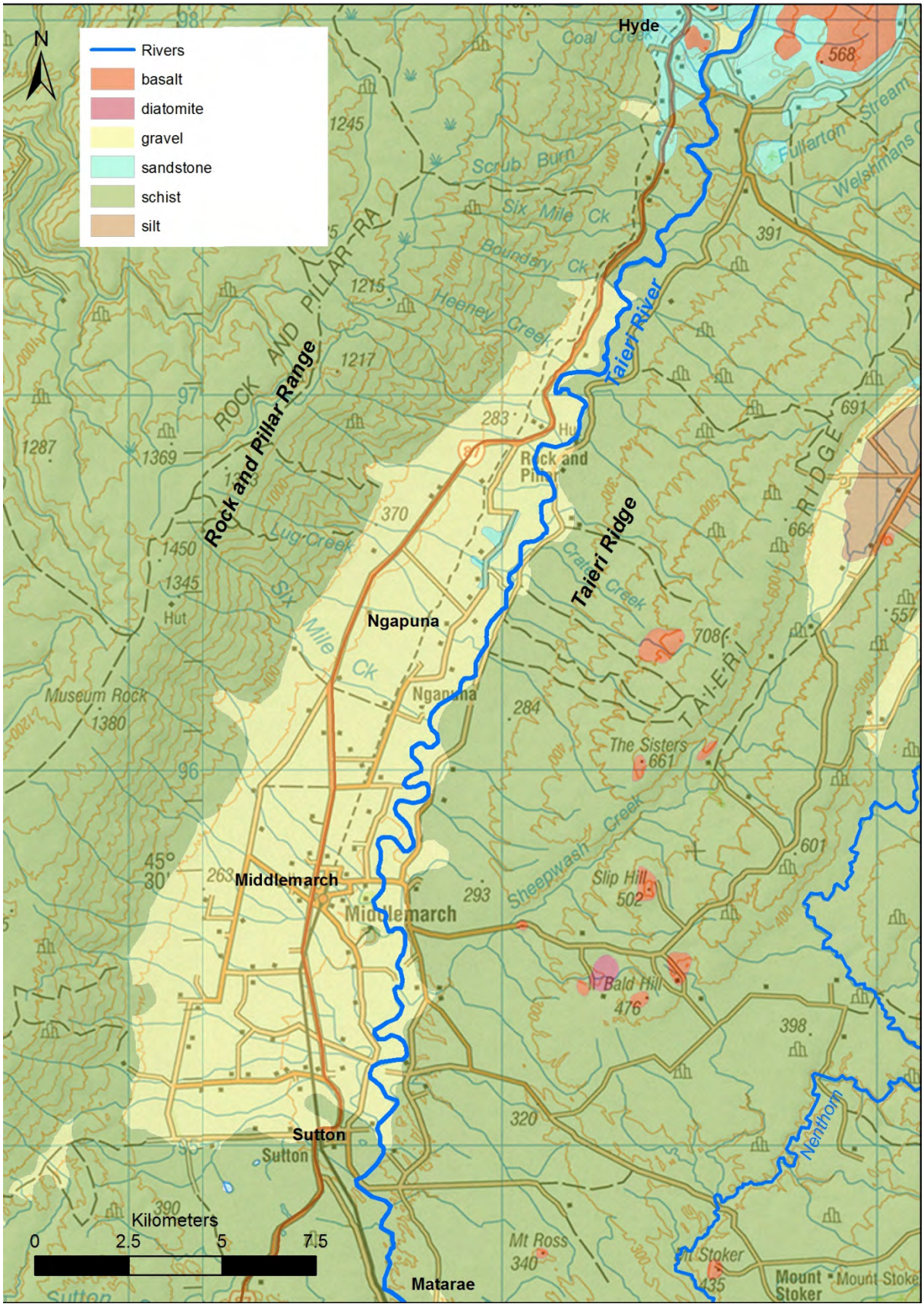

Figure 4. **Geological map showing the reach of the Taieri River to which this strategy applied. The period the rocks were formed in is shown.**

3.2. Geographical setting

The Taieri River begins in the Lammermore and Lammerlaw Ranges (Figure 5) and flows north towards Ranfurly before turning south at Waipiata and flowing through the Strath Taieri region and out towards the Taieri Plain and its confluence with the Pacific Ocean at Taieri Mouth. The Taieri River has a total catchment area of about 5,700 km^2 and has a varied topography that comprises of low mountain ranges, areas of steep hill country, large areas of gently rolling hillcountry, and three major plains (ORC, 1991). Farming is the major landuse in the catchment with sheep and beef farming occurring in the steeper areas of the catchment with more intensive sheep and cattle farming as well as dairying occurring in the flatter plains areas.

The major tributaries of the Taieri River are the Loganburn (which drains from the Loganburn Reservoir), the Kyeburn, Sutton Stream, Deep Stream, Lee Stream, Nenthorn Stream, and the Silverstream and Waipori River which join the on the Taieri Plain. The only main tributary which joins the Taieri River in the study area is Sutton Stream which flows into the Taieri about 1 km upstream of Matarae.

Figure 5. **Upper Taieri River catchment in the Lammermoor Range (Google Earth) (May 2014)**

3.3. Meteorological setting

The Taieri River catchment is located on the east coast of the South Island, within the Central Otago and Dunedin City District's. Flood events in the Taieri River catchment are generally caused by southerly or easterly flood producing storms and are associated with slow moving depressions that may stall over the Taieri catchment (ORC, 2013). Due to the horse shoe shape of the Taieri River as well as the combination of wetlands/scroll plains, gorges, and floodplains the pattern of flood flows can vary considerably throughout its length (ORC, 2013).

The Taieri River at Sutton hydrological site generally experiences two flood peaks during flood events but may experience up to four peaks during large floods (OCB, 1983). This is a factor associated with the ability of the scroll plains in the upper catchment to retain flood water as well as additional inputs between the upper catchment and Sutton e.g. Kyeburn.

The nearest long term automatic raingauges are located at Danseys Pass, Middlemarch, and Mount Stoker. Annual average and peak 24 hour rainfall intensities for these sites are listed in Table 1.

Table 1. Annual average and maximum observed rainfall intensities for rain gauges in the area around the Strath Taieri

Hydrological monitoring site (rain) (date record commences)	Annual average rainfall (mm)	Peak 24 hour rainfall (mm)	Date of peak 24 hour rainfall
Kyeburn at Danseys Pass (May 1996)	780	119	16-17 Jun 2013
Taieri at Middlemarch (Aug 2000)	468	51	29-30 Jul 2007
Nenthorn at Mount Stoker (Aug 1993)	455	83	12-13 Jan 1996

3.4. Hydrological setting

Information on river flow is available from two long term monitoring sites in the vicinity of the Strath Taieri (with other sites also available in the Taieri catchment). The Taieri River at Tiroiti and Taieri River at Sutton sites have been operating since May 1982 and August 1960 respectively. The ten largest flows on record for these sites are shown in Figure 6 and Figure 7. The Taieri River can rise rapidly during flood events, with a rate of rise greater than 52 m^3/sec. Average velocities observed at these sites during flood events range from 2 to 5 m/sec with velocities likely to be even higher in the steeper more confined sections of the Taieri River.

Table 2. Summary of hydrological information for the sites within the Strath Taieri reach of the Taieri River

Hydrological monitoring site (River flow) (date record commences)	Maximum observed flow (m^3/sec)	Annual flood (2.3 year return period) (m^3/sec)	Median flow (m^3/sec)
Taieri at Tiroiti (May 1982)	380 (20 Jul 1961)	100	10
Taieri at Sutton (Aug 1960)	560 (24 Dec 1993)	133	13

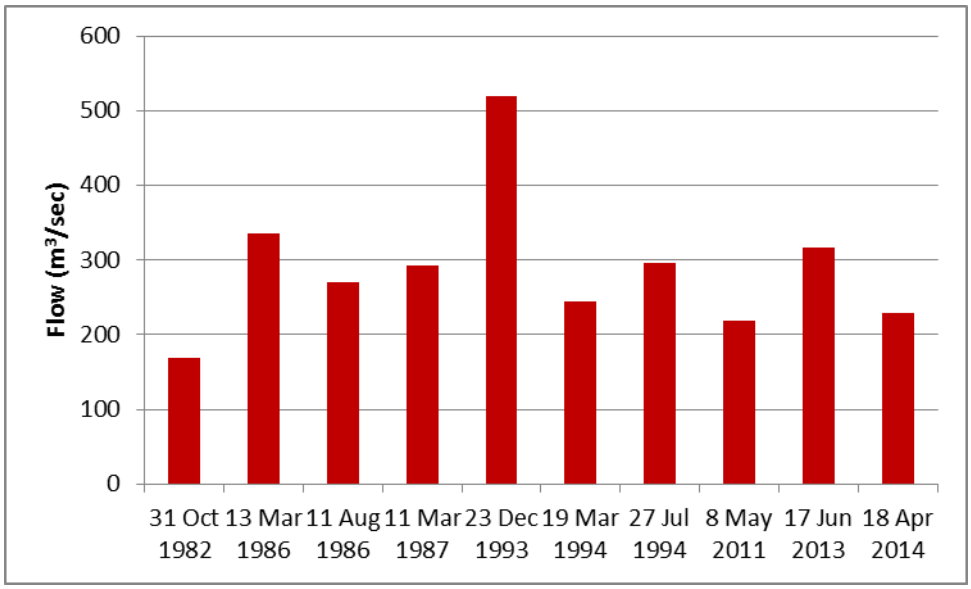

Figure 6. **Ten highest flows in the Taieri River at the Tiroiti recorder since flows began in 1982**

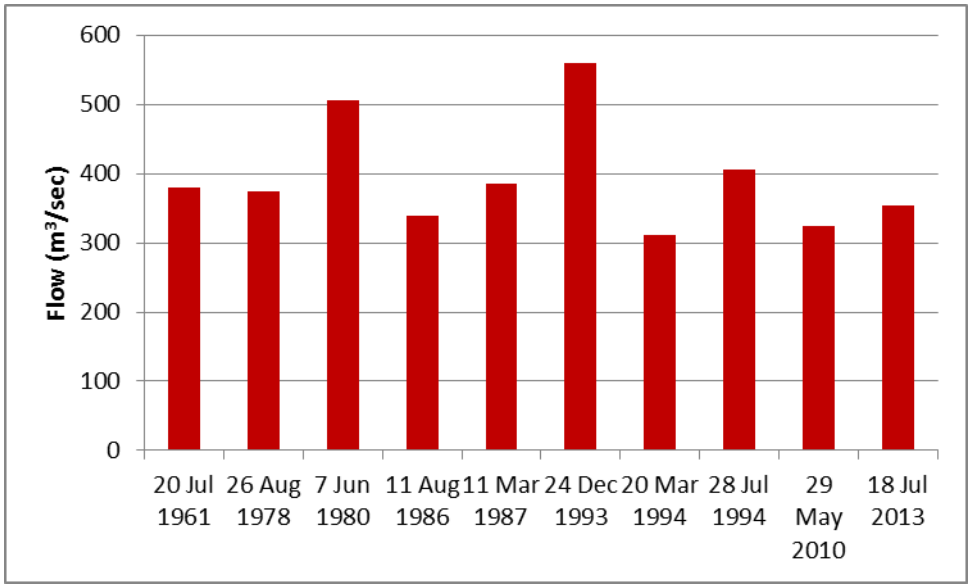

Figure 7. **Ten highest flows in the Taieri River at the Sutton recorder since records began in 1960**

3.5. Flooding

Changes in the morphology of the Taieri River channel are in part driven by the hydrological characteristics of the river including the magnitude and frequency of flood flows. Between 2007 and 2015 there were three flood events in the study area that ranked in the top ten largest flood events at the Tiroiti flow recorder (Figure 6), the Sutton flow recorder has two events in the top ten for this same period (Figure 7). The Taieri River has experienced large flood events in the past with the December 1993 event being the largest on record (Tiroiti and Sutton flow recorders) as well as in recent times (Figure 8). The December 1993 event caused flooding of land adjacent to the Taieri River as well as road damage (ODT, 27 December 1993) with three families having to evacuate their homes (ODT, 24 December 1993). The mapped flood hazard area for the Taieri River in the study area can be seen in Figure 9.

Figure 8. **June 2013 flood event, looking north along the Strath Taieri (Middlemarch can be seen on the left) (photograph taken 18 June 2013, after the peak of the flood (411 m^3/sec at the Sutton recorder))**

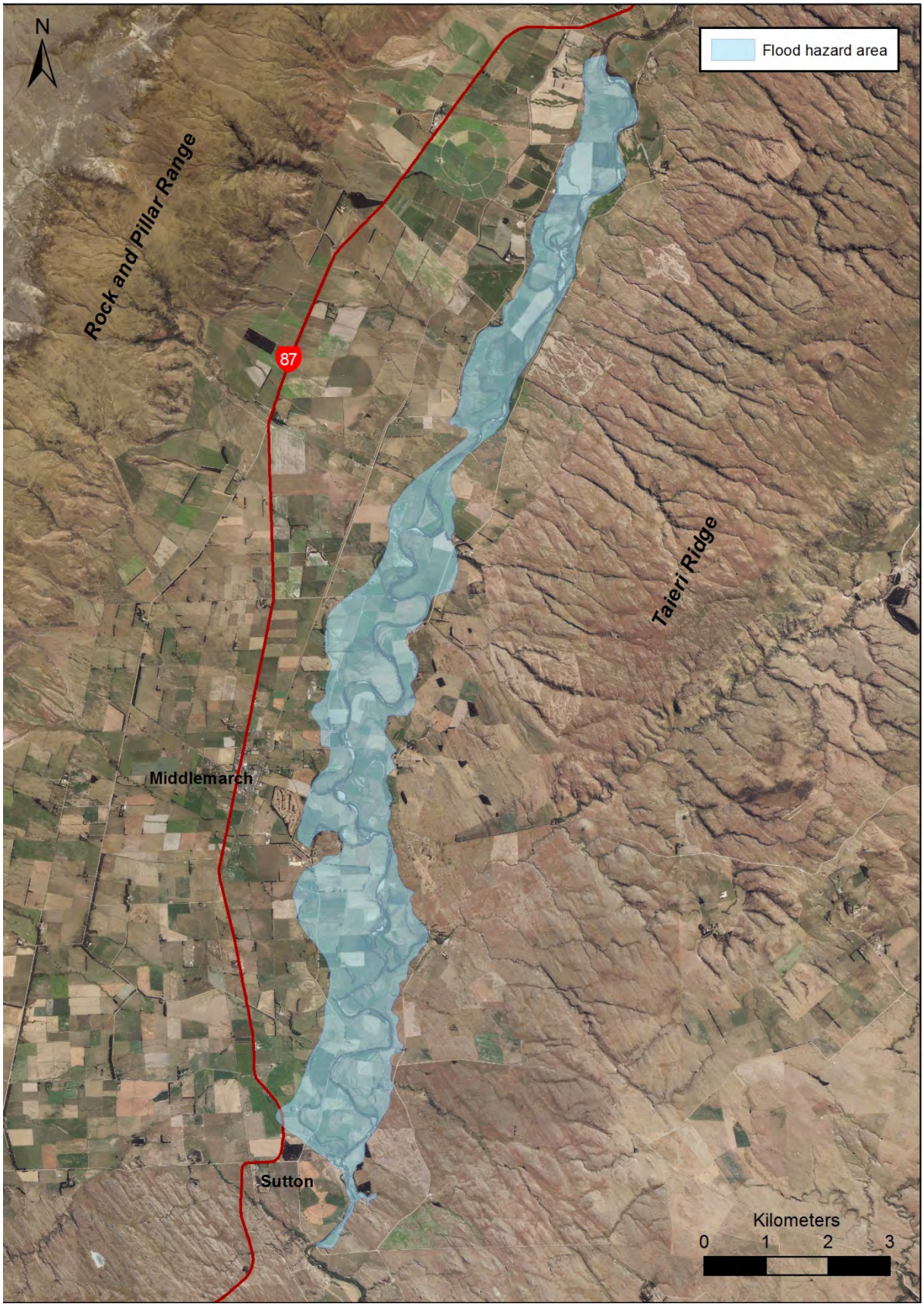

Figure 9. **Taieri River flood hazard area extent (ORC, 1993)**

3.6. Riverbed morphology

The active channel of the Taieri River is a dynamic system where flood events and sediment transport movement regularly cause changes in riverbed morphology. Changes in the longitudinal profile of the riverbed occur due to aggradation and degradation along the channel, and as a result of lateral bank erosion. Significant changes often occur over longer timeframes. Human activities, such as gravel extraction and physical works can also result in significant morphological change, particularly near these works, but they can also occur across the wider river system.

ORC undertakes work to describe these changes in morphology using visual inspections, aerial and ground photography, and cross-section analysis. As the ORC cross-sections in the Strath Taieri area have only been surveyed twice, the first analysis of these are contained in this report (Appendix 4).

A comparison between aerial photography collected between 1945 to 1947 and 2013 to 2014 highlights the dynamic nature of the Taieri River. In places the active river channel has changed positions and eroded into farmland, while in other places the channel movement has allowed land to become farmable. The 1945 to 1947 aerial photography shows larger areas of gravel accumulation with the several meander loops occupying areas that are now abandoned oxbow channels (Figure 10).

Figure 10. **Taieri River - left 1947, right 2013/2014**

Figure 11. **Comparison of the Taieri River betwen 1945 and 2013 between .7 km and 5.7 km downstream of Middlemarch (aerial photography collected in 2012 and 2013)**

3.7. Riparian margins

The riparian margin is the area beside waterways that forms the interface between water and land. As noted in the introduction, more intensive use of the land that borders the Taieri River has occurred in recent decades. In some parts of the catchment, farmland has encroached onto what was previously a more natural area of rough vegetation (Figure 10). This has resulted in a narrowing (or in some cases, complete removal) of the riparian margin which separates the active river fairway from land which is used for farming or which accommodates community infrastructure. It is worth noting that the Taieri River in the study area has a good coverage of riparian vegetation, however some areas do not have any coverage. Channel widening, bank collapse and erosion are a process that has historically occurred and will continue to occur in the Taieri River catchment. The loss of agricultural land and physical property adjacent to eroding banks is very costly and the need for their protection has long been recognised.

Historically the permanent removal of gravel from the Taieri River system has been used as a tool in an attempt to address bank erosion issues. The strategy identifies that gravel extraction, and other management tools (such as the movement of gravel within the channel, and spraying), should still be considered for river management purposes, where that is appropriate. However, a number of authors have identified that the most effect means of controlling river bank erosion is to establish a vegetative cover of strongly rooting plants (Slui 1991, Marden *et al*. 2005, ORC 2005, Phillips & Daly 2008). In general terms, vegetation roots increase bank stability by protecting soils against entrainment from flood flows, and root mass and density provide soil shear strength and thereby protect against gravity collapse of undercut banks.

Other indirect benefits of riparian planting include trapping nutrients and fine sediment, shade, shelter, and filtering qualities for the aquatic eco-system, and aesthetic and recreation value. If well managed, riparian margins can help to improve water quality, provide food and habitat for freshwater life, and improve diversity (ORC, 2005). A strong desire to see the form of the river include riparian plantings, particularly native species, was also identified during the development of the strategy.

4. Values

Information on the values that the community and stakeholder have for the Taieri River was collected through community meetings and collecting feedback (Appendix 6). The Taieri River fulfils a number of important roles within the community, at a local, district, and regional scale. These roles include (but are not limited to) being:

- a source of water for irrigation, stock, and people
- a source of gravel for roading, and construction purposes
- for recreation purposes, including swimming, walking, fishing, hunting, boating, picnicking, and camping.
- A habitat for native and introduced species
- Amenity and landscape values

The below sections discuss the ecological, community, and maori cultural values that are held for the Taieri River. Limited information was provided / collected on the spatial location of the values discussed and presented by the community and stakeholders. The lack of geographical information on the values discussed in this strategy therefore means all values should be considered whenever activities are planned for the beds and banks of the Taieri River at any location.

4.1. Ecological values

Fish

The Taieri River between the Hyde Gorge and Matarae provides important habitat for a range of native and exotic freshwater species including longfin eels (*Anguilla dieffenbachii*), lamprey (*Geotria australis*), upland bullies (*Gobiomorphus breviceps*), and common bullies (*Gobiomorphus cotidianus*). Brown trout (*Salmo trutta*) is an introduced species and is the most common fish in the study reach. Central Otago roundhead galaxias (*Galaxias anomalus*) can frequent this reach but are likely expatriates from the Sow Burn and Kye Burn. Chinook salmon (*Oncorhynchus tshawytscha)* pass through this reach as they travel upstream. The tributary streams in this reach also support a wide range of native and exotic fish species. The Regional Plan: Water for Otago also lists many ecosystem values for the Taieri River, including important bed composition, spawning sites for trout and development of juvenile trout, and a significant presence of eels.

The Strath reach of the Taieri River supports a regionally important brown trout fishery. The national angler survey suggests that angler effort in the reach of the Taieri River between Kokonga to the Outram bridge has increased in recent surveys (2001/2002 to 2007/2008) (Table 3).

Table 3. Angler effort on the Taieri River (angler days $^{+}/_{-}$ sandard error) based on the national angler survey (Unwin, 2009)

River	Angler usage (angler days $^{+}/_{-}$ SE)	
	2001/2002	2007/2008
Taieri River (Kokonga to Outram bridge)	1050 $^{+}/_{-}$ 270	2730 $^{+}/_{-}$ 1260

4.2. Community

To help identify aspects of the wider river environment that is important to the local community, ORC consulted with a wide range of stakeholder in 2016. These included landowners, local iwi, Fish and Game, Department of Conservation (DoC), and DCC.

The values that the community and other stakeholder groups said they identified with the Taieri River environment and its form and function as well as desired outcomes are summarised in the box below.

That the ***function*** of the river continues to support social, cultural, spiritual, recreational, and farming activities – as well as continuing to provide for the taking of gravel as a resource

That the ***form*** of the river includes riparian management including planting (including both native vegetation and willows) where appropriate

- The river supports recreational activities such as swimming, fishing, and picnicing.
- Important river for mahika kai
- Regionally important brown trout fishery
- Important habitat for native fish (longfin eel, and galaxiids)
- The river can be used for gold mining

Desiered outcomes

- The habitat of existing wildlife must be maintained and enhanced.
- Access must be able to continue.
- Riparian margins are maintained.
- Gravel extraction should be encouraged in appropriate places
- That the river channel is able to shift laterally within an identified riparian margin, but:
    - farmland beyond that margin is not eroded, and
    - main flood flows are kept in the channel.
- Infrastructure (eg, roads, bridges and water takes) is resilient and able to be quickly reinstated following flood events.

4.3. Gravel extraction

The removal of gravel from the riverbed of the Taieri River has occurred for many decades with extracted material generally used for roading and construction purposes. Gravel extraction typically occurs from locations where sediment naturally accumulates (for example where there is a decrease in the gradient of the river, leading to a reduction in the velocity of flood flows), or in an attempt to mitigate issues such as bank erosion. In either case, extraction from the bed of the river will tend to increase the conveyance of water during flood events, by widening the channel and reducing MBL at that location. It can also lead to a decrease in the sinuosity of the river channel as bends are straightened in an attempt to reduce the effects of bank erosion.

Records provided by gravel extractors to the ORC show that approximately 27,239 m^3 of gravel was extracted from the Strath reach of the Taieri River between 1998 and 2016. Gravel has not been extracted from the Strath reach since 2013.

Ongoing channel degradation can allow increased water velocities (particularly during flood events) to scour the river bed, deepening the channel, which can result in continued bed degradation. As the channel deepens, flood flows become confined within the channel and continue to scour the bed. This ongoing degradation decouples the channel from the floodplain and alters the floodplain catchment interactions (Fuller *et al.*, 2014). Deeper channels contain larger floods and concentrate flows, leading to more incised channels, potentially generating higher sediment transport rates (due to bank erosion and further removal of material from the riverbed). This process gives the appearance of more prominent gravel bars within the active channel due to the deeper channel. As the channel deepens and gravel bars become more prominent, pressure is often exerted by adjacent landowners to remove the obvious (but in fact non-existent) excess gravel accumulation, which in turn exacerbates the degradation trend (Fuller *et al*., 2014).

The permanent removal of gravel from the Taieri River system can result in the undermining of river protection works and other assets (e.g. water intakes, bridges, and roads), as well as degrading ecological values. Gravel extraction can have a negative effect on the local ecology, with the severity of effects dependent on the extraction methods used and the environment from which the gravel is being extracted. Gravel extraction activities can lead to a reduction in habitat heterogeneity/diversity, an increase in fine sediment, as well as bed compaction that can have a negative impact on the native and exotic animals residing in an on the banks of the Taieri River (Canterbury Regional Council, 2015). The potential beneficial and adverse effects of significant gravel extraction are summarised in Table 4.

Table 4. Potential beneficial and adverse effects of gravel extraction (Canterbury Regional Council, 2015)

Potential beneficial effects	***Potential adverse effects***
Channel capacity increased, flood levels lowered	Disturbance of fish and bird habitat
Concentration of flow against riverbanks, resultant lateral erosion, and localised bed scour is minimised	Accidental discharge of fuels and lubricants from machinery
Stable channel alignment and optimum bed level is maintained	Disturbance of the natural meander patter and channel stability
Open gravel beaches can provide a good habitat for indigenous birds	Overall degradation of the riverbed
A renewable gravel resource for local construction may be utilised	Increased bank erosion
	Sediment is discharged, increasing turbidity and smothering habitat
	Temporary reduction in recreational access
	Mauri (life force) of the riverbed affected
	Disturbance of fish spawning sites

	Dust generation
	Reduced river bed heterogeneity

ORC will investigate the possibilities, benefits, and legality of a consent held by the ORC to allow for the management of gravel extraction and river management activities in the Strath reach of the Taieri River (Hyde to Matarae). ORC will aim to use the consent to enable landholders to achieve river management objectives i.e. to help mitigate bank erosion/scouring or excessive gravel accumulation.

5. Legislative context

The manner and degree to which the issues in the Taieri River can be managed by the community, stakeholders and local councils is influenced by the obligation, powers and restrictions set out in various statues. No legislation confers the exclusive power or the right to manage the Taieri River to ORC or DCC. Whether through works or services, individuals are empowered to initiate their own measures provided they operate within the law. They are also allowed to develop and promote proposals for bank protection works, to apply for and hold the necessary resource consents and to privately fund works and services should they wish to.

The law provides for a range of methods that both councils and the community can use to manage the Taieri River. These methods do not only relate to physical works, but also to planning, information, emergency preparedness and response. They can only be implemented after taking environmental effects into account (under the Resource Management Act (RMA)) and funding consideration (under the Local Government Act (LGA)). The latter includes consideration of the distribution of benefits between the community as a whole, any identifiable part of the community and individuals.

The Otago Regional Policy Statement (RPS) provides a high-level policy framework for the sustainable integrated management of Otago's resources, as well as giving effect to the requirements of the RMA. This includes the management of the values of water bodies, natural resource systems and the form and function of Otago's rivers, whilst still enabling communities to provide for their needs.

This strategy is concerned with the form and function of the Taieri River. Any activities in or on the bed and banks of the Taieri River need to be focused on maintaining or enhancing that form and function. The strategy is not a statutory document; rather it is intended to present the aspirations of the community and the various stakeholder agencies. However, the statutory processes which do influence river management activities are more likely to be used effectively and efficiently if there is a general consensus on what is valued about the river, and commonly understood objectives. The strategy sets out the values identified by the community, and the outcomes they seek from managing river form and function, and will be used to inform resource consent decision-making.

6. Principles

The strategy provides a framework to guide activities and decision-making, based on an agreed set of principles. It is intended to help protect the recreational, cultural and ecological values of the Taieri River, and to enable long-term sustainable use of the riverbed and its riparian margins.

ORC has developed the framework, in consultation with the local community and other stakeholders. The principles and associated strategic elements are outlined below, and these are intended to protect or enhance the important values and features of the river identified by the community and other stakeholders.

Principle 1: Ensure sustainable river management

Ensure that:

- There is clear and consistent communication between the ORC and other parties
- there is recognition that certain river and catchment processes, such as flooding, bank and channel erosion and sedimentation, will occur naturally, and an understanding of the potential effects of those processes
- any practices undertaken limit exposure to negative natural-river and catchment processes
- there is an awareness and acknowledgement of the benefits and the risks (including the risk associated with 'super-design' events) that exist for activities such as farming that occur in areas prone to natural-river and catchment processes
- any negative effects of natural-river processes do not increase beyond their current levels, and are actively reduced where there is opportunity to do so
- activities are managed in a way that result in:

- limited effects on assets during flood events
- essential community infrastructure that is resilient (roads, bridges, water supply)
- acceptable level of effects to farming caused by river processes
- sustainable use of river resources.
- there is a recognition of the kaitiaki responsibilities of the local iwi

Principle 2: Plan ahead

Ensure that:

- There is clear and consistent communication between the ORC and other parties
- there is an adaptive approach to river management that will allow for the dynamic nature of the Taieri River

- resources are used wisely to ensure that the location and form of community assets and essential infrastructure will result in a more resilient community
- the impacts of climate change and natural climate variability are considered so that future generations do not have to cope with the results of poor decisions made today
- the risk associated with natural-river processes are reduced over time by taking a broad-scale, adaptive approach over the longer term.

Principle 3: Maintain and enhance the natural environment

Ensure that:

- There is clear and consistent communication between the ORC and other parties
- activities are managed in a way that results in:

- a habitat that supports existing wildlife, fish, and suitable plant species
- a more visually appealing river system
- the ability of the local community and visitors to access and enjoy the river is maintained and or enhanced
- traditional and cultural use is enabled, maintained and enhanced

7. River form and habitat enhancement

7.1. River corridor design and management

ORC has undertaken work to identify the location and width of the active fairway (or riverbed), as well as appropriate buffer zones, which together form a corridor within which the river would naturally lie. The widths of fairway and buffer zones were completed by assessing the appropriate meander form in relation to the nature and width of the river channel. The design channel has been drawn up using a consistent meander length or wavelength oscillation, while taking into account the existing channel location, channel areas and natural controls and restraints. This work has been undertaken in the Taieri River between the Hyde Gorge and the Matarae (Williams, 2016). An example is shown in Figure 12, and a full set of river corridor maps is provided in Appendix 5

The river fairway and corridor mapping provides guidance for multi-purpose river management, and for the design and implementation of management measures, protection works and in-channel design. When physical works or activities are being considered within the fairway or on the riparian margin, these should be undertaken with reference to the mapped fairway and buffer zones. Guidance for managing the river within this corridor, and across the wider floodplain is summarised in Figure 13.

ORC will work towards maintaining the Taieri River to the mapped corridor lines in the Strath reach where reasonable and practicable. The fairway management will be achieved through river-management processes such as sediment movement (i.e. cross-blading, bank reinstatement, targeted vegetation spraying, and in extreme cases, channel realignment). Keeping the fairways to the mapped lines will be undertaken as a pre-emptive process with the aim of limiting the degree of movement/deviation from these areas in flood events. This work will take into account the community values (as discussed in Section 0). Maintenance work undertaken in the Taieri River (as discussed above) will be provided for through the budget set in the ORC Annual Plan.

In some locations, the mapped corridor crosses land that does not currently form part of the active channel of the Taieri River (e.g. Figure 12). This is due to the fact that the mapped corridors show an ‘envelope’ within which the river would migrate under natural conditions. In many instances, they do not reflect the current position of the Taieri River. In these situations, ORC will not actively move the fairway into these mapped areas; however, if the channel switches its location into these areas (e.g. in response to a large flood event), ORC may decide not to undertake work to reverse the new alignment if the channel still lies within the mapped corridor.

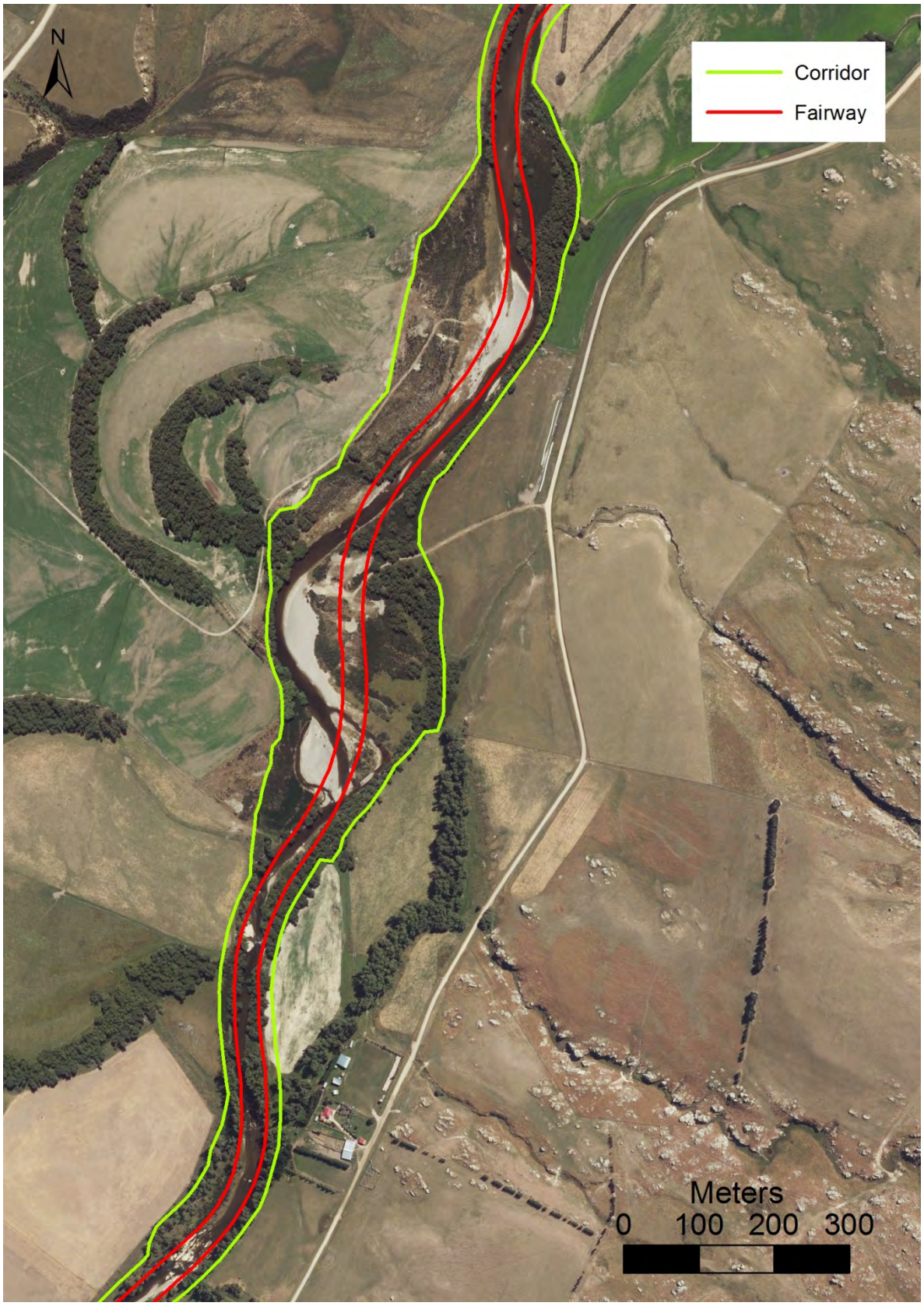

Figure 12. **Taieri River mapped mapped fairway and corridor lines**

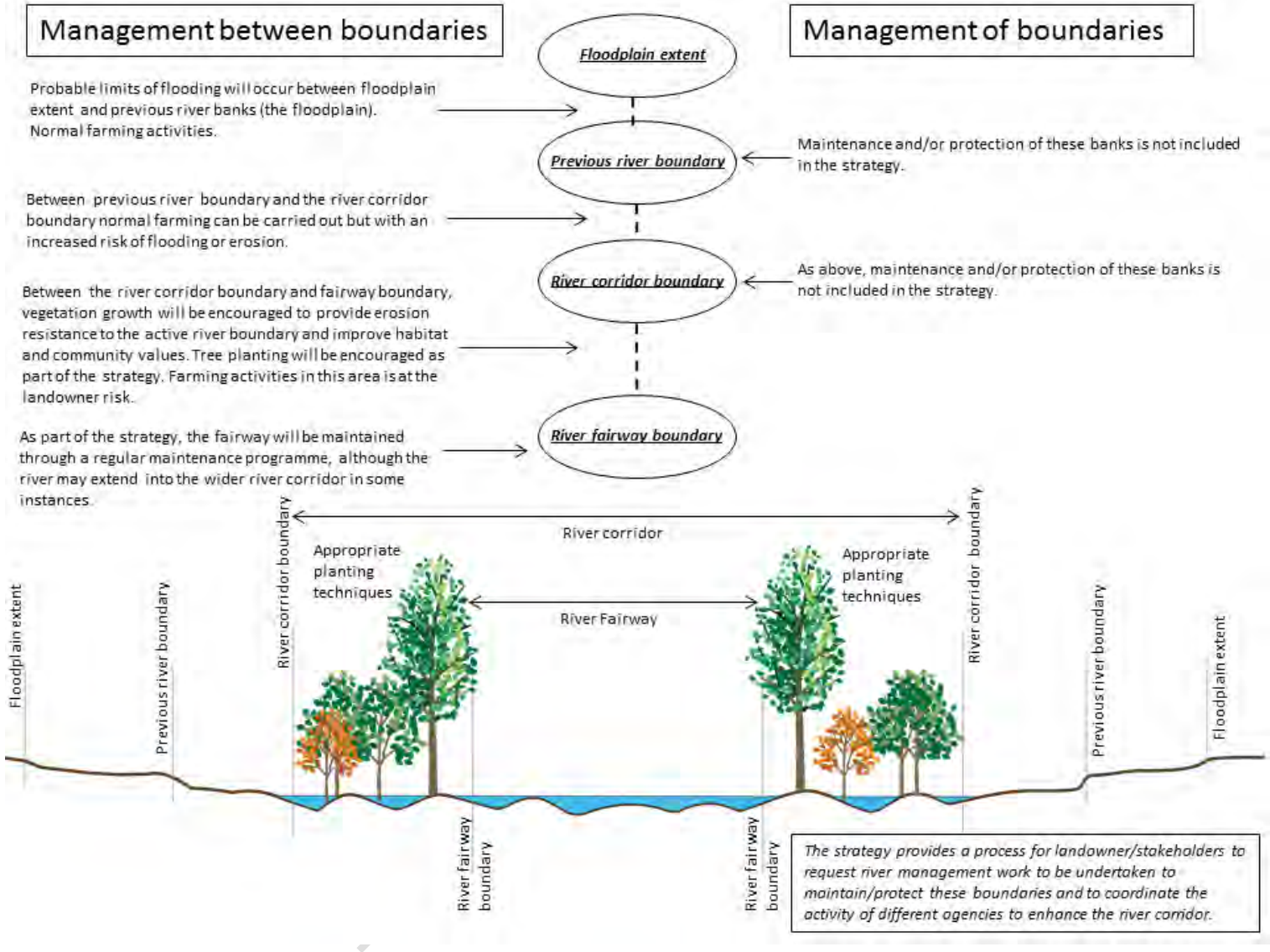

Figure 13. Policy diagram for management of river boundaries and appropriate land-use on floodplain areas of the Taieri River

7.2. Riparian plantings

As identified in Section 3.7, careful management of riparian margins is key to achieving positive river management outcomes. In addition, one of the key values identified by the community and stakeholders was that they would like to see additional planting and management of riparian plantings included in the strategy as a means of improving the amenity and habitat values of the Taieri River, and to help to reduce the effects of erosion (Section 0). The principles identified in Section 0 reflect the importance of sustainable river management and enhancing the natural environment.

Research (Slui, 1991; Phillips & Daly, 2008) shows that to achieve bank protection, the Taieri River riparian margins should be planted in vegetation that assists with bank stabilisation. Planting these buffer areas would provide the banks of the rivers with greater stability and assist with limiting bank erosion, as well as providing vegetative cover to slow flood flows and limit the amount of sediment deposited out of the main channel, as well as providing habitat for aquatic life. The wider the area of buffer zone planting, the more effective this will be.

Willow species (particularly moutere and kemuti willow) are more suitable for planting close to the river margin, due to their rapid growth, ease of propagation and usefulness for vegetative groynes or bank-lining layering. Other vegetation can also be used, including poplars and alders on the relatively higher/drier land. Native vegetation can be used further back from the active river margin and can be useful, especially when part of other/wider riparian planting.

Development of the buffer areas can be undertaken as a staged approach, with planting of the active river margin occurring in areas where there is bank exposure as well as at possible river breakout locations. Planting of the back area can be undertaken where direct river attack (i.e. bank erosion) is less likely to occur and the native species will have time to become established. Buffer development is about establishing a wide and dense vegetated margin that can absorb river attack and provide habitat for aquatic life.

Planting of the banks of the Taieri River is generally seen as a beneficial process in most locations. There are several methods to plant the banks of the two rivers with the best method being dependent on the environment where the planting is to take place (Appendix 2).

8. Implementation

The objectives of the strategy are listed at the start of this document (in the overview section). The mechanisms that can be used to achieve, or implement, these objectives are shown in the following tables. These have been derived using the principles outlined in Section 0. The tables below highlight the actions that should be undertaken to maintain and enhance the values associated with the Taieri River, as well as the key parties responsible for undertaking the listed actions.

In some cases, ORC has already undertaken work to help achieve objectives, and this work is described within this document (for example, mapping of natural-river corridors and identifying target profiles). It is noted that many of the actions listed below are voluntary, and will rely on interactions between the key stakeholders and the community to be successful. It is also noted that many of the activities will be ongoing, and progress will depend on funding, not only through the ORC Annual Plan process, but also from other agencies and the wider community.

ORC has prepared the strategy, with input from the local community, to help protect the recreational, cultural and ecological values of the Taieri riverbed, and to enable long-term, sustainable use of the land that borders the river. The objectives and actions listed below are intended to help achieve this, by guiding work programmes, decision-making and activities for the community, stakeholders and ORC. It is therefore recommended that people who live, work or play within the Taieri catchment consider, and give effect to the principles, objectives and actions listed in this strategy.

Due to the dynamic nature of the Taieri River, parts of this strategy are likely to change as the rivers themselves change; this strategy must therefore be treated as a ‘live’ document (Section 2.3). This means that some sections and maps in the strategy may change in response to changes in the Taieri river (e.g. areas of gravel accumulation may shift).

Objective 1 Recognise and characterise natural-river processes

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
1.1. Collect information about flood and erosion processes					
	Map, describe and report on changes in channel morphology	Improved understanding of natural river processes	ORC	Ongoing	Previous reports describing changes in channel morphology are available
	Identify locations where erosion is occurring	Avoid high-value assets in erosion-prone areas	ORC	Ongoing	
	Make information publicly available, including through the Natural Hazards Database	Improved decision-making around placement of assets and land-use activities	ORC	Ongoing	Information is currently available through the Natural Hazards Database
1.2. Identify the location of river corridors, within which the river will naturally meander					
	Determine the natural meander form of the river, considering the existing channel location, and natural controls and restraints	Improved decision-making around placement of assets and land-use activities	ORC	Complete	Maps included in Appendix 5

Objective 2 Equip the community to live with the effects of changes in river morphology

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
2.1. Asset management and land-use practices (e.g. fences, vegetation clearance, and irrigation structure placement) are undertaken in such a way that reduces the risk associated with natural river processes					
	Land-use practices and other activities have greater regard to natural river processes	A reduction in risk over time	Landowners	Ongoing	ORC to provide guidance and information through field-days and other community programmes
	Consider implementation of land-use controls through the District Plan in areas with greater erosion risk	No net increase in risk over time	DCC	Long-term (5-10 years)	Elements are incorporated into the proposed DCC Second Generation District Plan (2GP).
	Identify mechanisms to modify / protect infrastructure assets that consider natural river processes	Infrastructure is resilient	ORC / DCC	Ongoing	ORC to provide information as necessary. DCC to consider this.
2.2. Consider all available options to manage the effects of bank erosion, including structural and non-structural options					
	Less intensive use of riparian margins	A reduction in risk over time	Landowners	Ongoing	
	Planting of native and exotic species on riparian margins	Increased stability of riparian margins and riverbanks, improve habitat and community values	Landowners	Ongoing	ORC to provide support, as determined through the ORC Annual Plan process

	Produce guidelines for undertaking planting appropriate for river control and provision of habitat	Increased stability of riparian margins and riverbanks	ORC	Complete	Guidance included as Appendix 2
	Produce maps showing priority planting locations	Community requirements and natural river processes are considered before planting is undertaken	ORC	Ongoing	
	Proactive river management programme	Bank erosion and other river management issues addressed early	ORC	Ongoing	Maintenance work undertaken as provided for through the budget set in the ORC Annual Plan
	Provide information on the Regional Plan: Water permitted activity rules	The community is enabled to complete activities that manage the effects of bank erosion and other river management issues	ORC	Ongoing	Information on permitted activities to be provided to the community at any opportunity
2.3. Enable works that improve the conveyance of floodwater and 'train' the river within its natural corridor, without compromising features that are of high value to the community					
	Physical works by ORC to address existing river management issues	The Taieri River is contained, as far as possible, within the natural river fairway / corridor, and convey small to medium floods without overtopping	ORC	Ongoing	Locations and detail of work to be undertaken between October 2016 and 2019 included in Appendix 1
	Physical works by landowners and other agencies to address river management issues	The Taieri River is contained, as far as possible, within the natural river fairway / corridor, and convey small to medium floods without overtopping	Landowners	Ongoing	ORC to provide guidance on suitable river-management methods (including resource consent requirements) through field days and other

					community programmes
	Provide information discussing the importance of community/stakeholder values	Works are undertaken in a manner that does not compromise features that are of high value to the community	ORC and the community	Complete	Discussed in Section 0, these may be modified or adjusted as part of future reviews of this strategy. Values also mapped in the proposed DCC 2GP.

Objective 3 Enable sustainable gravel extraction

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
3.1. Enable sustainable gravel extraction for river management benefits					
	ORC will investigate the possibilities, benefits and legal ramifications of holding a consent to extract gravel	Gravel extraction is completed in a sustainable manner	ORC	Feb 2017 (to inform the 2017/18 draft Annual Plan)	
3.2. Identify areas where gravel extraction may affect community values					
	Provide information discussing the location and importance of community/stakeholder values	Extraction is undertaken in locations, and in a manner that does not compromise features which are of high value to the community	ORC and the community	Completed	Values discussed in Section 0, these may be modified or adjusted as part of future reviews of this strategy. Values also mapped in the proposed DCC 2GP.

Objective 4 Promote activities that enhance the natural character and enjoyment of the river

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
4.1. Identify the location and characteristics of features that are of high value to the community					
	Community values obtained through consultation and clearly identified within the strategy	Consideration of community values when making decisions	ORC	Completed	Values discussed in Section 0, these may be modified or adjusted as part of future reviews of this strategy. Values also mapped in the proposed DCC 2GP.
4.2. Establish riparian plantings that serve a purpose, and are appealing					
	Produce guidelines for undertaking planting appropriate for river control and provision of habitat	Increased stability of riparian margins and riverbanks. Improved aquatic and terrestrial habitat.	ORC	Completed. See also 2.2 above.	Guidance included as Appendix 2
4.3. Provide access for fishing activities and habitat for fish					
	Planting work that facilitates fishing activities and enhances	The Taieri River supports a regionally important sports	Fish & Game, DoC[6]	Ongoing	

[6] DoC will take an advocacy role for this action

	fish habitat and does not impede access	fishery, important populations of native fish (including threatened and endangered species)			
	Consent conditions ensure that gravel extraction and physical works are undertaken in a way that does not damage habitat	The Taieri River supports a regionally important sports fishery, important populations of native fish (including threatened and endangered species)	ORC, DCC, extractors and landholders	Ongoing	ORC and DCC staff to consider as part of resource consents. See Objective 3 also
	Encourage the creation of additional public access points	River-access opportunities are increased	ORC / DDC / landowners	Ongoing	The proposed 2GP identifies esplanade strips and access points.
4.4. Adequate pest and weed control activities					
	Landowners (including LINZ) and other stakeholders work collaboratively to manage pest species	The Taieri river fairway and riparian margin are relatively free of pest species	Landowners, stakeholders, ORC	Ongoing	
4.5. Discourage dumping, and arrange the regular collection of rubbish					
	Collection of rubbish through regular/routine work at key locations.[7] Signs warning of penalties for rubbish dumping to be erected if issues persist.	Improved visual amenity and enjoyment of recreational areas	ORC/DCC	Ongoing	Work to be completed by relevant parties for their area of jurisdiction.

[7] No new additional work to be completed

4.6. Protect and enhance the natural character of the Taieri River					
	Promote and encourage local restoration initiatives such as bank planting, and wetland restoration	Riparian margins are planted / restored, look visually appealing, and provide aquatic and terrestrial habitat	Community, with support from other agencies	Ongoing	

Appendix 1. ORC river maintenance work within the Dunedin Special Rating District

12 locations within the mapped river corridor have been identified as requiring work to maintain the fairway within its natural position (as mapped in Appendix 5) and/or to ensure the adequate conveyance of floodwater. These locations are shown on Figure 14 and Figure 15. These priority locations have been determined using the latest information available (November 2015) about specific locations that are experiencing river management issues. ORC intends commencing work at these locations during the 2016/2017 financial year, and funding has been provided through the long term plan process to complete work at these locations within the next three years (i.e. by 2018/2019). Ongoing maintenance may also be required at some of these locations into the future.

This list and the need to undertake work at particular locations may change into the future, in response to flood events and to other river management issues that the community may identify through the processes outlined in Section 2.3.

The river management work (outlined below) that is scheduled to take place in the Taieri River will need to consider the following:

- The principles outlined in Section 0
- The location and width of the natural river corridor and active fairway, as described in Section 7.1, and other natural river processes as described in the strategy.
- The objectives and associated activities listed in Section 8. In particular objective 2 (equip the community to live with the effects of changes in river morphology) and activity 2.3 (enable works that improve the conveyance of floodwater and 'train' the river within its natural corridor, without compromising features which are of high value to the community).
- The ecological, community, and Maori values discussed in Section 0.

The increased program of work in the Taieri River by ORC will result in increased costs for the Dunedin Special Rating District (SRD). Revenue from rates within the SRD is not expected to increase, however the reserve level will decrease as additional funding is required to complete instream work required to meet community river management expectations.

The anticipated budget for river management operations (physical works) in the Dunedin SRD until 2019/20 is shown in Table 5 below. This shows that $256,000 is budgeted for this work during the 2016/17 year, up from $174,000 in 2014/15. This budget is not solely for the Taieri River and includes other rivers in the Dunedin District.

The dynamic nature of the Taieri River and inability to predict the timing or consequences of future flood events in the Dunedin District means there is a risk that this additional funding for river management work may still be insufficient. As noted above, all ratepayers within the Dunedin District contribute towards the Dunedin SRD.

Table 5. ORC river management budget for the Dunedin District

Year	ORC river management (operation) budget
2014/15	$174,000
2015/16	$254,000
2016/17	$256,000
2017/18	$268,000
2018/19	$275,000
2019/2020	$282,000

Planned river maintenance work – Taieri River

A. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events as well as willow planting to limit the effects of bank erosion.

B. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

C. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

D. Work at this location will involve willow planting to limit the effects of bank erosion.

E. Work at this location will involve willow planting to limit the effects of bank erosion.

F. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

G. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

H. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

I. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events as well as willow planting to limit the effects of bank erosion.

J. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

K. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events.

L. Work at this location will involve raking gravel to remove vegetation build up and allow sediment to move during flood events**.**

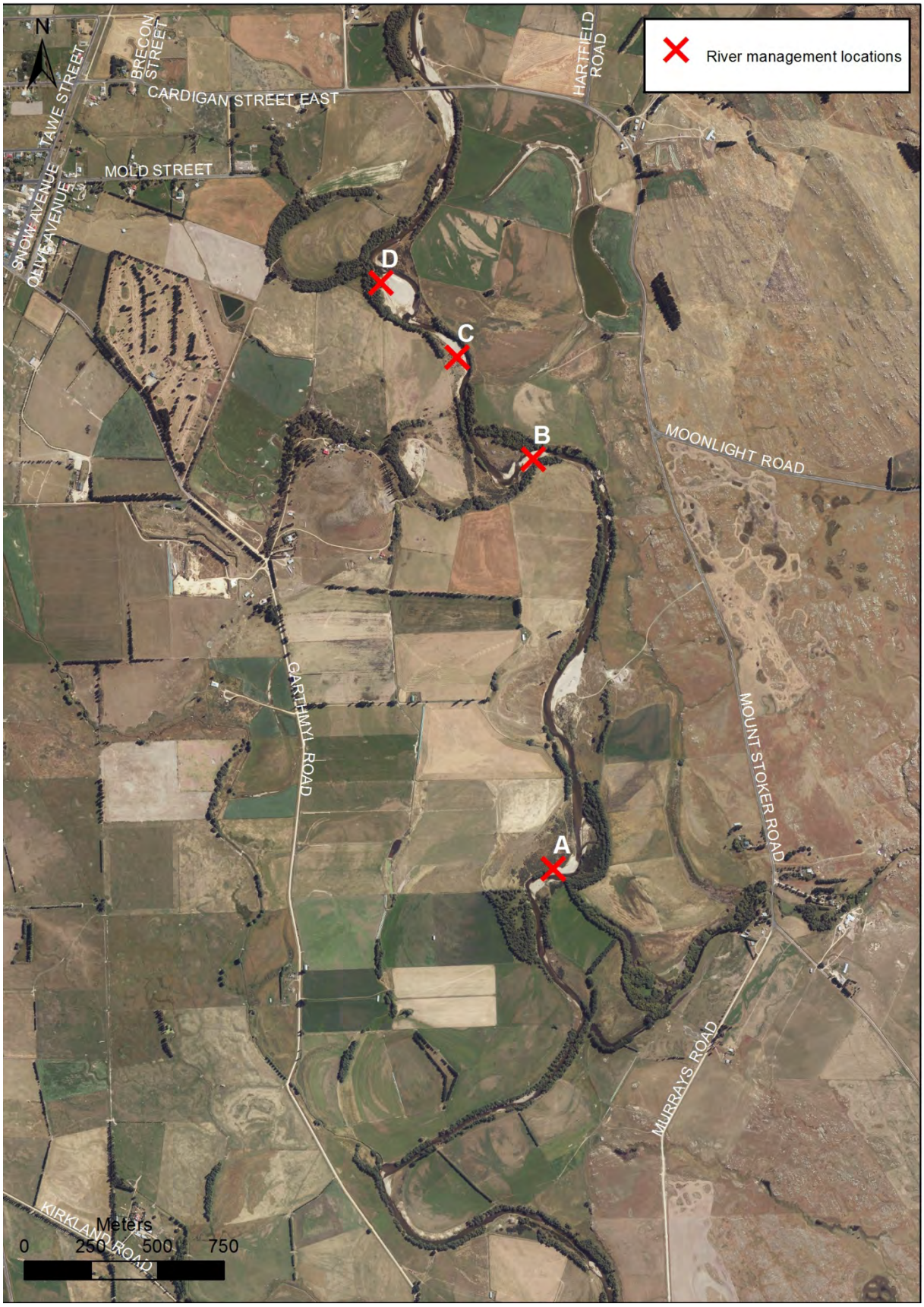

Figure 14. Priority locations for operations work - map 1

Figure 15. Priority locations for operations work - map 2

Appendix 2. Planting guide

Benefits of riparian planting[8]

The benefits of well-planned and well managed riparian planting areas on farms are considerable, and include:

- increasing the quality and health of waterways
- increasing the ability to filter nutrients before they reach waterways – Nitrogen, Phosphorus, and bacteria/viruses e.g. *E.Coli*
- reducing sediment runoff
- reducing soil erosion of banks in waterways
- providing shade, which reduces waterway temperatures and shelter for stock
- minimising stock losses as animals are excluded by fences from riparian strips
- increasing biodiversity – aquatic life, native plants, birds and insects
- improving recreational opportunities (e.g. fishing)
- enhancing and beautifying the river margins.

Both native and exotic species can be suitable for riparian planting. The species to be used will depend upon many factors including environmental factors (exposure, soils, etc.) but also the width of the riparian strip, the height of plantings that is desired and personal preference.

Using trees to stabilise stream banks[9]

Exotics

The most effective trees for stream bank erosion control are exotic willows and poplars. These are planted as stakes (less than 1 m high) or poles (1.5 – 3 m in height). Avoid invasive spreading species, such as crack willow, weeping willow, silver poplar and all non-sterile tree and shrub willows. Before planting fast growing trees, consider their longer-term maintenance needs.

Winter is the best time to plant these species before stakes or poles sprout new growth. Plant about a third of the length below ground. On waterlogged ground, you can force them in by hand. On firm ground, you may be able to sharpen poles at one end and drive them in with a rammer or use a post auger. Stakes can be planted by putting them into a hole made with a length of reinforcing rod or similar. The most important thing is to make sure stakes and poles are firmly planted.

[8] Adapted from KCCP planting guide (2015)

[9] Adapted from ORC (2005)

Guide to planting willow poles

Storage

It is recommended that poles are planted as soon as possible following delivery. Poles can be stored for a few weeks in water, stand up in a water trough or pond/creek. The bottoms of the poles should be kept wet to keep them alive and absorbing water. Poles should be stored away from stock.

Planting

Poles should ideally be planted on the outside of river bends, or sections of river where erosion is occurring. Plant poles in rows with 2 – 3 m spacing between them. Poles need to be planted 300-500 mm deep. Try and plant down to ground water level. Either a crow bar, post-hole borer or tractor forks/digger with a spike can be used to make a hole in the ground that the pole can be dropped into, and then packed firm.

Looking after plantings

Fence planting off from stock to protect plants; plant protectors can also be purchased and can help give protection. It is recommended that poles are watered the day after planting and at least once a week during dry weather until they are established.

1. ***To stabilise banks:***

- pair-plant along straight reaches – one tree on one bank, one tree on the opposite bank, five to seven meters apart.
- plant at two to three metre spacing at critical points, such as the outside of the bends where erosion is the greatest.
- avoid planting on the inside of bends – soil builds up rather than erodes here, so trees will trap sediment and force current against the outer bank.
- avoid planting narrow channels where trees might impede floodwaters.

By the time trees are four- or five-years old, there will be a solid mass of roots along the bank. At 10 to 20 years, trees can be thinned to 10 to 12 metre spacing, but no wider. If you use sleeves on poles to protect the willows and poplars, sheep can be grazed around the trees from the time they are planted.

Natives[10]

There are many advantages of utilising native plants. These include:

- Enhancing natural character and landscape values.
- Forming a habitat corridor and potentially ecological linkage in the catchment.

[10] Information on native planting and previous Taieri River catchment vegetation provided curtesy of DoC

- Restoration of rare riparian forest (and other habitats).
- Creating /enhancing habitat for native birds and invertebrates (including pollinators).
- Restoration or enhancement of threatened plant habitats.
- Do not grow as high or require maintenance (e.g. pruning or thinning).
- Self-regenerating and maintaining.

Planting natives for bank stability will enhance the natural biodiversity of your riparian margin and provide habitat for invertebrates and birds. While exotic tree species are proven to stabilise banks, new research shows that native trees, such as ribbonwood, cabbage tree and pittosporum species, are suitable for bank stabilisation. These species are deep rooting, with a good root spread. Planting native species alongside exotics will help to maintain a mostly native planting on your banks. Table 6 lists suitable native vegetation to plant in the Taieri catchment including: trees, shrubs, and non woody plants. Table 7 lists nationally threatened species to use in the Strath reach, incorporating these species will add diversity to riparian plantings and contribute to the conservation and recovery of those species.

Original Taieri River catchment vegetation cover

An appreciation of the likely original vegetation of the Taieri River between Hyde and Matarae is helpful in guiding riparian restoration goals. Unfortunately this is difficult to attain now that the patterns of natural vegetation have been so disrupted by human occupation and so little native vegetation remains.

Previous areas of swamps contained stands of kahikatea on floodplains, totara, mountain totara, rimu, matai and kahikatea on the better drained low terraces, and kowhai and lowland ribbonwood along river banks. Pre-European burning would have extended areas of harakeke, tutu and other grasses.

Within the downlands of north Otago (including the Taieri River between Hyde and Matarae) were once covered with forest of totara, matai and trees such as broadleaf, ribbonwood, narrow-leaved lacebark and kowhai. The highest, driest, more inland parts once supported forests of mountain totara and mountain toatoa but these forests are now all but destroyed. The prevailing pre-European cover was grassland of fescue and silver tussocks, but with red tussock on cooler and damper sites. There was also scrub of matagouri and small-leaved coprosma and abundant cabbage trees, with Carex secta along water courses.

Table 6. Suitable native species for the Taieri River catchment (Hyde to Matarae)

Trees **Common name**	**Scientific name**	**Mix of plants**[11]
kohuhu	Pittosporum tenuifolium	major
lowland ribbonwood	Plagianthus regius	major
narrow-leaved lacebark	Hoheria angustifolia	major
South Island kowhai	Sophora microphylla	major
Cabbage tree	Cordyline australis	major
broadleaf	Griselinia littoralis	major
kanuka	Kunzea robusta	major
marbleleaf	Carpodetus serratus	moderate
manuka	Leptospermum scoparium	moderate
mountain totara	Podocarpus laetus	moderate
matai	Prumnopitys taxifolia	minor
kahikatea	Dacrycarpus dacrydioides	minor
Shrubs		
mingimingi	Coprosma propinqua	major
small-leaved coprosma	Coprosma dumosa	major
small-leaved coprosma	Coprosma rigida	major
koromiko	Hebe salicifolia	major
cottonwood	Ozothamnus vauvilliersii	major
mountain akeake	Olearia avicenniifolia	major
	Olearia bullata	major
mountain wineberry	Aristotelia fruticosa	moderate
weeping mapou	Myrsine divaricata	minor

[11] The major, moderate or minor is intended to direct the numbers/mix of plants used in a riparian/restoration planting. Therefore the bulk of the plants would compose the 'major' species, with some of the 'moderate' species and only a few of the 'minor' species. The species mix may be in the order of 10 of a 'major' species to 5 of a 'moderate' species to 1 of a 'minor' species.

Non-woody plants		
toetoe	Austroderia richardii	major
lowland flax	Phormium tenax	major
purei	Carex secta	major
red tussock	Chionochloa rubra subsp. cuprea	moderate
Buchanans sedge	Carex buchananii	minor

Table 7. Suitable native species for the Taieri River catchment (Hyde to Matarae) (rare species)

tree daisy	Olearia fimbriata
Hectors tree daisy	Olearia hectorii
tree daisy	Olearia lineata
bloodwood	Coprosma wallii
climbing broom	Carmichaelia kirkii
native verbena	Teucridium parvifolium

Appendix 3. River morphology trends

Bedload sediment in the Strath reach of the Taieri River is mainly sourced from the Kyeburn catchment with the majority of sediment being sourced from the western side of the catchment in the greywacke dominated geology (Forsyth, 2001). This report contains the first analysis of changes in ORC cross-section profiles for the Strath reach of the Taieri River (Appendix 4). Due to issues associated with the initial survey data collected in 2007 a quantitative analysis cannot be completed i.e. MBL analysis, however Appendix 4 describes the changes in general terms at the cross-section locations.

An analysis of hydrological data for the monitoring site, Taieri at Tiroiti highlight changes in river morphology at the site as well as in the general area of Tiroiti. At the Tiroiti site there is a significant downward trend in stage levels (water levels) between 1983 and 2015. This can be used as a proxy to indicate that that bed level is decreasing at the site, indicating that limited gravel is moving downstream and becoming deposited at the site, however it may indicate that gravel is passing through the system and not becoming deposited at this location.

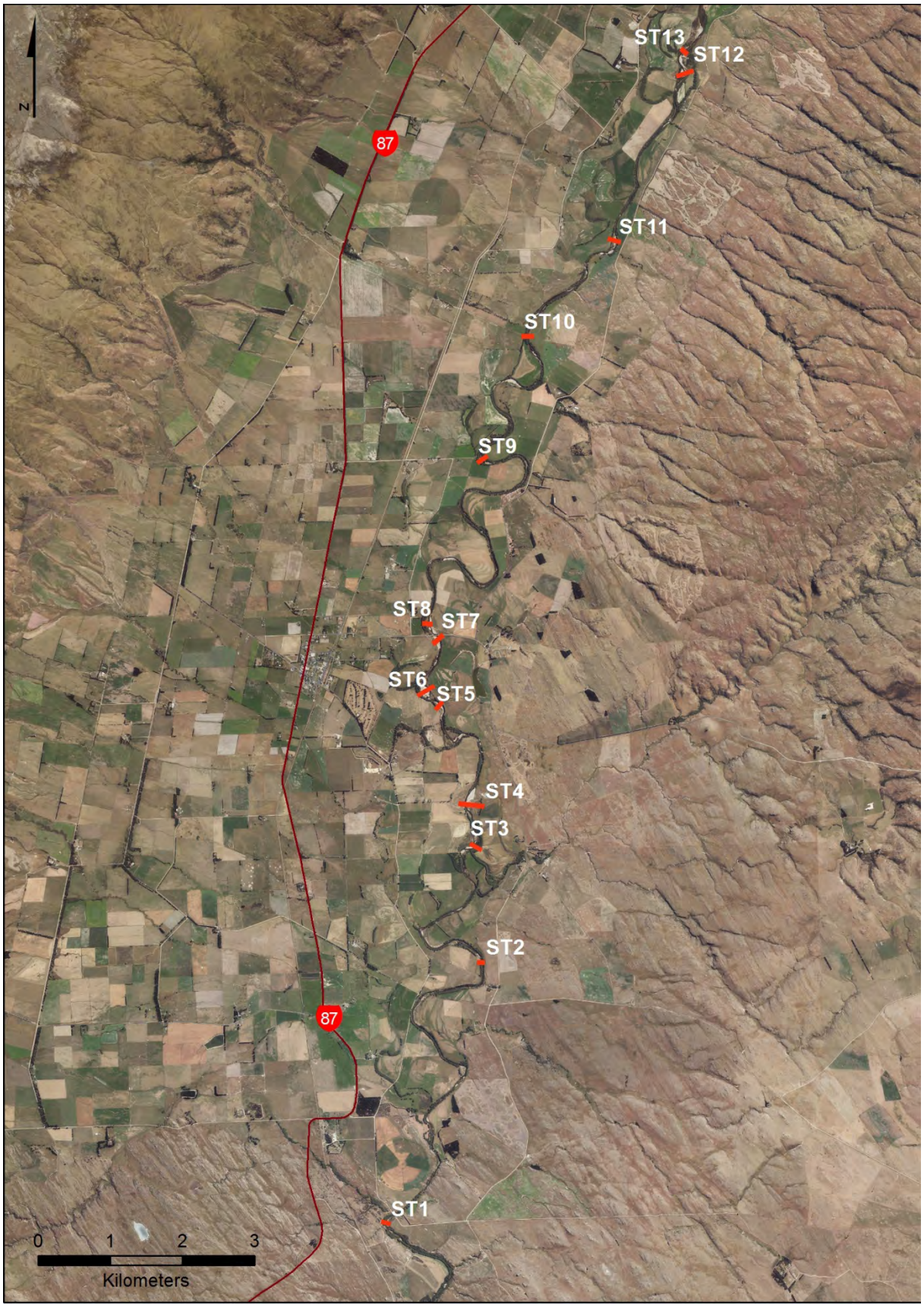

Figure 16. Taieri River cross-section locations (aerial photograph taken 2013)

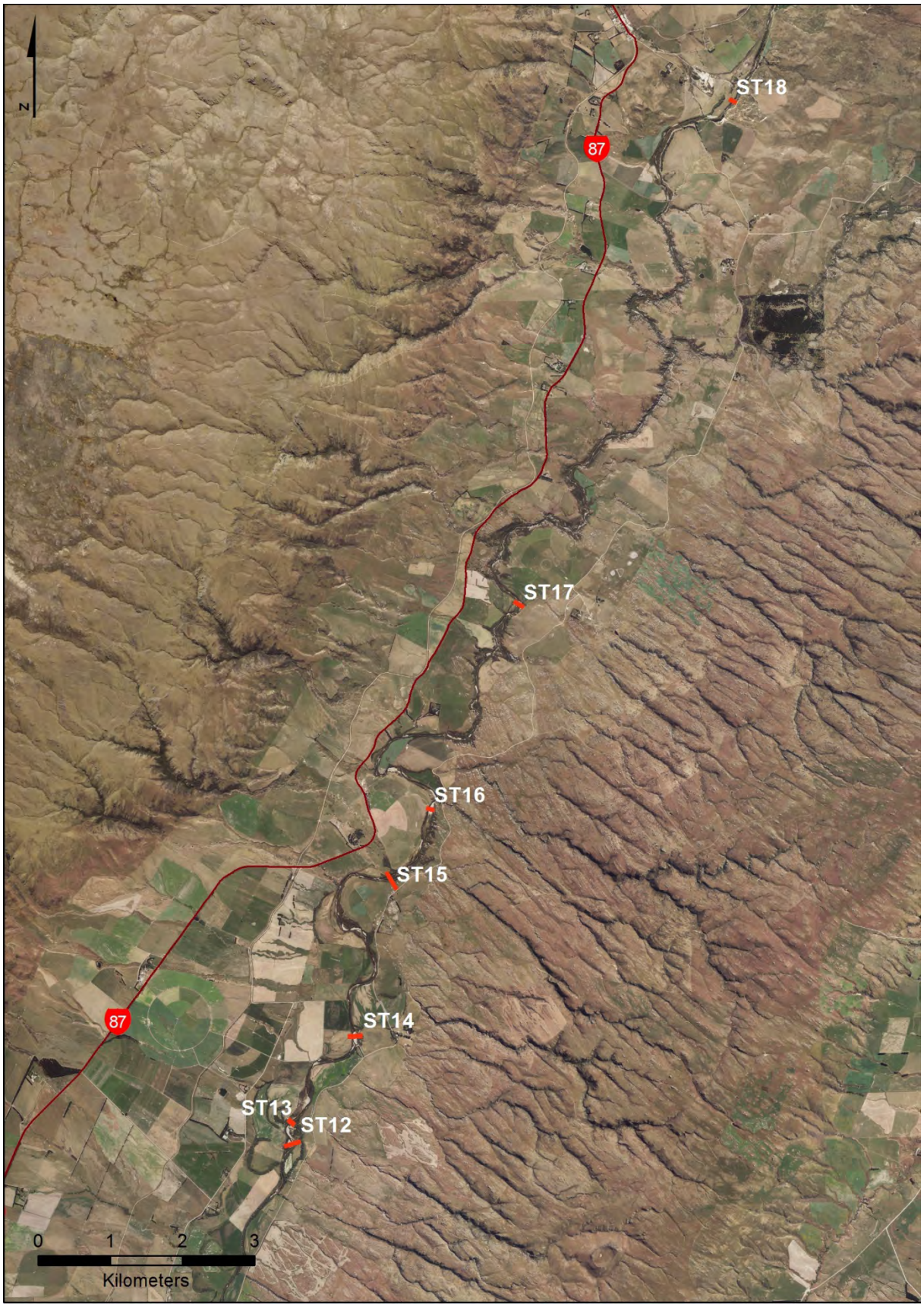

Figure 17. Taieri River cross-section locations (aerial photography taken 2013)

Appendix 4. Taieri River cross-sections

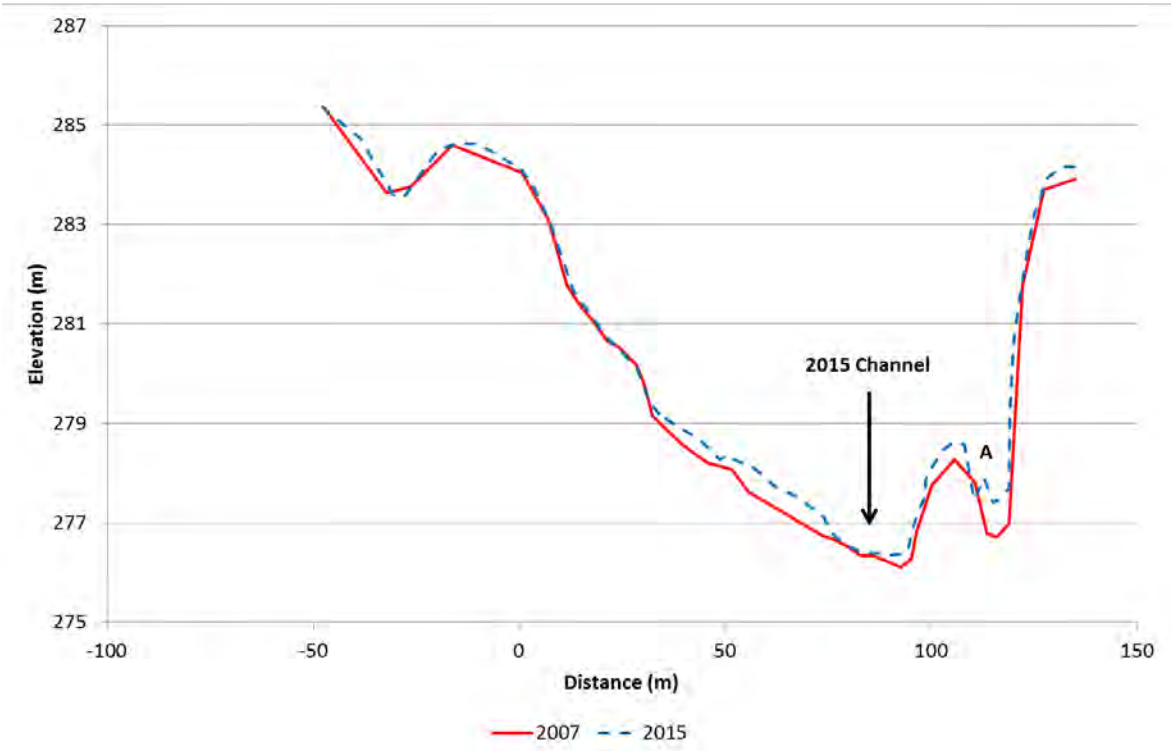

Figure 18. Taieri River cross-section ST1, looking downstream

Figure 19. Cross-section ST1, looking downstream, November 2015

Cross-section ST1 is located 0.14 km downstream of the Sutton-Mount Ross Road bridge. The main channel has remained in a similar position with some aggradation occurring on the true left berm area and in the secondary channel (point labelled A) between 2007 and 2015.

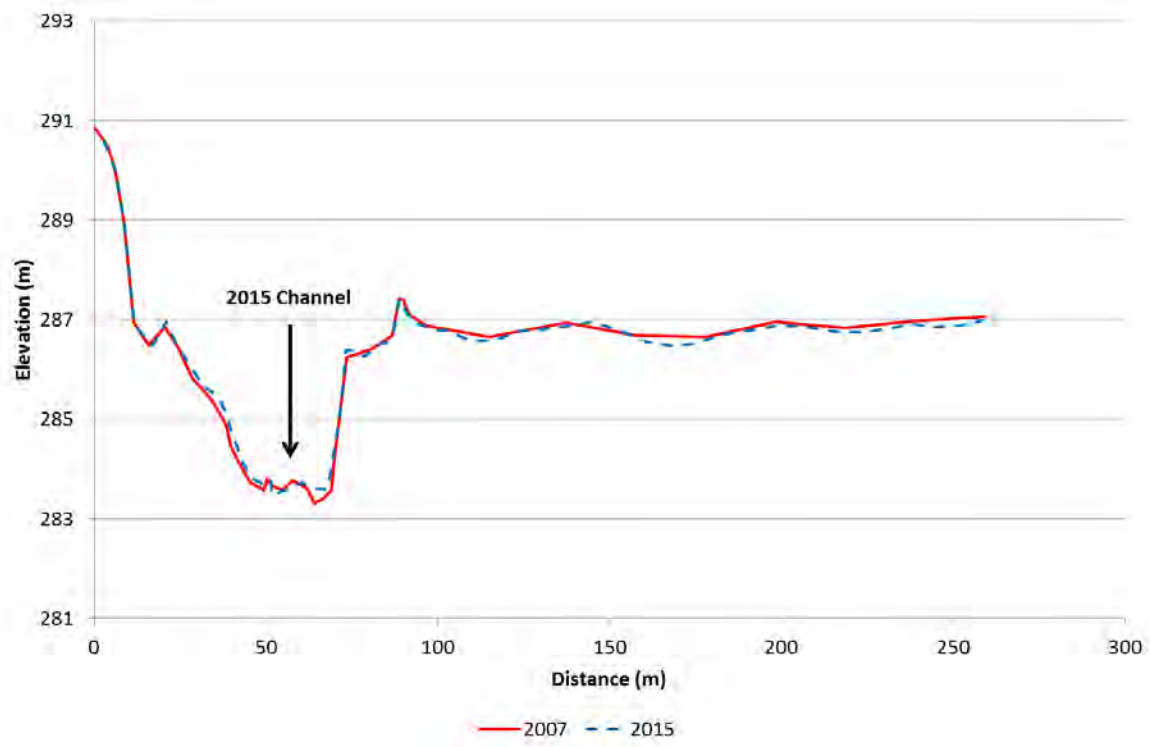

Figure 20. Taieir River cross-section ST2, looking downstream

Figure 21. Cross-section ST2, looking from the true right to true left bank, November 2015

Cross-section ST2 is located 5.2 km upstream of the Sutton-Mount Ross Road bridge. The channel and wider floodplain has remained in a similar position between 2007 and 2015.

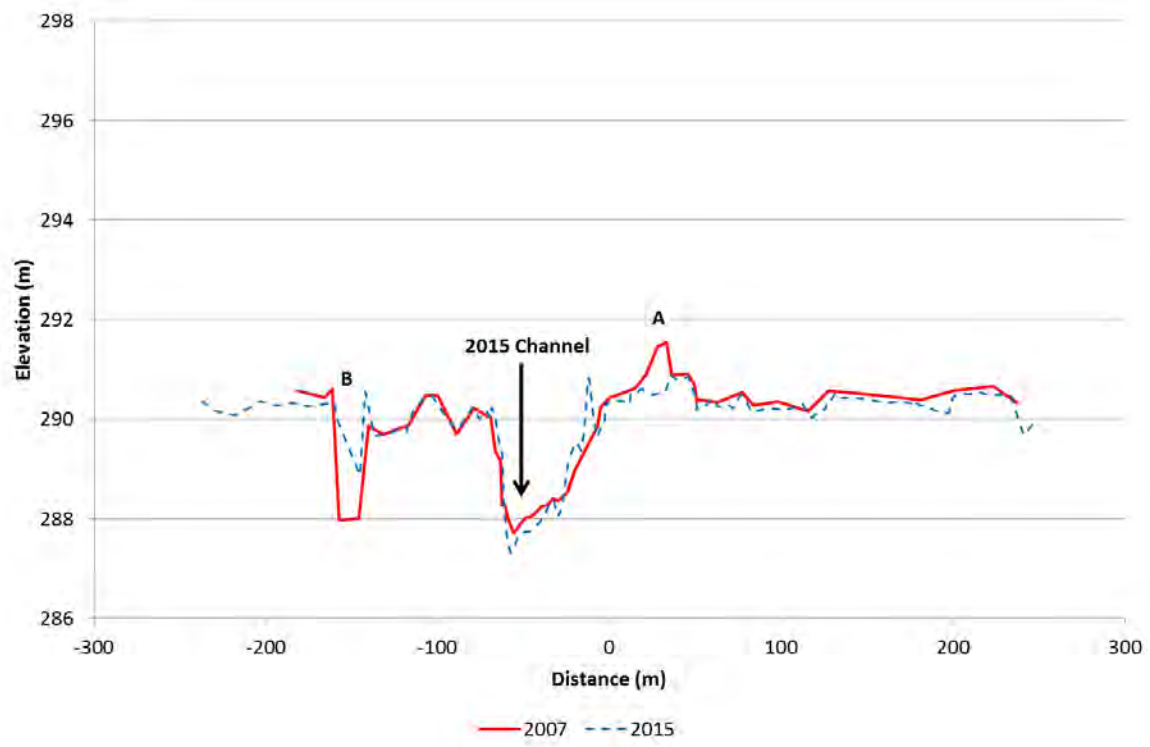

Figure 22. Taieri River cross-section ST3, looking downstream

Figure 23. Cross-section ST3, looking upstream, November 2015

Cross-section ST3 is located 3.7 km downstream of the Moonlight Road bridge. The main channel has remained in a similar position between 2007 and 2015 with degradation occurring in the main channel. The true right bank has degraded (at the point labelled A) with minor degradation occurring on the true right floodplain. The secondary channel (at the point labelled B) has aggraded between 2007 and 2015.

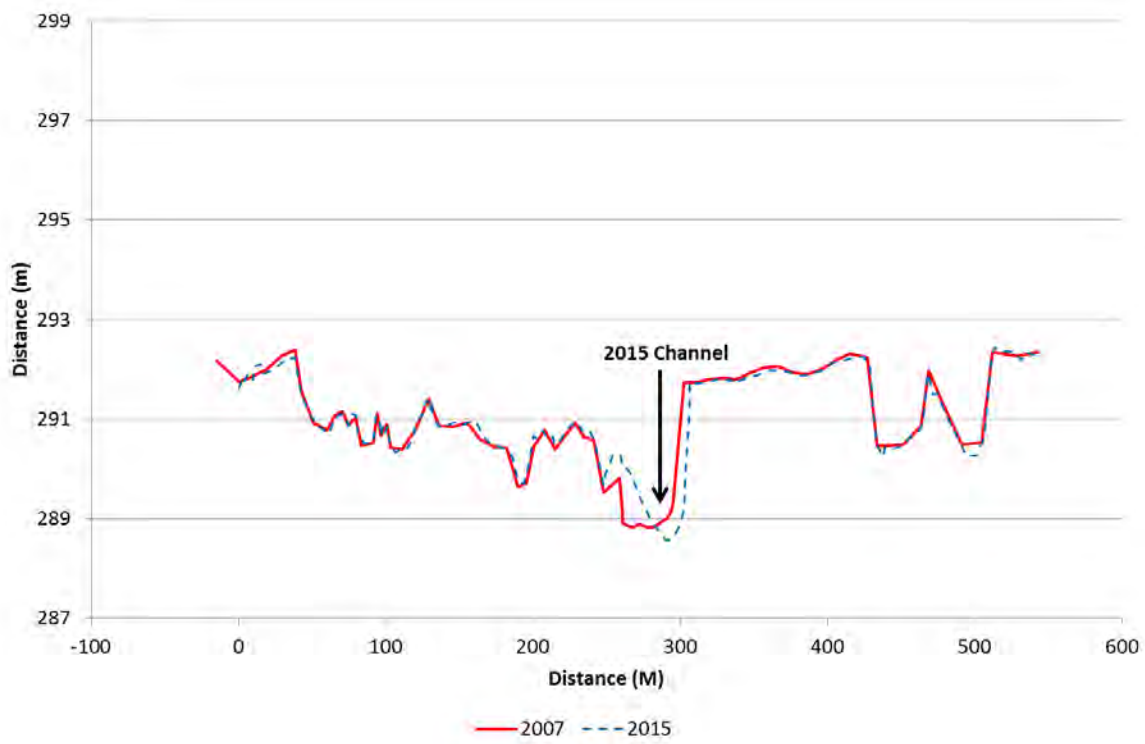

Figure 24. Taieri River cross-section ST4, looking downstream

Figure 25. Cross-section ST4, looking upstream, November 2015

Cross-section ST4 is located 3.1 km downstream of the Moonlight Road bridge. The berm area and wider floodplain has remained similar between 2007 and 2015. The main channel has degraded and eroded the true right bank but has aggraded on the true left.

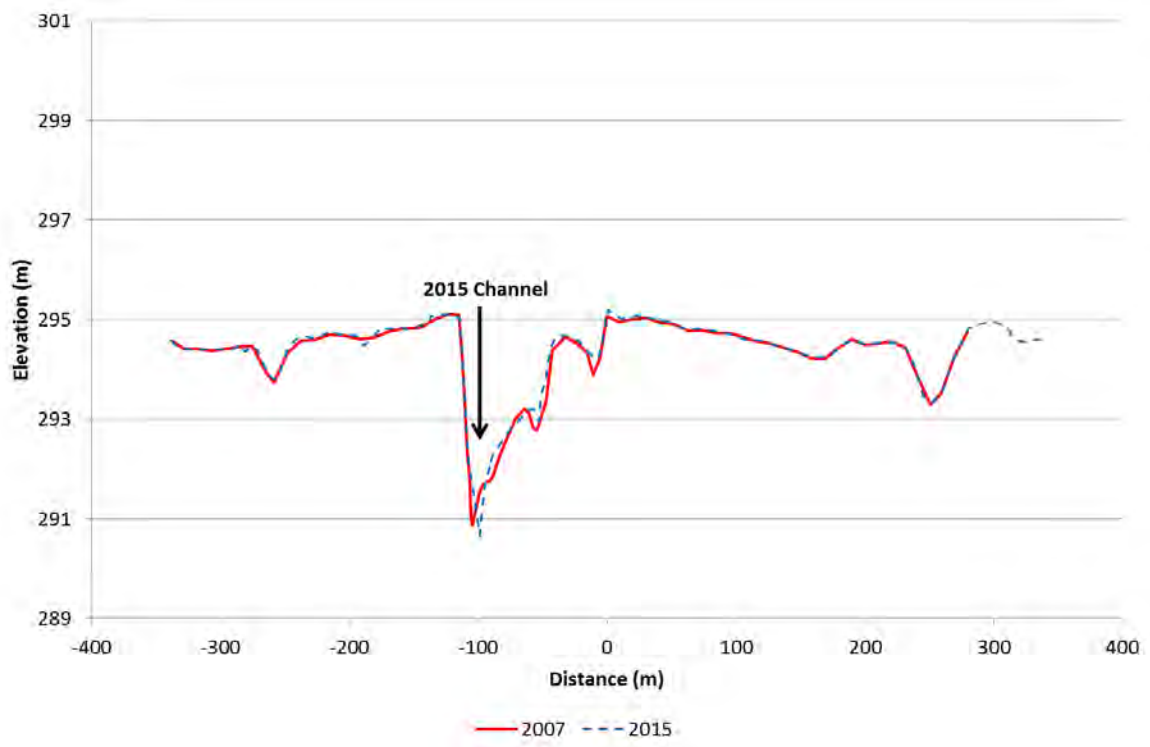

Figure 26. Taieri River cross-section ST5, looking downstream

Figure 27. Cross-section ST5, looking downstream, November 2015

Cross-section ST5 is located 1.2 km downstream of the Moonlight Road bridge. Between 2007 and 2015 the main channel became more confined with little change occurring across the wider berm area and floodplain.

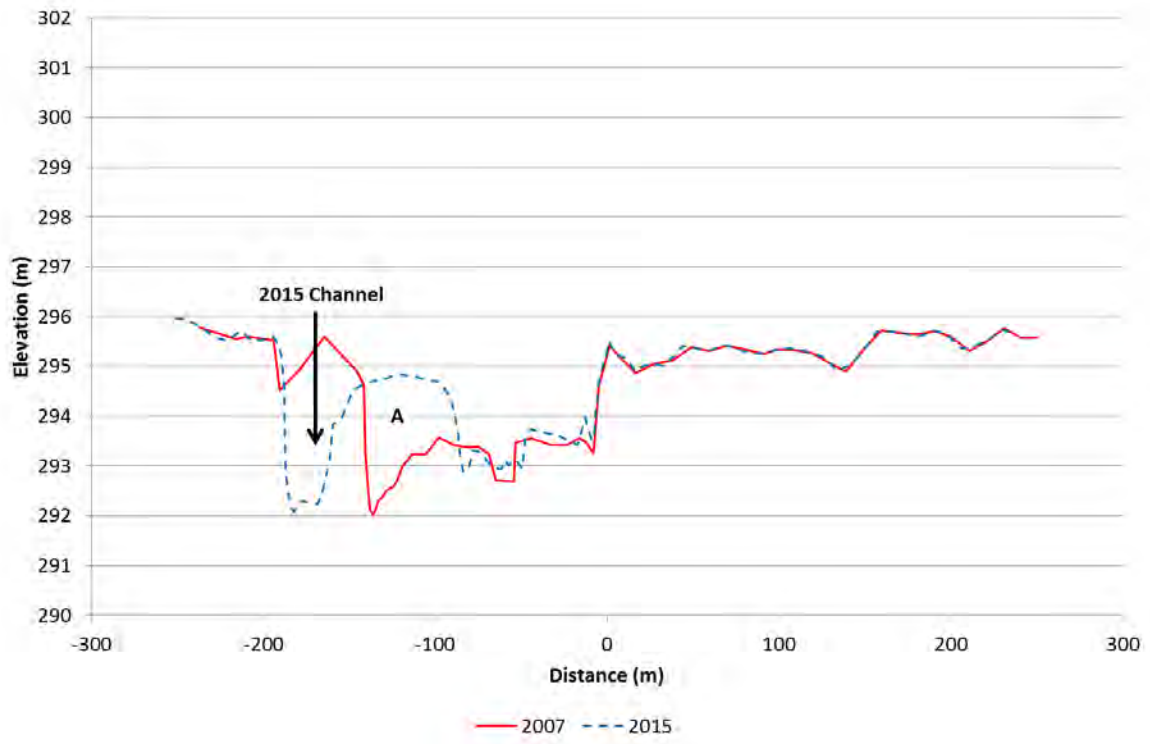

Figure 28. Taieri River cross-section ST6, looking downstream

Figure 29. Cross-section ST6, looking upstream, November 2015

Cross-section ST6 is located 0.93 km downstream of the Moonlight Road bridge. Between 2007 and 2015 the main channel shifted towards the true left and eroded the bank by about 54 m. A gravel island has built up between 2007 and 2015 (at the point labelled A) with minimal change occurring across the wider floodplain.

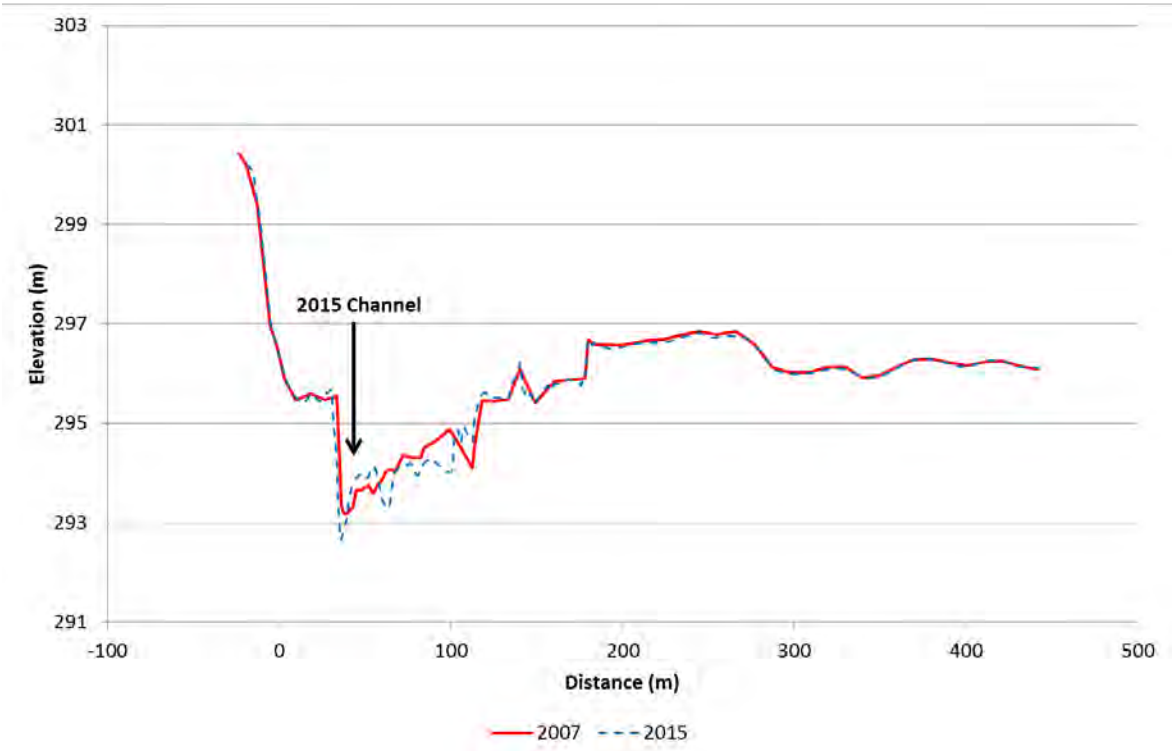

Figure 30. Taieri River cross-section ST7, looking downstream

Figure 31. Cross-section ST7, looking upstream, November 2015

Cross-section ST7 is located at the Moonlight Road bridge. The main channel has become more confined between 2007 and 2015 as well as more undulating. The true right berm area has degraded with minimal change occurring across the wider floodplain between 2007 and 2015.

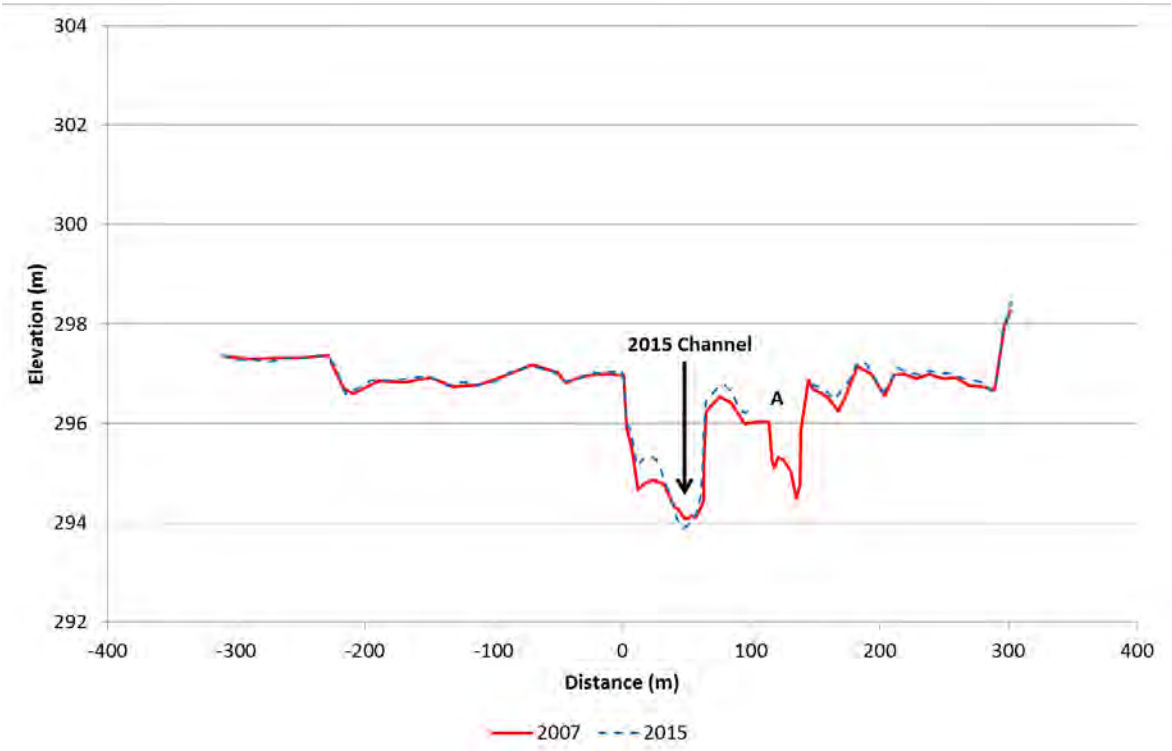

Figure 32. **Taieri River cross-section ST8, looking downstream**

Figure 33. **Cross-section ST8, looking from the true left to true right bank, November 2015**

Cross-section ST8 is located 0.18 km upstream of the Moonlight Road bridge. Between 2007 and 2008 the main channel has become more confined. A secondary channel (at the point labelled A) does not contain sufficient survey points in the 2015 survey to allow a comparison to be made. The wider floodplain has remained similar between 2007 and 2015.

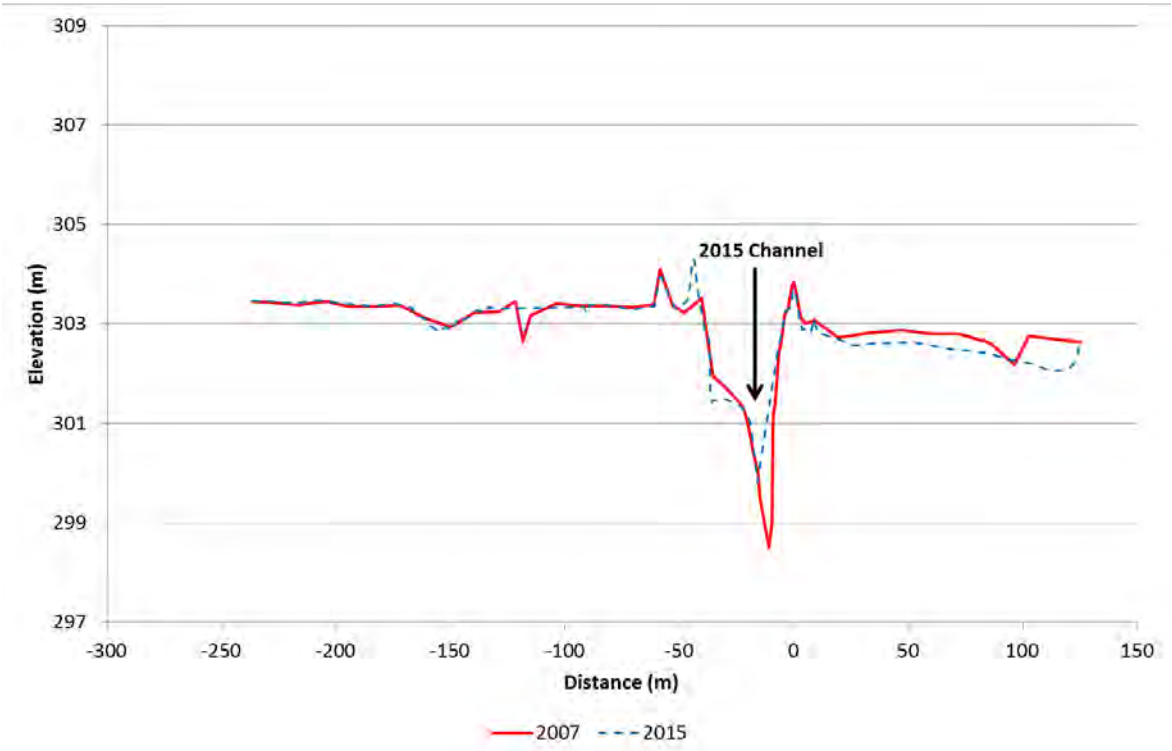

Figure 34. Taieri River cross-section ST9, looking downstream

Figure 35. Cross-section ST9, looking downstream, November 2015

Cross-section ST9 is located 5.4 km upstream of the Moonlight Road bridge. The main channel has aggraded between 2007 and 2015. The true right floodplain has experienced degradation between 2007 and 2015.

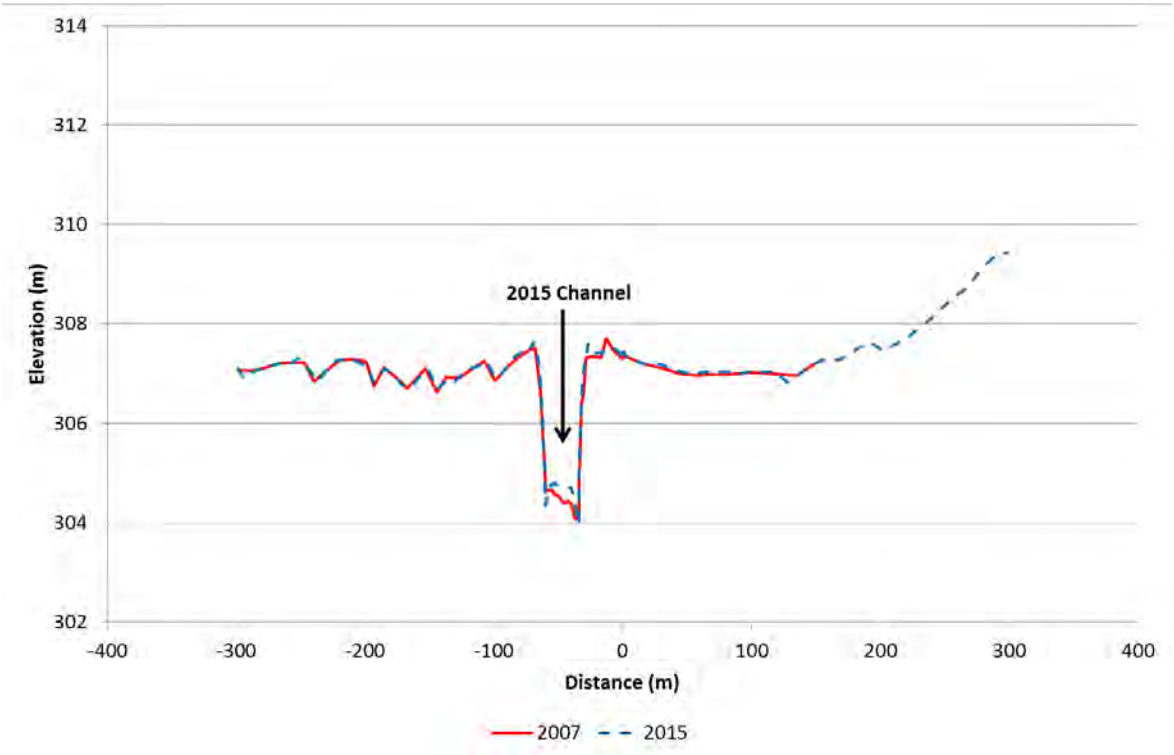

Figure 36. Taieri River cross-section ST10, looking downstream

Figure 37. Cross-section ST10, looking upstream, November 2015

Cross-section ST10 is located at the end of Pugh Road, 8.2 km upstream of the Moonlight Road bridge. Aggradation has occurred in the main channel between 2007 and 2015 with minimal change occurring across the wider floodplain.

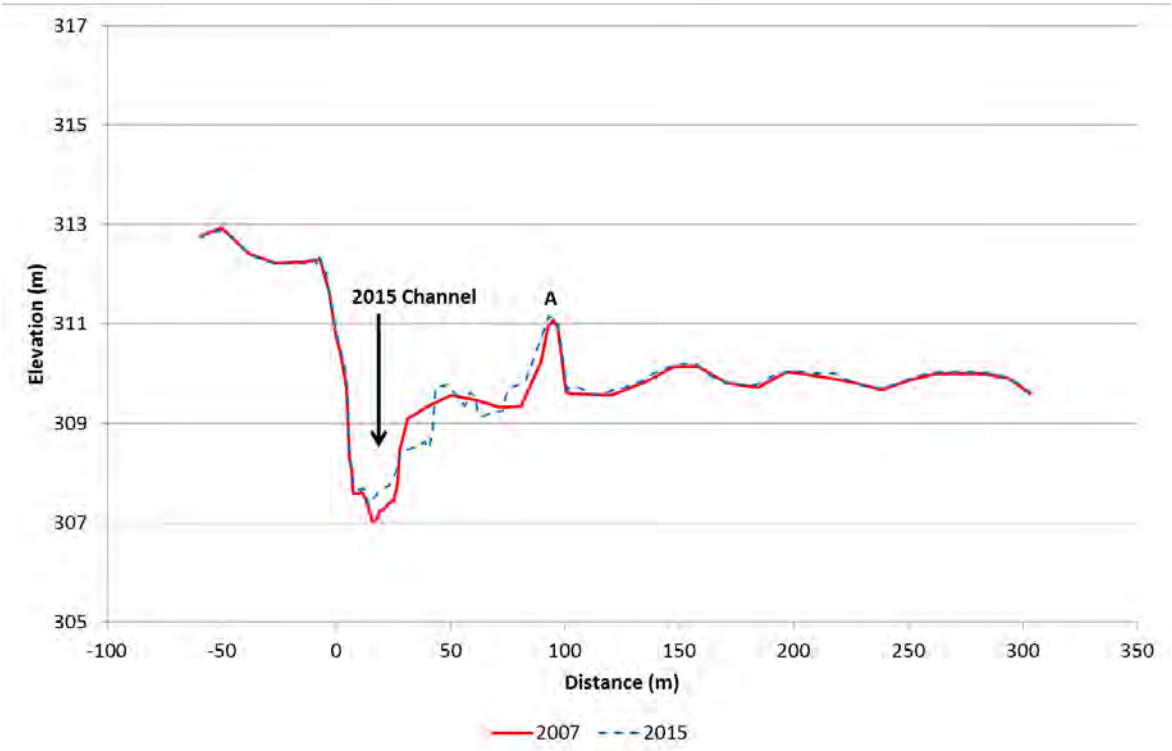

Figure 38. Taieri River cross-section ST11, looking downstream

Figure 39. Cross-section ST11, looking downstream, November 2015

Cross-section ST11 is located 10.2 km upstream of the Moonlight Road bridge. Between 2007 and 2015 the main channel has aggraded with some erosion occurring on the true right channel bank. A feature (at the point labelled A) has become wider and minimal change has occurred across the wider floodplain.

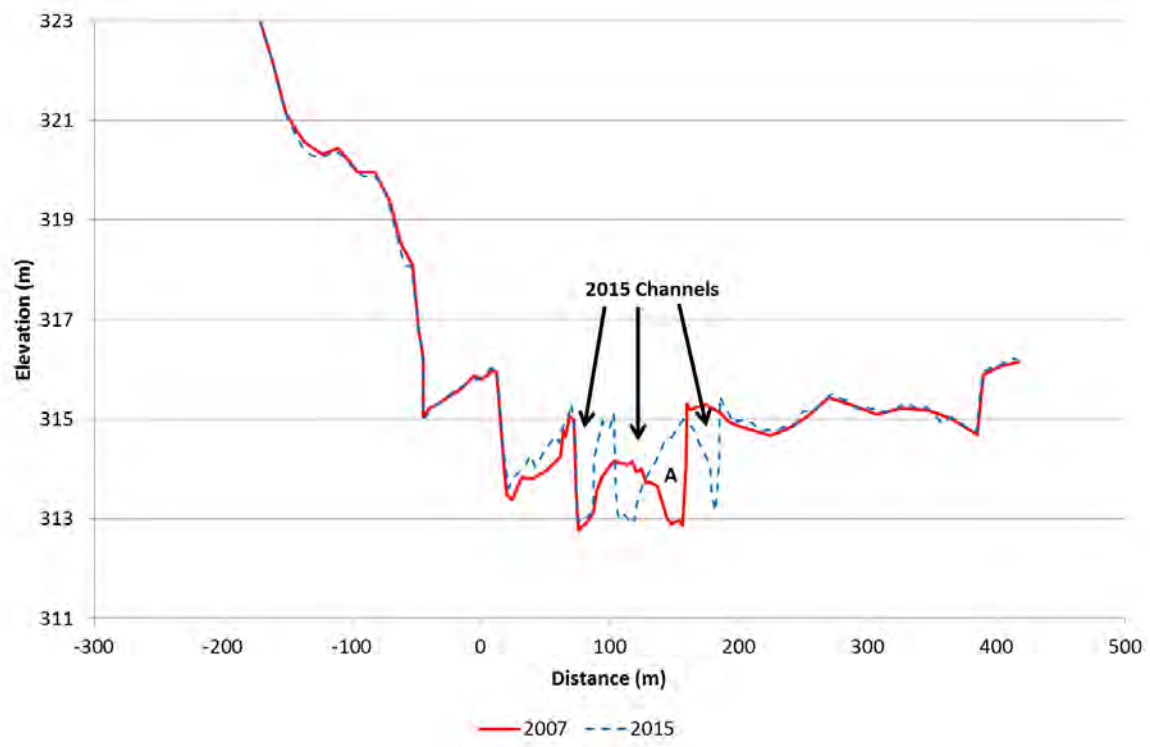

Figure 40. Taieri River cross-section ST12, looking downstream

Figure 41. Cross-section ST12, looking upstream, November 2015

Cross-section ST12 is located 12.9 km upstream of the Moonlight Road bridge. Between 2007 and 2015 the true left berm area experienced aggradation. In 2007 there were two main low flow channels, in 2015 the main channel has split into three low flow channels which has caused the true right bank to eroded as well as creating more confined channels separated by a gravel bar (at the point labelled A). The wider floodplain has experienced minimal change between 2007 and 2015.

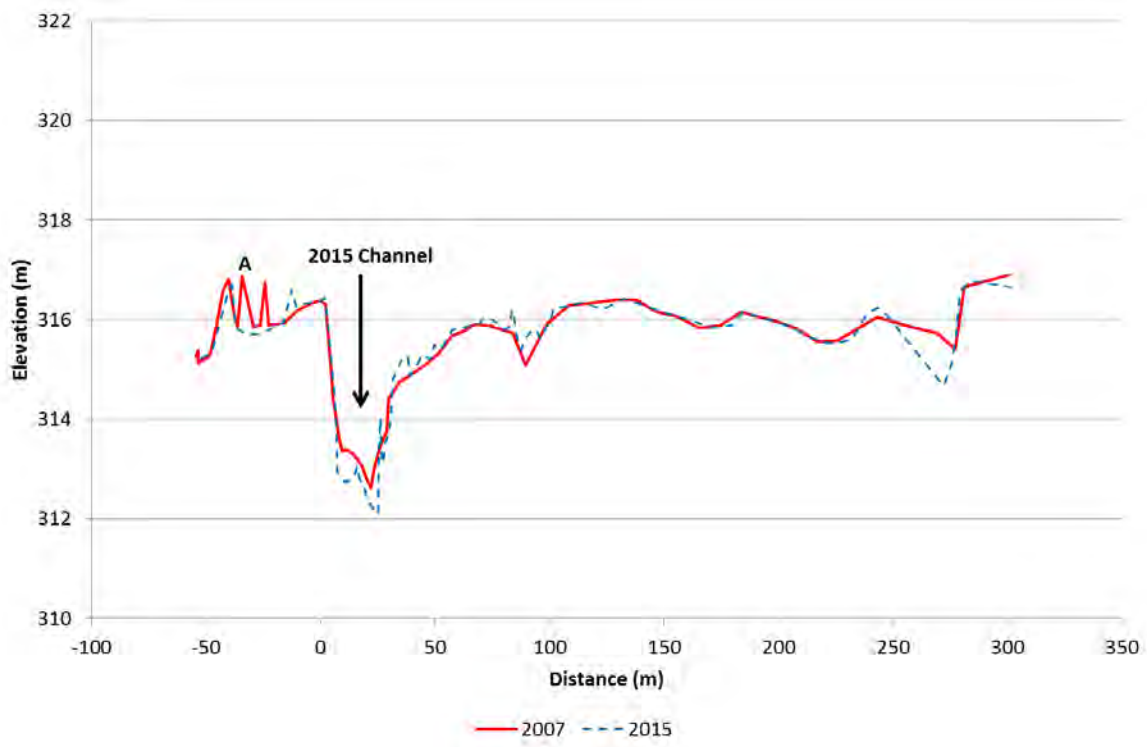

Figure 42. Taieri River cross-section ST13, looking downstream

Figure 43. Cross-section ST13, looking upstream, November 2015

Cross-section ST13 is located 13.2 km upstream of the Moonlight Road bridge. Features located on the true left berm (at the point labelled A) in 2007 have been eroded and are not present in 2015. The main channel has degraded with both aggradation and degradation occurring across the wider floodplain.

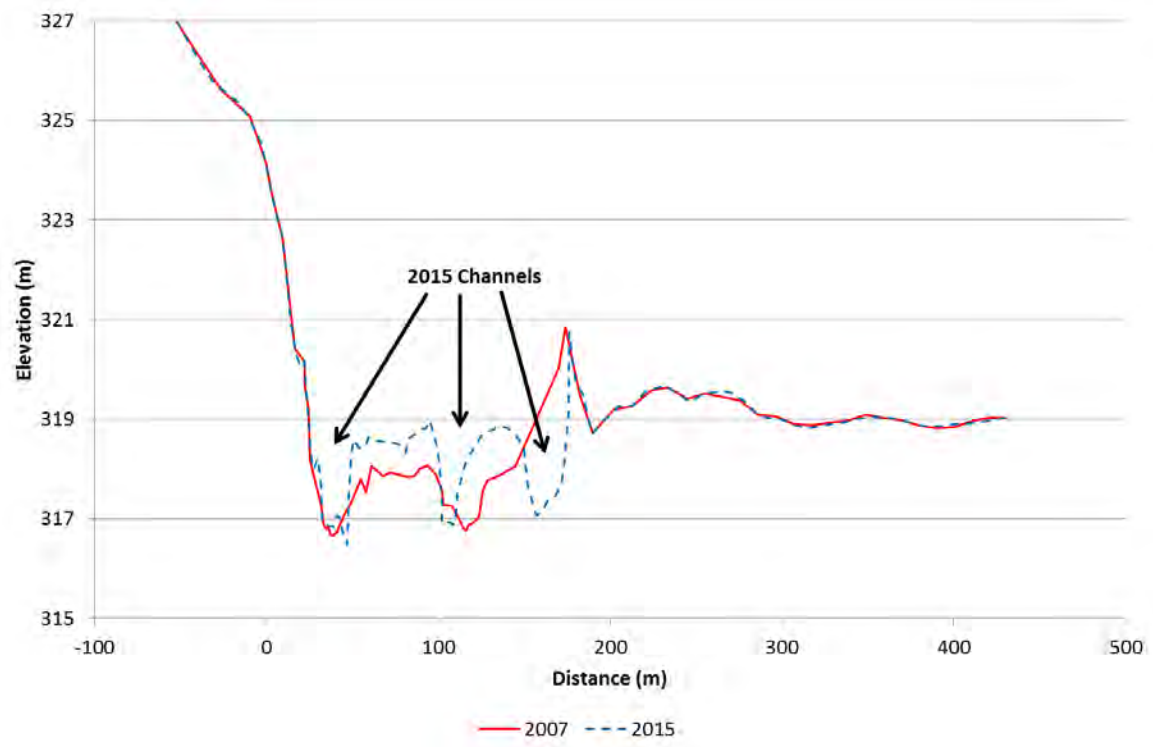

Figure 44. Taieri River cross-section ST14, looking downstream

Figure 45. Cross-section ST14, looking from the true right to true left bank, November 2015

Cross-section ST14 is located 14.9 km upstream of the Moonlight Road bridge. In 2007 there were two low flow channels at this location, in 2015 three low flow channels have developed causing some erosion of the true right bank and both aggradation and degradation within the active fairway.

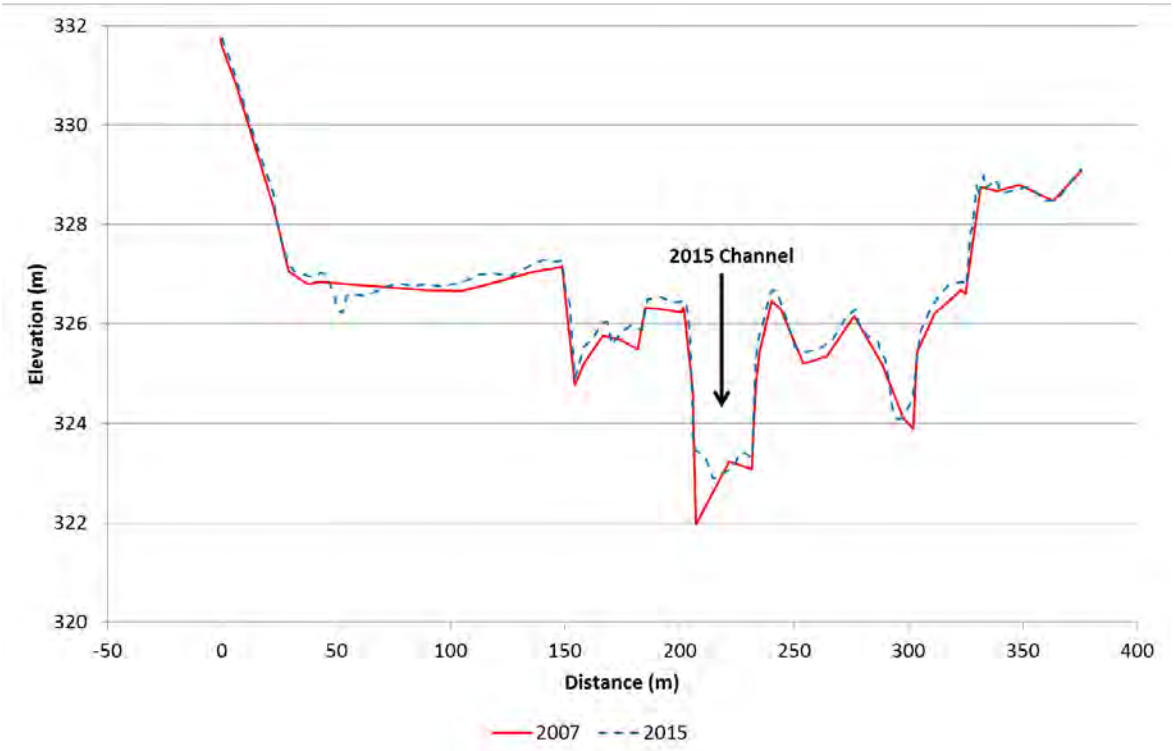

Figure 46. Taieri River cross-section ST15, looking downstream

Figure 47. Cross-section ST14, looking downstream, November 2015

Cross-section ST15 is located 18.3 km upstream of the Moonlight Road bridge. Between 2007 and 2015 the main channel experienced aggradation. The wider floodplain experienced aggradation with some minor degradation between 2007 and 2015.

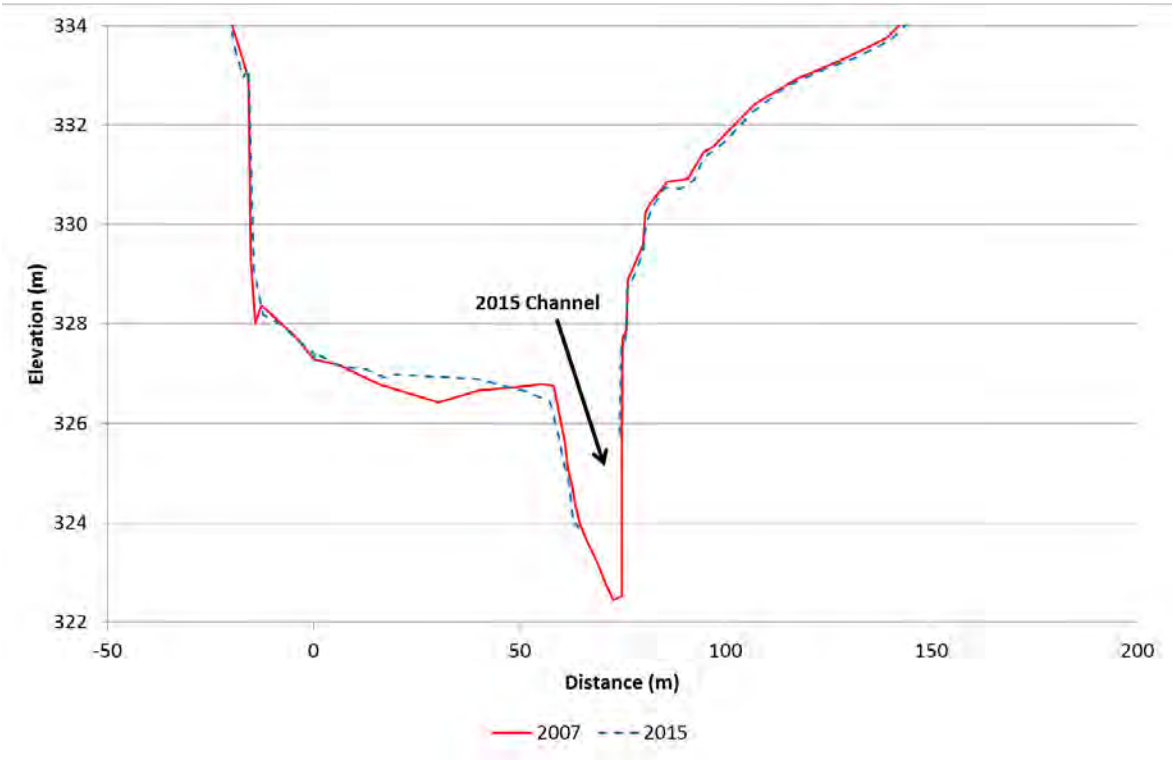

Figure 48. Taieri River cross-section ST16, looking downstream

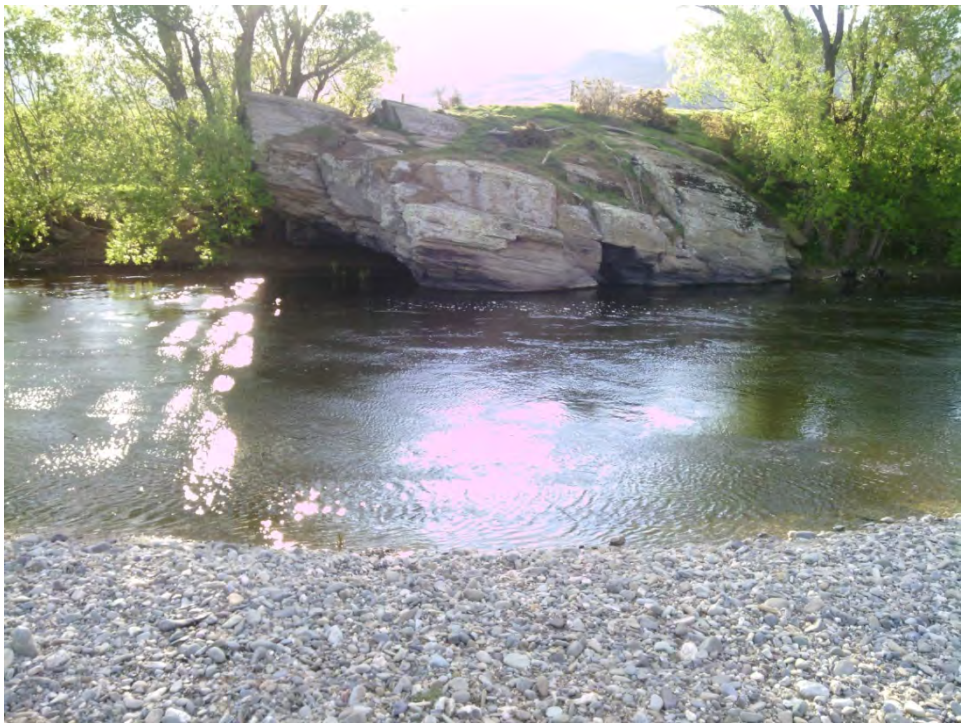

Figure 49. Cross-section ST16, looking from the true right to true left bank, November 2015

Cross-section ST16 is located 14.1 km downstream of the Hyde-Macraes Road bridge. The main channel does not contain sufficient survey points in the 2015 survey to allow a comparison to be made. The true left berm has experienced aggradation with some minor erosion of the channel edge between 2007 and 2015.

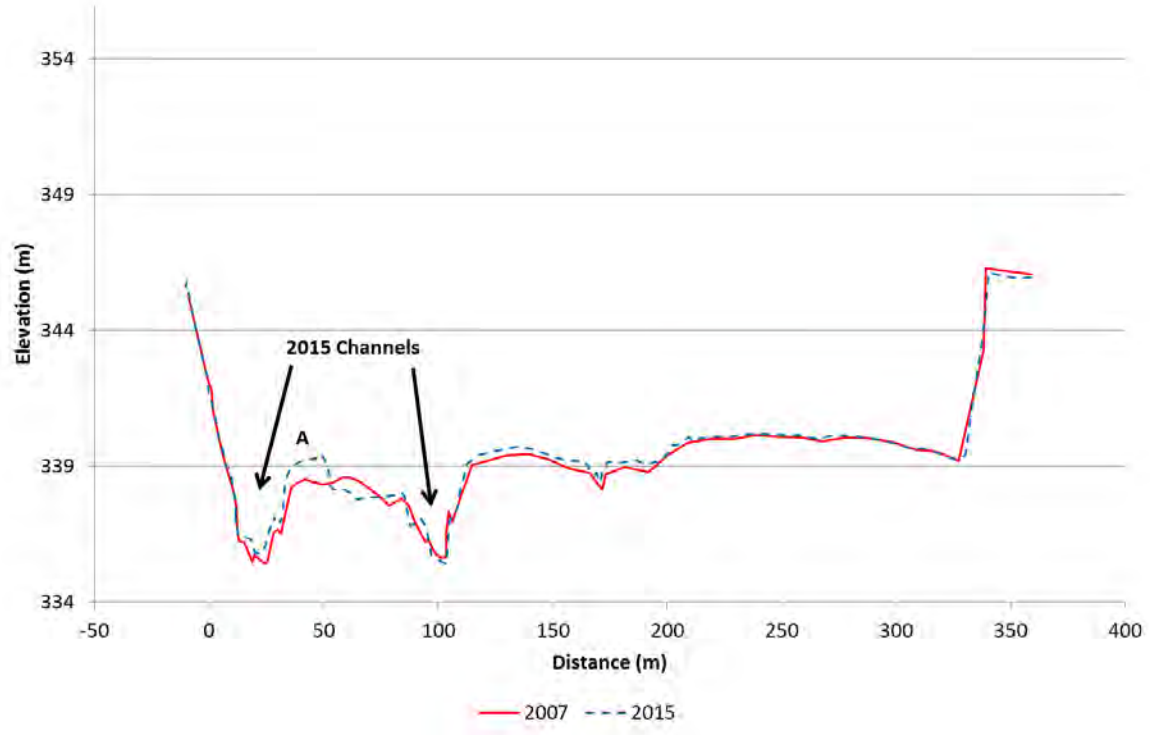

Figure 50. Taieri River cross-section ST17, looking downstream

Figure 51. Cross-section ST17, looking downstream, November 2015

Cross-section ST17 is located 9 km below the Hyde-Macraes Road bridge. The true left low flow channel and the mid channel bar (at the point labelled A) has aggraded between 2007 and 2015 with some degradation present on the true right of the bar. The true right floodplain has experienced aggradation and minimal change between 2007 and 2015.

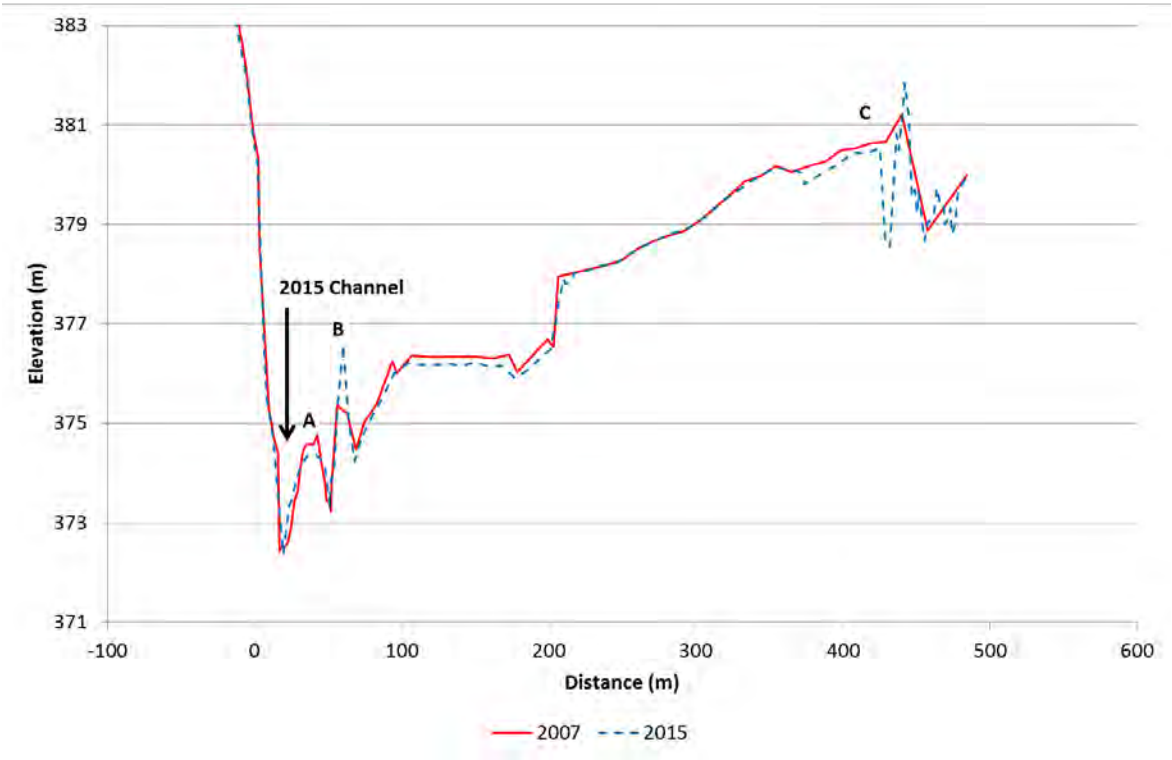

Figure 52. Taieri River cross-section ST18, looking downstream

Figure 53. Cross-section ST18, looking upstream, November 2015

Cross-section ST18 is located 2.1 km upstream of the Hyde-Macraes Road bridge. The main channel has remained in a similar position between 2007 and 2015 with some degradation occurring on the gravel bar (at the point labelled A). A feature on the true right of the channel (at the point labelled B) has aggraded, degradation has occurred on the true right berm area between 2007 and 2015. The right side of the cross-section (at the point labelled C) is showing degradation between 2007 and 2015 and can be associated with industrial activity.

Appendix 5. Taieri River corridor/fairway maps.

The river fairway and corridor provides guidance for multi-purpose river management, and for the design and implementation of management measures, protection works and in-channel design. When physical works or activities are being considered within the fairway or on the riparian margin, these should be undertaken with reference to the mapped fairway and buffer zones. The method used to define the river corridor is explained in Section 7.1.

Figure 54. **Taieri River fairway and corridor Map 1 (aerial photography collected 2013)**

Figure 55. Taieri River fairway and corridor Map 2 (aerial photography collected 2013)

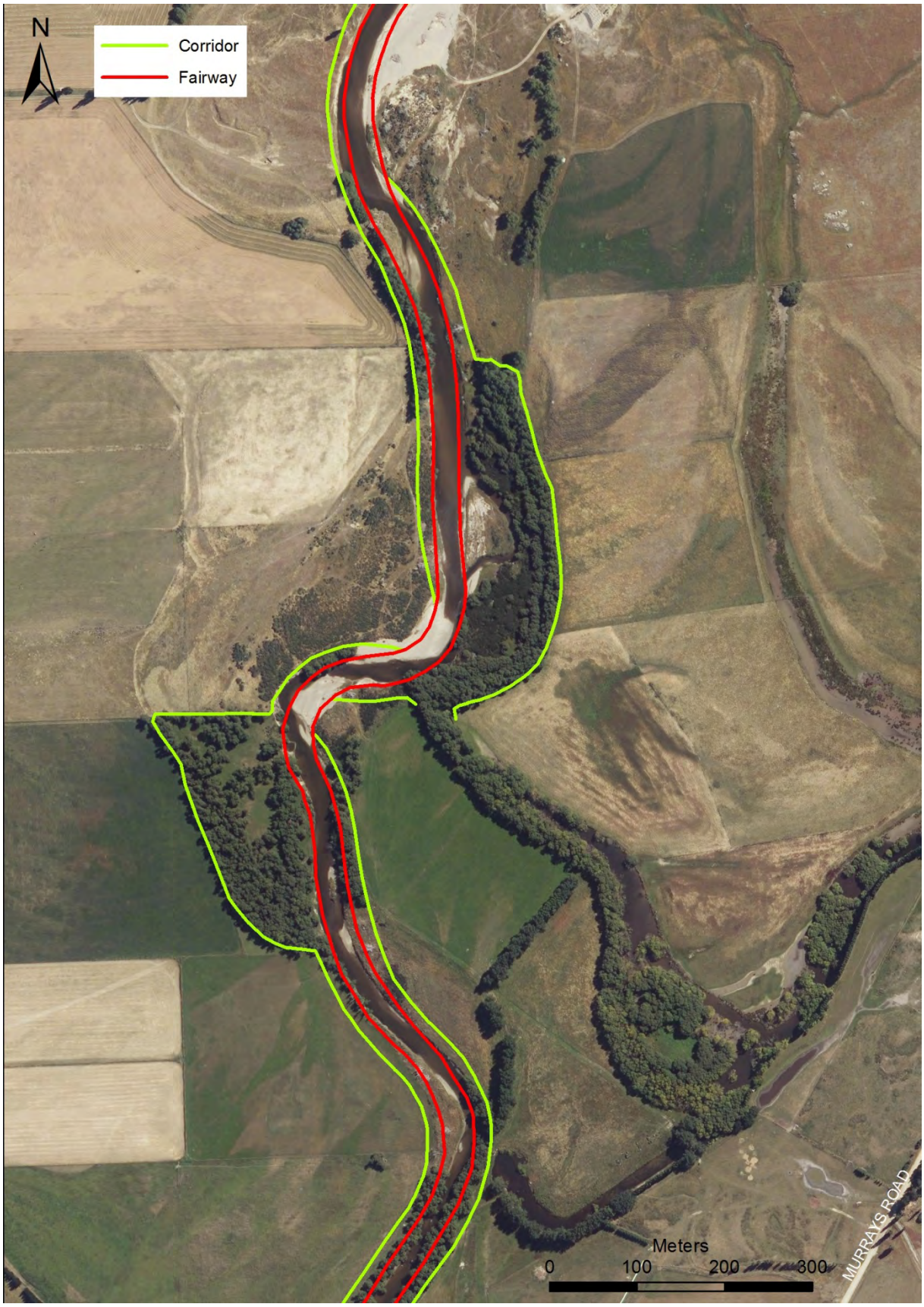

Figure 56. Taieri River fairway and corridor Map 3 (aerial photography collected 2013)

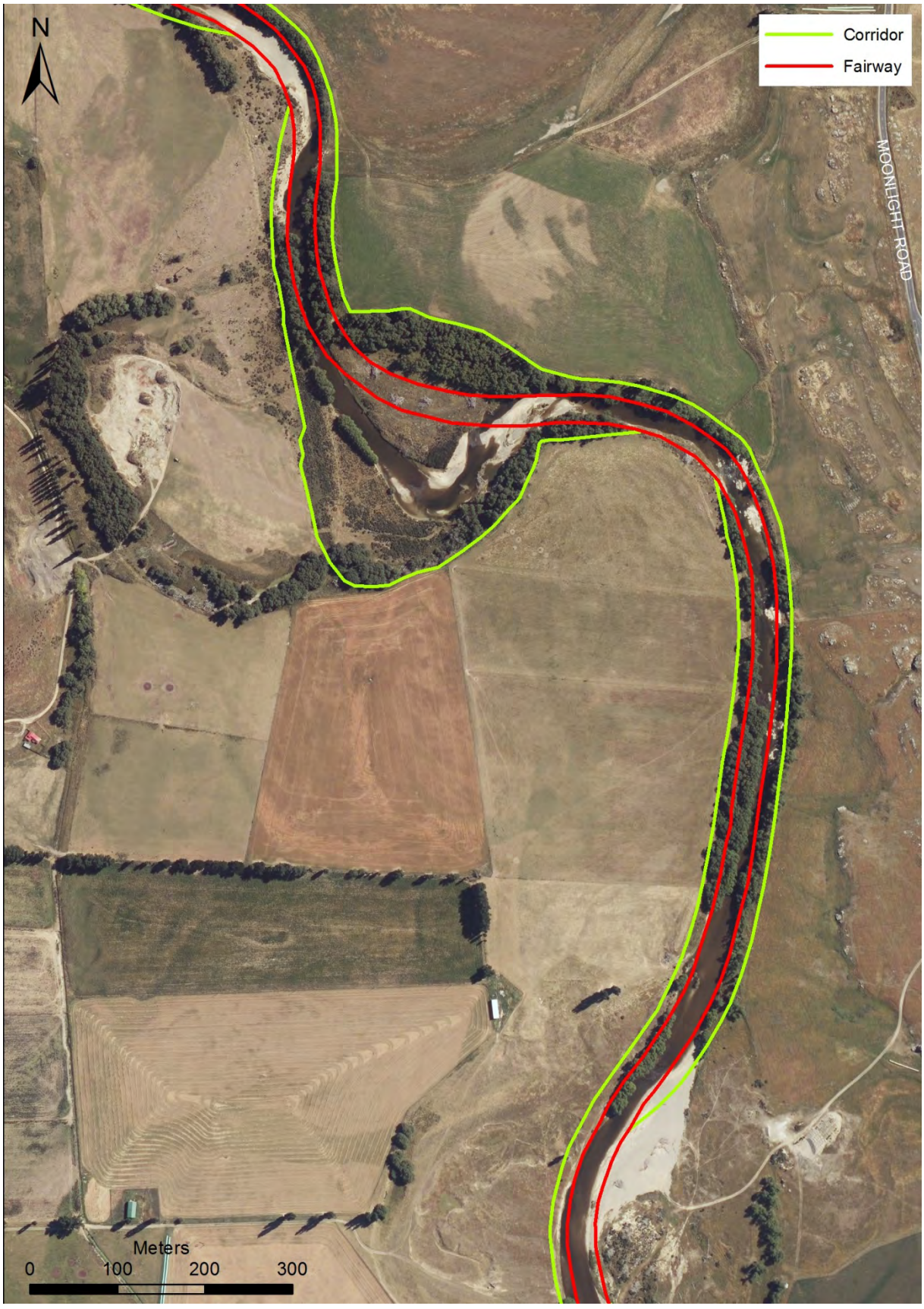

Figure 57. Taieri River fairway and corridor Map 4 (aerial photography collected 2013)

Figure 58. **Taieri River fairway and corridor Map 5 (aerial photography collected 2013)**

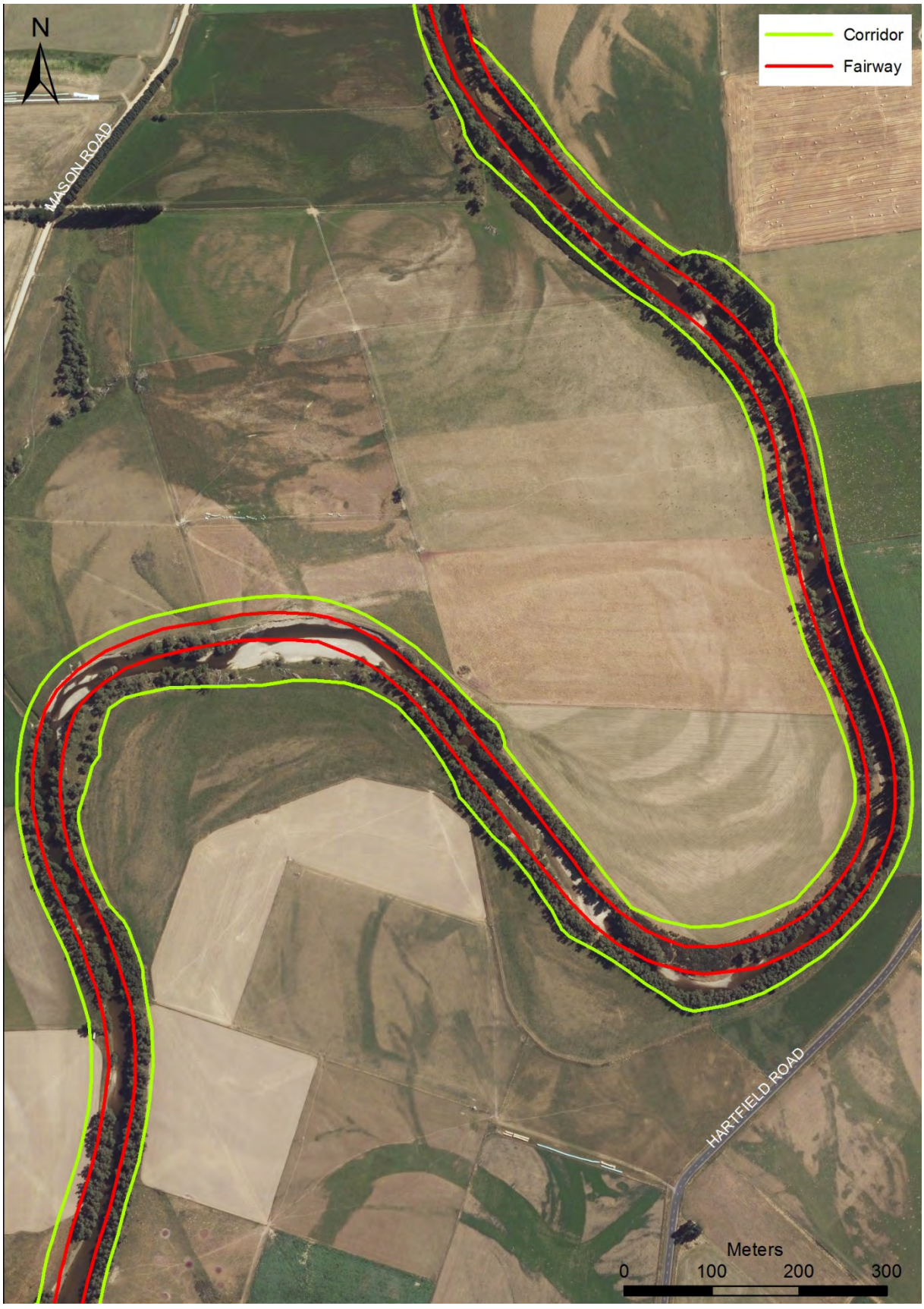

Figure 59. Taieri River fairway and corridor Map 6 (aerial photography collected 2013)

Figure 60. Taieri River fairway and corridor Map 7 (aerial photography collected 2013)

Figure 61. Taieri River fairway and corridor Map 8 (aerial photography collected 2013)

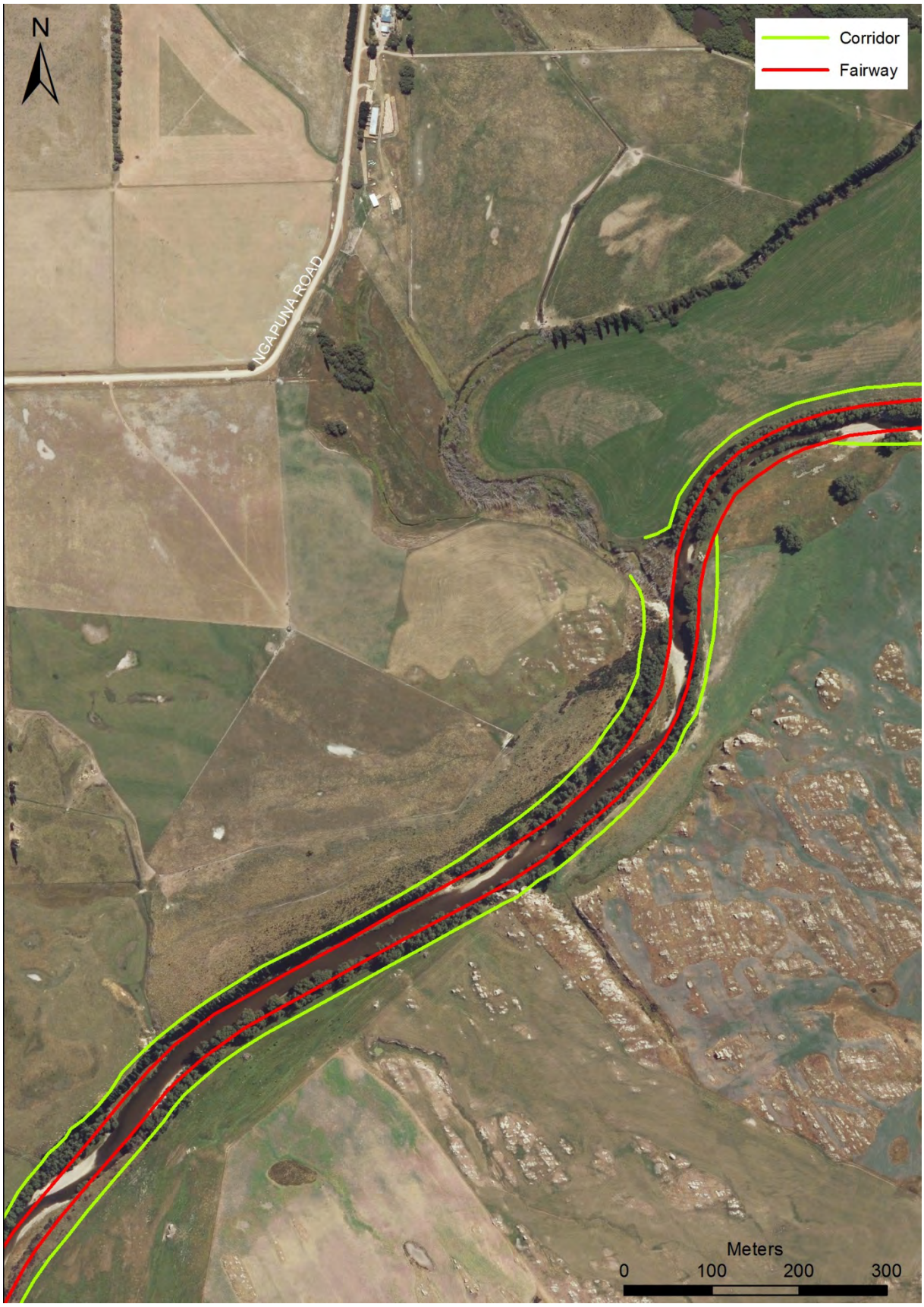

Figure 62. **Taieri River fairway and corridor Map 9 (aerial photography collected 2013)**

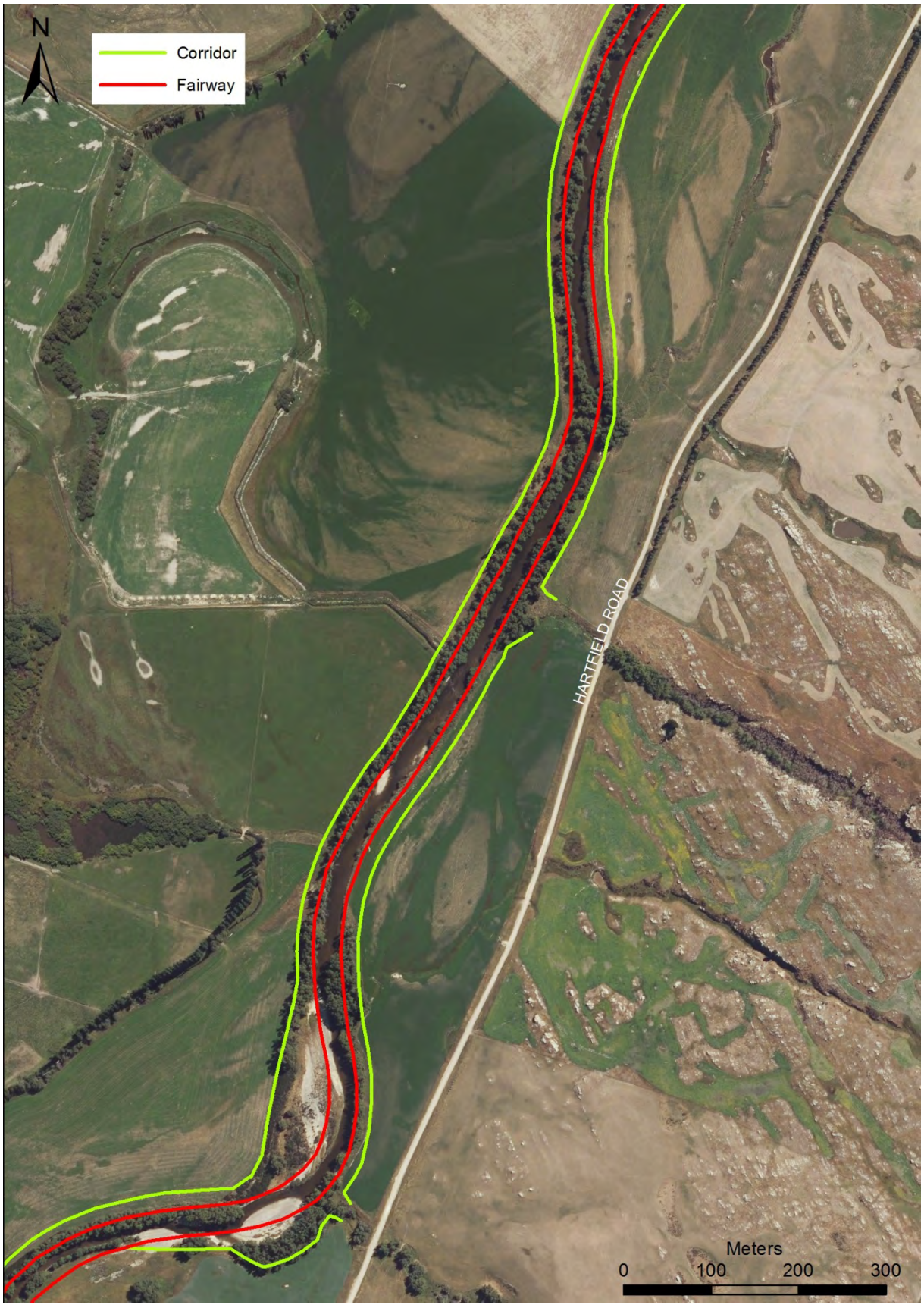

Figure 63. Taieri River fairway and corridor Map 10 (aerial photography collected 2013)

Figure 64. **Taieri River fairway and corridor Map 11 (aerial photography collected 2013)**

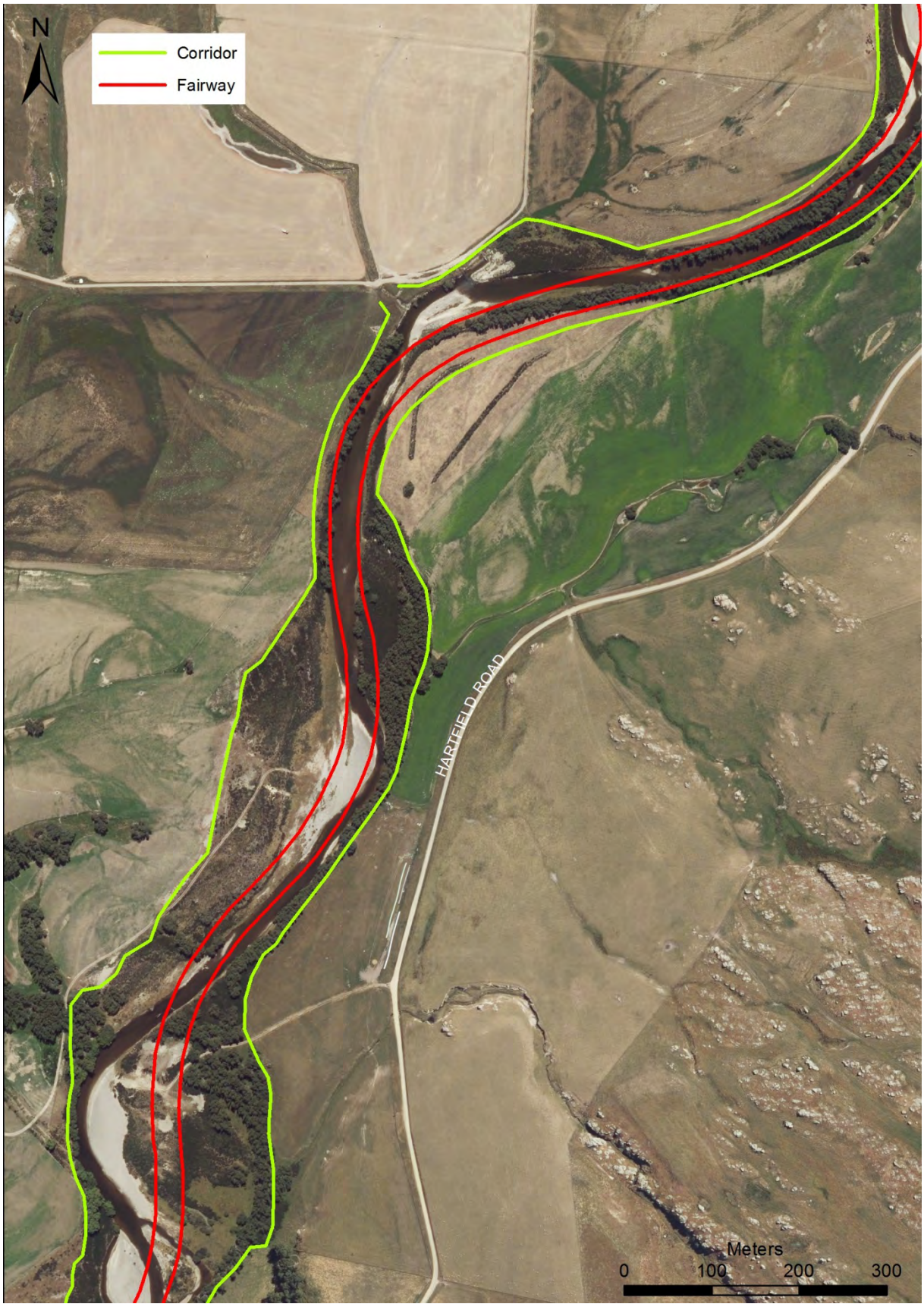

Figure 65. Taieri River fairway and corridor Map 12 (aerial photography collected 2013)

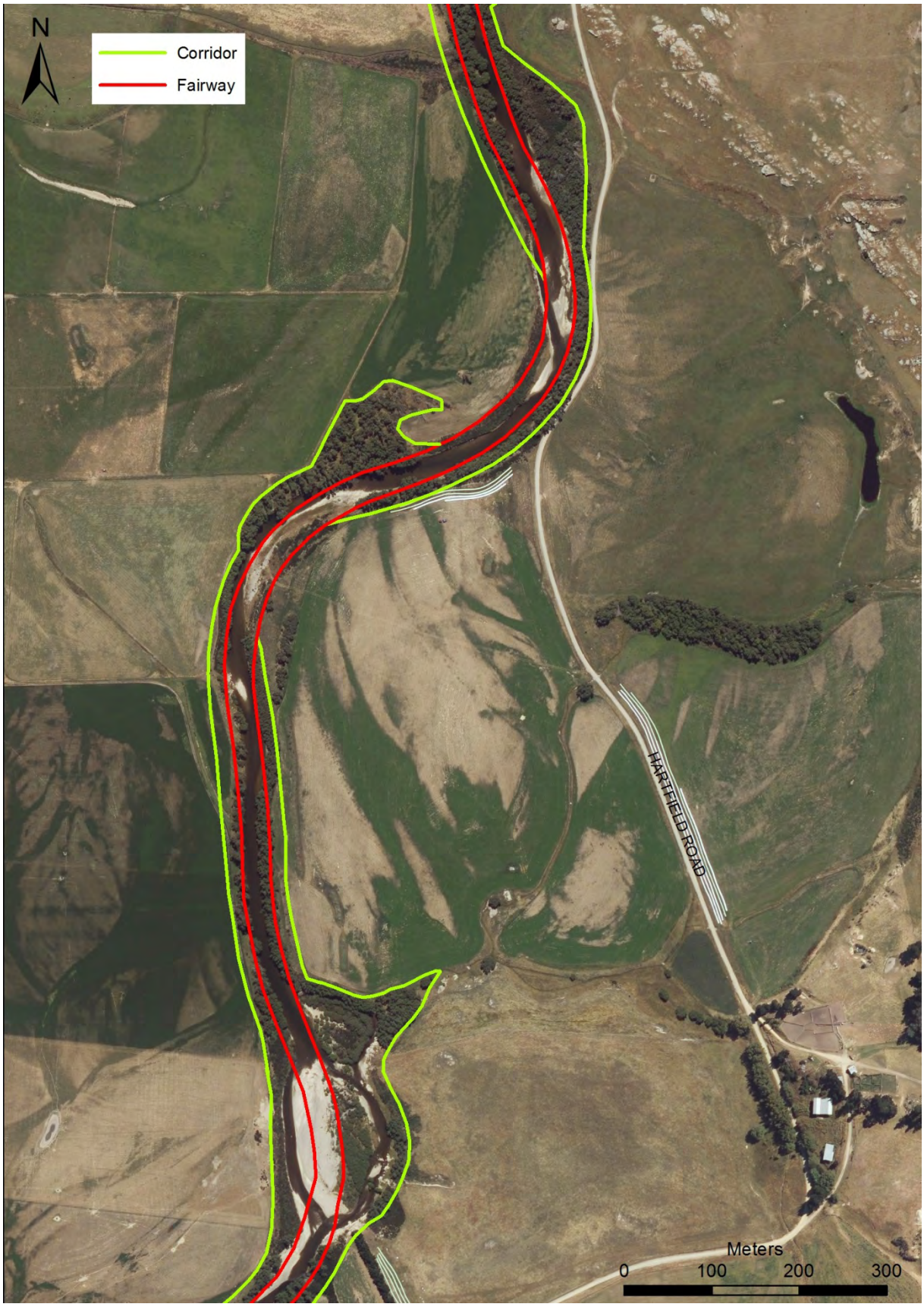

Figure 66. **Taieri River fairway and corridor Map 13 (aerial photography collected 2013)**

Figure 67. Taieri River fairway and corridor Map 14 (aerial photography collected 2013)

Figure 68. **Taieri River fairway and corridor Map 15 (aerial photography collected 2013)**

Appendix 6. Community consultation - public submissions

The community consultation undertaken in March to May 2016 included an opportunity for the public to submit on their concerns, as well as a chance to state what they valued about the Taieri River and what they would like the strategy to achieve. A diverse range of views and concerns were put forward: some people were concerned that that has be insufficient or too much gravel extraction occurring while others were more concerned with maintenance of the riparian margins e.g. willow planting and removal, habitat for native and exotic fish, and a lack of understanding of the permitted activity rules. An ongoing topic that was raised at the public meetings was in regards to the difficulty and cost associated with obtaining a resource consent to extract gravel, the community also discussed the importance of being able to protect their own land. Feedback received from through the consultation process included highlighting a lack of clear and consistent communication between ORC and the community as well as taking a holistic approach to management of the Taieri River including areas outside of the strategy study area. The placement of irrigation infrastructures on the banks of the Taieri River in an appropriate manner as well as ensuring ongoing access were points that were also raised through the feedback process.

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