Boffa Miskell

Manuherekia River & Tributaries

Natural Character, Riverscape & Historic Values Assessment
Prepared for Otago Regional Council

10 March 2021

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<tr><td>Prepared by:</td><td>Rhys Girvan
Senior Principal/ Landscape Architect
Boffa Miskell Limited</td><td></td></tr>
<tr><td></td><td>Yvonne Pfluger
Senior Principal / Landscape Planner
Boffa Miskell Limited</td><td></td></tr>
<tr><td>Reviewed by:</td><td>Yvonne Pfluger
Senior Principal / Landscape Planner
Boffa Miskell Limited</td><td></td></tr>
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Contents

1.0 Introduction

Otago Regional Council (ORC) has commissioned this report to inform the development of a new Land and Water Regional Plan for Otago. Included in the scope of the assessment are:

Value assessments and associated environmental flows for:

- The main stem of the Manuherekia[1] River
- Dunstan Creek

This technical assessment prepared by Boffa Miskell sets out the relevant landscape / riverscape, natural character and heritage values across the Manuherekia catchment and basis to establish a suitable framework which considers and informs the likely effects of identified flow scenarios and associated river management options.

1.1 Project Scope

This project involves the identification of the natural character, riverscape and heritage values associated with the Manuherekia River and selected tributaries.

Five indicative reaches were identified on the Manuherekia River mainstem which are detailed below and illustrated on the map shown in Figure 1**.** The reaches on the Manuherikia mainstem are based on stretches of the river that display similar attributes in terms of their channel morphology, banks and immediate context, as well as flow characteristics (eg major tributaries joining). There are also four tributaries to the mainstem that were assessed as one reach each, since they are relatively short.

A. Manuherekia Mainstem
  i. The Forks to Falls Dam **(Reach 1)**
  ii. Falls Dam to Dunstan Creek confluence at SH85 crossing **(Reach 2)**
  iii. Dunstan Creek confluence to Ophir Bridge **(Reach 3)**
  iv. Ophir Gorge to Chatto Creek confluence **(Reach 4)**
  v. Lower Manuherekia to Clutha/ Mata-Au confluence **(Reach 5)**

B. Ida Burn – base of Hawkduns to Auripo Rd confluence **(Reach 6)**

C. Dunstan Creek below base of Dunstan Mountains **(Reach 7)**

D. Thomsons Creek below gorge/base of Dunstan Mountains **(Reach 8)**

E. Chatto Creek below base of Dunstan Mountains **(Reach 9)**

[1] The Otago Regional Council began using the Manuherekia spelling (vs Manuherikia as shown on topo maps) after clarifying with Aukaha (previously Kai Tahu ki Otago Natural Resource Management Limited) that it was their preferred spelling. This spelling is adopted throughout this report, apart from direct quotes/ references.

1.2 Assessment Limitations and Assumptions

Scale of the Study

The study area for this project is extensive; at a regional scale each of the waterways/ reaches can be considered to be relatively homogenous. However, at a local scale there would be obvious diversity of elements and qualities within each waterway/ reach.

While the key characteristics are described in some detail in this report, the evaluation inevitably results to an extent, in an 'averaging' effect where very good or high value attributes can at times, balance out poorer or low value attributes within a reach. Notwithstanding this, the assessment has identified obvious differences in the attributes and qualities between the reaches.

Natural Character a Culmination of Many Factors

Natural character is essentially a measure of the naturalness (or modification) of the natural elements, patterns and processes that comprise a waterbody (refer to Section 2 for detailed description). The process to assess the level of natural character involves an understanding of the many systems and attributes that contribute to a waterbody including abiotic, biotic and experiential factors.

Consequently, this requires input from a range of technical disciplines such as river hydrology and morphology, aquatic and terrestrial ecology, water quality and landscape architecture. This assessment is based on a desktop review of relevant available data, expert input and review by ORC staff and a site survey.

The site survey was carried out over 2 days (24th and 25th February 2020; flow 1,800 l/s at Campground) visiting most of the locations accessible from public roads, including bridges and irrigation takes where possible. In between these publicly accessible points are often long stretches where the rivers/ waterways flow through private land. For these areas aerial photos and GIS data was used to compare results from the site survey. An additional site visit was carried out on 20th November 2020 to view the river at a different flow (2,512l/s at Campground) for comparative purposes.

1.3 Statutory Context

The Resource Management Act 1991 (RMA) requires regional councils to manage the taking and use of water and manage the quantity, level and flow of water bodies. The National Policy Statement for Freshwater Management 2020 (NPSFM) requires regional councils to set allocation limits and minimum water levels/flows for all freshwater management units and ensure efficient water use.

In order to meet the requirements of the NPSFM, the Otago Regional Council (ORC) is now undertaking a review of the Regional Plan: Water for Otago (Water Plan). As part of this review, allocation limits and environmental flows and levels will be set for the surface water and groundwater resources of all of Otago catchments.

Section 32 of the RMA directs regional councils to identify and assess the environmental, economic, social and cultural impacts (cost and benefits) of any changes to regional plans. Natural character, riverscape, visual amenity and historic values together contribute to the economic, environmental and social and cultural wellbeing in the following ways:

- the quality of life experienced by New Zealanders.
- areas with high natural character often support high value biodiversity and ecosystems
- supporting tourism and film industries and can strengthen local economies by attracting residents and investment to an area, as well as tourists
- providing links to the past and enabling valued ways of life to carry on into the future.

2.0 Assessment Methodology

Rivers and lakes are dynamic and complex features set within a broader landscape context. They are often a visual, ecological and recreational focus in a landscape as well as providing physical links throughout their catchments. Historic and heritage values are often associated with waterways and lakes due to early settlement in these areas. Rivers and lakes and their margins have natural character, amenity, historic and landscape values that require consideration in water allocation decisions particularly relating to how changing river flows and lake levels can affect those values.

Many aspects of riverscapes, natural character and visual amenity are inevitably interrelated and overlapping. The sections below describe each of the three assessments and the matters taken into consideration for each.

2.1 Natural Character Assessment

The Resource Management Act (Section 6(a)) considers as a matter of national importance: *…the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development.*

Natural character is a term used to describe the naturalness of an environment. The definition[2] used for this study is:

> Natural character is a term used to describe the naturalness of river/lake environments. The degree or level of natural character within an environment depends on:

- The extent to which natural elements, patterns and processes occur
- The nature and extent of modifications to the ecosystems and landscape/riverscape.
- The highest degree of natural character (greatest naturalness) occurs where there is least modification.
- The effect of different types of modification upon the natural character of an area varies with the context and may be perceived differently by different parts of the community.

The natural character of rivers and lakes may be affected by structural modifications (e.g. the construction of dams, water take structures, groynes, stopbanks, bridges or boat ramps), changes in appearance resulting from particular flows or lake levels (in the most extreme case a dewatered river channel), or by longer term effects of river flow regime/lake level changes such as vegetation encroachment onto river beds, the loss of river braids, extent of lake margin etc. Dams, bridges, and infrastructure associated with water takes are examples of built modifications that may be in or close to the river/ lake bed. However, roads, structures and buildings occurring further from the river/ lake on adjacent land may also have effects on the natural character of a water body.

The methodology used for this natural character assessment is based on previously developed guidelines for river assessment (Boffa Miskell Ltd & NIWA, 2009).

[2] A definition that has been widely adopted by landscape architects and other resource management practitioners.

2.1.1 Natural Character Assessment Methodology

A workshop with ORC hydrologists and ecologists was held to consider the relevant biophysical (natural character) aspects which make up the waterbodies of the Manuherekia. This adopted the methodology developed for ORC by Boffa Miskell below.

The key factors considered to assess the naturalness of rivers and lakes relate to the degree of intactness of the natural elements, patterns, processes, and extent of any physical modifications to landforms or presence of built structures. We also consider the perceptual or experiential component of naturalness.

Natural elements incorporate all key river elements, such as the water, bed and banks, as well as particular attributes occurring within the river environment, such as geological formations, native vegetation and fauna. Exotic species also have natural characteristics that can positively contribute to natural character. However, their presence will reduce levels of natural character from ‘pristine’ because they have been introduced and displace indigenous vegetation.

Natural patterns take the channel and the riparian edge into account, as well as patterns created by humans on adjacent land, such as shelterbelts, land use boundaries, etc.

Natural processes include river/ lake dynamics, flows and currents, erosion, freshes and floods, and regeneration processes of riparian vegetation and ecological health.

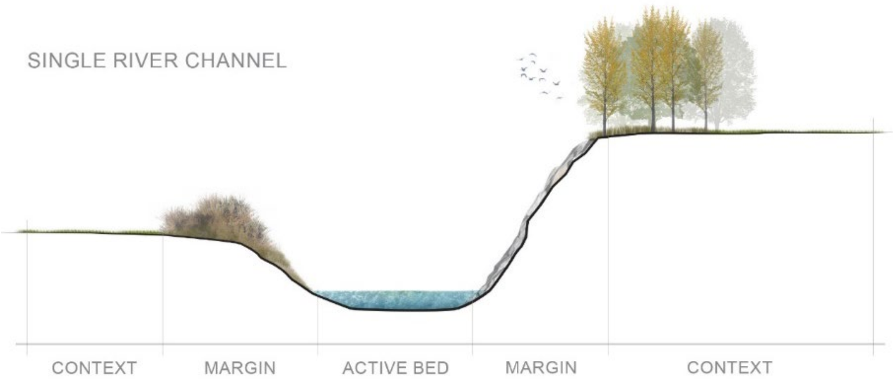
Experiential/perceptual- relates to how we experience naturalness, the sense of untamed remoteness, the sounds and smells of a place and how natural it appears and feels.

2.1.2 Natural Character Components

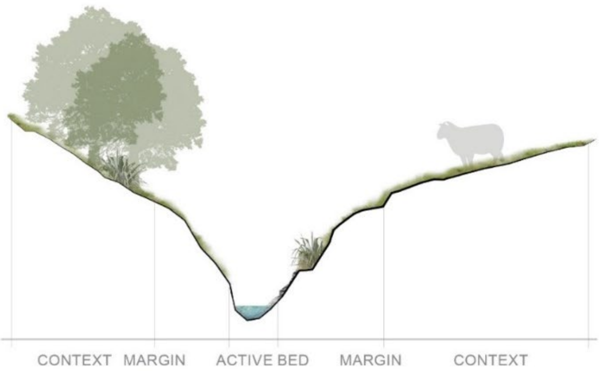
The components are; the channel/ river bed, the riparian margin/ banks and the adjacent landscape context. These components are illustrated in the cross section of the different types of rivers and streams:

BRAIDED RIVER

SINGLE RIVER CHANNEL



STREAM



2.1.3 Natural Character Assessment Tables

When assessing each reach, input was sought from ORC's technical experts in relation to the following biophysical and experiential attributes:

River/Lake component	Natural Character Attributes	Level of Natural Character Rating
River channel (May include dry margins that form part of the active river channel)	**Abiotic** • Physical features and processes- Channel shape, bed substrate, Natural patterns and processes (seasonal flows/floods, erosion), Degree of modification (bridges, irrigation takes, stopbanks and gauges) (ORC river management GIS data) • **Flow regime** modified/natural, degree of change to levels (based on hydrological and irrigation take data) • **Water quality** (if available)	
	Biotic- Presence of indigenous aquatic flora/fauna (if available), ecological health/habitat	
Margin (vegetation beyond active river channel)	**Abiotic-** Physical substrate, degree of modification, landuse, man-made structures (bridges, stopbanks and gauges)	
	Biotic-extent of indigenous vegetation, land use, degree of modification. Ecological health/habitat	
River Context	**Land use degree of modification** of adjacent land – land use and vegetation, character modifications (Broader scale landscape modification beyond the immediate river margin). Patterns of human modification (landuse boundaries, shelterbelts). Roads, structures and buildings occurring further from the river on adjacent land may also have effects on the natural character of a water body, including denser settlement (eg urban).	
River and margins considered as one	**Experiential Characteristics –** Human perception of how natural a place appears, underpinned by the biotic and abiotic attributes(above) of the river. It includes the remote/ untamed experience a place may provide and experiential attributes such as sounds and smells.	

2.1.4 Reach and Tributary Ratings

Natural character assessment will rate the level of natural character for each component of each reach/ tributary on a 5-point scale of (Very High, High, Moderate, Moderate Low, Low Very Low.)

Very High	High	Moderate	Low	Very Low
Very High levels of natural character due to Very Low or no levels of modification	High levels of natural character due to Low levels of modification	Moderate levels of natural character due to moderate levels of modification	Low levels of natural character due to High levels of modification	Very Low levels of natural character due to Very High levels of modification

2.2 Visual Amenity Assessment

Amenity values have been defined in the RMA as:

> *…those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes.*

The focus as part of this report is on the visual aspect of amenity (recreational values of the water bodies are covered as part of a separate assessment).

Descriptions and evaluation of the visual amenity of the river reaches/lake will not be broken down into components as for natural character assessment as the river environment can only be experienced visually in its entirety.

Attributes that influence the visual amenity (its pleasantness, and aesthetic coherence) are:

- **In river** - flow level, wetted surface/ dry channel, water clarity, water colour, water movement, algal proliferations and sedimentation
- **River margins** - vegetation, signs of human modification, litter, seasonal colour, exposed river/ lake margin (e.g. substrate of margin and banks, dried out algae),)
- **Potential viewing audience** - visibility of the lake/river, popularity of the location, recreational uses, outlook for nearby residents or roads

2.3 Landscape/ Riverscape Assessment

The term riverscape refers to the particular landscape qualities associated with the features of a river and its margins and can be thought of as a subset of the wider landscape. It simply indicates that it is the river component of the landscape that is being considered, rather than the whole catchment context. For this project the riverscape section of the report also includes the descriptions of Falls Dam and Idaburn Dam reservoirs. The descriptions provide the contextual landscape setting for each of the reaches.

The first step proposed to assess landscape / riverscape values entails defining the distinctive landscape character areas which make up the Manuherekia catchment. The landscape values of the catchment are characterised and evaluated for each spatial river reach (5 reaches Manuherekia mainstem and four tributary reaches - Chatto Creek, Thomsons Creek, Dunstan Creek and Ida Burn).

Each reach has been assessed in terms of the active channel, riparian edges and landscape context which includes a description of landform (existing topography of the land), landcover (the natural and human-made features on the land surface) alongside any specific attributes or distinctive features. Such criteria provide a reference point including 'key landscape characteristics' for analysing landscape / riverscape values and provide the basis enabling an evaluation of landscape and amenity change relating to flow. The consideration of broader landscape values refers to the landscape evaluation included within the Central Otago District Rural Review (2005) in terms of recognition of outstanding natural features and landscapes and significant amenity landscapes, as identified within the Central Otago District Plan.

2.4 Historic Values Assessment

In association with landscape values, an understanding of heritage values enables important linkages to the past and provides insight into the way communities and settlements have developed across the wider catchment. Such understanding contributes to the character and amenity value of a location or area and may include sites that are significant for their spiritual or historical associations or places where historic events took place. They may also overlap with cultural values such as those identified in the Cultural Values Report for the Manuherekia Catchment (Clucas, R., 2017).

In addition to any relevant cultural values provided by Otago Regional Council, the following databases were interrogated in order to capture this information:

> New Zealand Historic Places Trust (NZHPT) Register
>
> The Historic Place Register provides the national schedule of New Zealand's treasured heritage places. Such sites are established under the Historic Places Act 1993 and compiled by the New Zealand Historic Places Trust. Sites registered on this database include: Historic Places, Historic Areas and Wahi Tapu Areas.
>
> New Zealand Archaeological Association (NZAA) ArchSite
>
> ArchSite is an online database that contains information about recorded archaeological sites in New Zealand. An archaeological site contained within the ArchSite database, is defined as any specific locality where there is or has been evidence of human occupation or activity in the past, that is or maybe able to be investigated by archaeological techniques.
>
> Central Otago District Heritage Values
>
> The Central Otago District Plan identifies heritage buildings, places, sites and objects as well as heritage precincts in accordance with Section 6(f) of the RMA.

In short, the analysis of heritage values enables an understanding of natural and cultural influences including recorded human artefacts and areas which contribute to the Manuherekia Rohe's cultural landscapes. However, Kāi Tahu cultural values are not addressed in this report, since a separate report covers those particular heritage aspects. For the preparation of this report no engagement was undertaken with mana whenua or heritage advisors.

The analysis in this report focuses on the identification of historic water infrastructure such as water races, reservoirs, diggings and bridges as part of determining whether different flows would likely have any impact on the recorded heritage values of such elements. Our analysis has considered historical information that is publicly available or provided by ORC in relation to the Manuherekia River and its tributaries.

2.2 Flow Scenario Assessment

An understanding of landscape / riverscape, natural character and heritage values defined in each reach was used to inform the assessment of potential effects of four different flow scenarios provided by ORC. The potential impacts on the visual amenity of the river reaches and likely sensitivity to the identified scenarios were considered as part of this assessment.

In our experience, assessments of flow management scenarios may relate to minimum flows, low flow durations and/ or flushing flows required for a specific river type but could include other aspects such as seasonal timing. The flow scenarios provided by ORC only provided a minimum flow and no other management options. As part of the assessment the specific areas along the river will be highlighted where low flows may lead to more noticeable effects.

The flow scenarios proposed by ORC for consideration are as follows (measured at campground):

- Scenario 1: 911 l/s (Status quo)
- Scenario 2: 1,500 l/s
- Scenario 3: 2,500 l/s
- Scenario 4: 4,950 l/s (Naturalised Flow)

The flows encountered during the first site visit (on 25/02/2019) were around 1,800 l/s at the Manuherekia Campground, which is similar to Scenario 2 above (1,500 l/s). The intention was to undertake two additional site visits at a higher and a lower flow in order to be able to draw conclusions about the effect of those flows on the values outlined above. Due to timing in relation to seasonal flows it was, however, not possible to view lower flows on site. The winter flows (that coincided with the deadlines for this report) were well above 10 m^3/s and were therefore not considered representative in relation to the four potential flow scenarios that ORC is considering as options for the Manuherekia River. A second site visit was carried out on 20/11/2020 prior to finalising the report to view a flow of 2,512 l/s to assess the effects of Scenario 3.

In order to assess the lower (Scenario1) and higher (Scenario 4) flows, photos were provided by. ORC showing the Manuherekia River at a variety of flows. The photos provided were taken between 2005 and 2019 and the flows and photo locations were provided by ORC for those photos taken after 2018. The photo locations included some of those visited during the on-site investigations.

The photos provided with a range of flow measurements were those for the campground bridge location (Alexandra), which enabled a direct visual comparison of flows. Other locations used for visual assessment of flows based on photos were downstream of the Forks, Chatto Creek confluence and at Galloway Bridge. However, for these sites only one flow was provided comparisons, limiting the ability for comparison.

3.0 Assessments by Reach

4.1 The Forks to Falls Dam – Manuherekia: Reach 1

Upper Reach of the Manuherekia River

The headwaters of the Manuherekia River commence between the Hawkdun and St Bathans Ranges within the Oteake Conservation Park. For the purpose of this assessment, Reach 1 commences from The Forks, where upper east and west branches converge. The downstream end of this reach culminates where the river flows into the modified waterbody created by Falls Dam. The natural flow of the Manuherekia River in this reach is influenced by the Mt Ida Race which can take a large proportion of the flow from the Hawkdun Range.

The Upper Manuherekia River which forms Reach 1 occupies part of a broader open and expansive high-country landscape. Most of this landscape is grazed with extensive tussocks and pockets of matagouri established on fluvial river terraces which remain highly legible along the valley floor. Some red tussocks (*Chionochloa rubra*), particularly nearer The Forks, are very healthy and high and emphasise this vivid underlying tawny Central Otago landscape character. Occasional willow trees, trace alongside the course of the river, but the landscape is generally open with expansive views.

Except for a limited number of inconspicuous huts at the Fall Dam storage lake, the upper catchment is void of any settlement with no built modification apparent along the course of the river. Farming activity represents extensive dry stock grazing with stock fencing and cattle stops encountered along straight gravel access tracks. Unfettered stock access is typical along the course of the river, whilst public access is generally limited by intervening private farmland. A gravel road on the true left bank of the river provide access to the DOC managed conservation land in the headwaters with walking/ cycling tracks. Mt Ida Race is visible from the valley floor, etching a singular elevated linear path above the toe of the Hawkdun Range.

The course of the river weaves an intricate sequence of braids across the central valley floor. In some instances, braids are some distance apart and include several spring-fed tributaries entering along this reach. The bed is typically made up of fist sized gravels and generally supports clear flowing water of high quality. Stock access has resulted in pugging of soils along river margins in some areas including adjacent to the area where the river flows into Falls Dam. Despite this, the high-country land use and character of this Central Otago landscape setting encompassing the river valley generates very high scenic and landscape values.

Key Landscape Characteristics of Reach 1

- Part of a broader open and expansive tawny high county Central Otago landscape which retains very high scenic and landscape values
- River corridor forms a broad and intricate braided form which includes several spring-fed tributaries along the valley floor supporting unfettered stock access along the river margin
- Built development is inconspicuous and very limited with extensive grazing accentuating an isolated back country character
- Widespread tussock and pockets of matagouri occupy legible fluvial terraces along the valley floor with occasional willow trees established along the course of the river
- The Ida Water Race is visually apparent along the toe of the Hawkdun Range and diverts about a third of the low flow derived from this area

NATURAL CHARACTER – Manuherekia Reach 1		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• Reach above dam has relatively natural flow regime. • Hydrological alteration through Hawkdun Ida Race, which captures around a third of the flow at low flows. • The Ida Race take does not significantly alter frequency of high flows in the upper reaches. Flow regime is the only modified in-river component	High
Active bed- Bed Shape, incl modifications/ structures	• Semi -braided river bed. • Occurrence of willows is limited, which allows for a mobile bed that can move through flood flows. • No pressure on the boundary margins through flood protection structures or introduced plants.	Very High
Active bed- Aquatic ecological health/ Water Quality	• Manuherekia Alpine galaxias only found between Forks and Dam. • Trout present which have some influence on the galaxiid population .	Very High
Margin- Structures and Modifications	• No marginal pressure of fences up to boundaries, but stock access into the river bed. • Braided upper sections continue to move freely with shifting braids. • Changes to braids and margins as a result of major flood events. • Margins are not dominated by willows (as banks in lower reaches are). • Woody weeds are very limited.	Very High

Margin-Terrestrial ecology	• A lot of springs and wetlands along the base of Hawkdun Range, which are modified but still of high value. • Dotterels, Wry Bills, Terns and Black backed gulls are found in the area. • Some riverine wetland areas with springs along the margins. • Large red tussocks in particular in conservation land and at forks. • Low fertility introduced grass along some sections where extensive grazing occurs on private land, but native tussocks dominate. • Grazing mostly with cattle that have access to the river and associated springs/ wetlands; some pugging occurs.	High
Context	• Wider landscape context is dominated by Central Otago high-country landscape. • Outstanding Natural Landscape (ONL) in the entire upper catchment. • Pastoral grazing has altered vegetative character to some extent from native tussock cover but overall natural appearance. • Spaciousness of iconic landscape with extensive views to surrounding flat-topped mountain ranges is key attribute of the wider landscape. • The upper catchment of the Manuherekia is conservation land valued for its remoteness and high scenic and natural values.	Very High
Experiential	• The experiential elements of natural character for this part of the catchment are particularly important. • Relatively small viewing audience due to its remoteness. • Sensitive landscape due to its high natural character values and openness.	Very High
RIVERSCAPE AND VISUAL AMENITY – Manuherekia Reach 1		**Values and Visual Amenity**
Nature of views, viewing audience	• The upper reaches of the Manuherekia River are entirely within an ONL that encompasses the valley floor and surrounding mountain ranges. • Iconic part of the catchment set within open Central Otago high-country valley landscape. • Open extensive high-country pastoral land use overlaid upon legible fluvial terraces. • Extensive grassland with tussocks and pockets of matagouri and limited clusters of riverside willow trees. • Oteake Conservation Park with a variety of users, such as trampers, bikers and four- wheel drivers. • Trout fishing occurs in this reach.	Very High

4.2 Falls Dam to Dunstan Creek – Manuherekia: Reach 2

Gorge looking north in the direction of Falls Dam

This reach commences at Falls Dam and terminates at the confluence with Dunstan Creek. The form and setting of the river are varied through this part of the Manuherekia River which transitions from a tranquil and picturesque high-country setting at Falls Dam, through the rugged and enclosed gorge adjoining Fiddlers Flat Conservation Area, into part of the broader working rural landscape of the Manuherekia Valley.

Falls Dam was constructed in 1935 to provide a reservoir for local irrigation purposes and power generation. The dam itself forms a relatively low-key earth structure with a circular concrete spillway and intake structure at the head of a confined gorge. The resulting storage lake margins reveal typical signs of modified level fluctuation with barren exposed gravel banks and expansive mud flats extending into pasture at its northern end. The dam is designed to release up to 4 m^3/s when generating hydroelectricity, with the remainder of the water spilled in case of flood. It is understood that a relatively constant flow of around 2-3 m^3/s is typically released to meet downstream water demands during the irrigation season. Falls Dam can be near to empty of stored water at the end of the irrigation season (30 April) which requires collecting water in the dam from 1 May to refill the dam. The electricity generation consents require a residual flow of 0.5 m^3/s for the dam releases. For the whole river reach from Falls Dam to the Dunstan Creek confluence this flow represents a very low flow condition and its timing in autumn and winter is somewhat outside the expected natural low flow period that can occur in summer and autumn.

The small settlement at Falls Dam which has formed along the north-east edge of the lake retains a very rustic and vivid association with Central Otago's isolated landscape character. Most huts are made of corrugated iron and appear to have been established for some time. Several exotic trees are scattered along the margins of the lake and the settlement appears isolated and immersed within a backdrop of the Hawkdun Range viewed from the lake. It appears that there is some angling use and there are several walking tracks both around the dam and within the surrounding catchment that are popular with mountain bikers.

Below Falls Dam the river flows through a confined gorge before opening out onto broad fluvial terraces characteristic of the upper Manuherekia Valley. Steep bluffs and rock outcrops enclose and define a single channel river within the gorge and frame views from elevated terraces along which access is established. Below the gorge, the river corridor opens out and becomes semi-braided with pinch points evident at Loop Road and SH85 bridge at the confluence with Dunstan Creek. Formative processes remain highly legible including clay pans within the riverbed and surrounding fluvial terracing as well as actively eroding clay cliffs on the true right.

Land use surrounding the river within the gorge shows minimal grazing with exotic grasses, grey shrub and tussocks as well as some extensive areas of briar. As the river emerges from the gorge into the wider Manuherekia Valley intensive farming becomes increasingly apparent with poplars and willows lining the river visible from the bridge along Loop Road. Extensive broom and willows continue below Loop Road, in parts shading the margins of the river.

At its inflow to Falls Dam, the Manuherekia appears to maintain reasonably good water quality with a steady flow. Where there are shallow lake margins, water quality appears lower possibly due to stock access and accumulated silt on the margins. Below the dam, the river maintains a natural sequence of riffles and runs with relatively large substrate that 'fits' well within the enclosed river corridor. The water is slightly discoloured and somewhat green, but clear. It is understood that didymo occurs extensively throughout this reach due to the constant flow (absence of flood flows).

The confluence with Dunstan Creek marks the end of Reach 2. Dunstan Creek contributes a large percentage of the flow to the mainstem at this point. While a relatively constant flow is released at Falls Dam the flow in this reach of the Manuherekia is reduced by existing water takes above the Dunstan confluence (Blackstone and Omakau takes). In places the sides were chocked with algae, with dried out algae on exposed rocks leaving an unpleasant odour. Didymo is also well established in this area and willow margins likely assist with reducing water temperature.

Key Landscape Characteristics of Reach 2

- Falls Dam forms a memorable Central Otago high-country picturesque setting with rustic huts enhancing an isolated back country vernacular along part of the lake shore
- Below Falls Dam, the river passes through a narrow, rugged gorge adjoining Fiddlers Flat Conservation Area with steep rock bluffs along the margins retaining high natural character
- Fluvial terracing remains legible throughout the upper Manuherekia valley with intensive grazing becoming increasingly evident approaching the confluence with Dunstan Creek
- Willow and broom increase throughout the river's semi-braided form above Dunstan Creek with substantial water takes constricting the river's flow
- Water quality along this reach reduces below Falls Dam as didymo and algae become increasingly prolific as a result of stable flows rather than contaminants

NATURAL CHARACTER – Manuherekia Reach 2		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• Dammed reach with heavily modified flow regime. • Maximum flow that can be released through turbines is 4 m^3/s, at higher flows water gets spilled through the spillway. • Release from dam is not continuous but heavily managed. • In winter floods still go through this reach and clear out the bed, but smaller freshes in summer generally are captured in the Falls Dam storage lake. • Freshes clean out the braided river bed in upper reaches above Falls Dam, but bigger floods are required below the dam due to storage. • Cyano bacteria found in lake due to high temperatures- warning signs were erected in Feb 2020 (ORC press release 19/2/2020).	Low

	• Omakau Area Irrigation Company and Blackstone Irrigation Company takes are substantial. • Flow is generally 2 m^3/s below Dunstan Creek, as it is a major tributary that adds a substantial flow at the top of Reach 3.	
Active bed-Bed Shape, incl modifications/ structures	• Gorge is relatively free of modification, apart from Falls Dam. • Semi braided bed with some willows below the gorge section. • Clay pans occur below the gorge and the composition of the bed changes. • Bed shape quite natural with braids still shifting. • Channel is relatively mobile • While bed is not entirely locked up, Loop Road bridge pins the bed in this location. • Omakau take has a 2.5m high weir structure across the whole bed which leads to fish passage issues. • Groynes at Blackstone take push flow into intake structure.	High
Active bed-Aquatic ecological health/ Water Quality	• Periphyton problems at Loop Road, challenges with lack of variability of flow due to Dam above. • Didymo is suited to the low nutrient levels in this reach and is blooming extensively. • Trout fishery in the gorge is good. • Some native fish, such as upland bullies and eels, occur. • Fish passage is impeded by weir at Omakau water take.	Moderate
Margin-Structures and Modifications	• Water take impediment through 2 m high, 35 m wide Omakau concrete weir. • Bridges crossing at Loop Road and SH85 (bottom of reach) are fixed points the prevent the river from moving in these areas.	Moderate
Margin-Terrestrial ecology	• Red tussocks at Falls Dam • No braided river birds, only shags • Vegetation in the gorge is more native (eg matagouri) than in area below, but briar and other weeds such as Hawthorne are also found in the gorge. • In reach below the gorge are occasional willow, but hinterland is dominated by pastures • Farming is the predominant land use.	Moderate
Context	• Falls Dam is surrounded by a basin with surrounding hills, creating gorge from the dam structure downstream. • The gorge section contains more native vegetation and farming is less intense. • The wider context below the gorge is increasingly modified. • Part of the true left bank of the river in the gorge section (base of Home Hills) is part of an ONL and Falls Dam lake is included in a Significant Amenity Landscape (SAL) - see Riverscape values.	High in gorge; Moderate below
Experiential	• Impressive gorge with high natural character. • The gorge can be experienced from the DOC conservation area. • Didymo has adverse effect on the perception of natural character. • The absence of structures and presence of native vegetation in the gorge creates a more natural appearance than below Loop Road bridge.	High in gorge; Moderate below

RIVERSCAPE AND VISUAL AMENITY – Manuherekia Reach 2		Values and Visual Amenity
Nature of views, viewing audience	• Falls Dam is a popular structure to visit which creates an iconic lake and setting. • Heritage values associated with dam itself and settlement. • The power house was constructed in 1935 and generates 1,250 kW of electricity. • Many paintings show this Central Otago Landscape in various seasons. • Fishing in the Falls Dam lake is popular. • A number of huts/ baches are located at the lake. • Recreation opportunities that include boating, swimming, walking and bike trails. • The ONL that includes all of Reach 1 above the Falls Dam storage lake extends onto the true left bank of the river in the gorge section (base of Home Hills). Falls Dam lake is included in a Significant Amenity Landscape that extends from the Mata/ Stanton Creek valley eastwards.	High in gorge; Moderate below.

4.3 Dunstan Creek to Ophir Gorge – Manuherekia: Reach 3

Manuherekia looking upstream from Omakau Bridge

This reach starts at the confluence with Dunstan Creek and finishes where the Manuherekia River flows into the Ophir Gorge. This reach remains semi-braided where it flows through the valley floor and occupies part of a wider working rural landscape throughout the Manuherekia Valley. Parts of this reach cut through the western toe of the Raggedy Range, in particular the confined section through Lauder Gorge.

The surrounding land use forms a patchwork of intensive grazing, including pivot irrigation, which provides the context for this reach through much of the Manuherekia Valley. Notwithstanding this, historic channels and undulations remain legible along fluvial terraces stepping alongside the river margin. Where the river approaches confined terraces or enters incised gorges, rock outcrops and tors punctuate the landform and accentuate its interaction with part of the broader Central Otago landscape. About halfway, the Ida Burn flows into this reach through the Raggedy Range with a similar channel to the one that cuts through Lauder Gorge further south along the foothills of the Raggedy Range. A series of tributaries also flow and replenish this reach from the Dunstan Hills to the west, including Lauder and Thomsons Creeks.

The river corridor is generally confined by willow margins with broom established in some areas. The

. active bed typically remains relatively mobile within wide gravel banks and islands and some shelving. Through the Lauder Gorge it appears that the bed is quite confined, as with Ophir Gorge where it compresses into a single stem. The flow generally increases as tributaries feed this reach, with the flow appearing healthy and well suited to the riverbed at the entrance to Ophir Gorge. Some filamentous algae is evident in the bed, in particular along the sides of the river but due to the swifter flow this seems to be quite limited and there is little dried out algae on the rocks.

Access to the river along this reach is limited by adjoining farmland, with the river channel generally located over a kilometre from SH85. Below the SH85 Bridge, access is limited to a viaduct along the Otago Rail Trail near the township of Lauder and two further bridges adjoining the towns of Omakau and Ophir. Ophir which includes a heritage precinct with several historic buildings, also adjoins the historic Ophir Bridge overlooking the river at the start of the Ophir gorge.

Key Landscape Characteristics of Reach 3

- Part of a wider working rural landscape within the Manuherekia Valley characterised by intensive pastural grazing supported through irrigation
- The river corridor remains semi-braided along legible fluvial terraces with several incised sections hugging the toe of the Raggedy Range including the Lauder Gorge
- Willow and broom typically line the river corridor and restrict views of the river channel from surrounding areas
- The river remains largely inaccessible with public access limited to three bridges in the vicinity of adjoining towns

NATURAL CHARACTER – Manuherekia Reach 3		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• Dunstan Creek contributes a substantial part of the flow below the confluence with the Manuherekia, in particular during low flows. • While the flow within Dunstan Creek is modified (and no minimum flow is currently set for Dunstan Creek) it contributes a substantial part of the total flow. • Lauder Creek flows into the central part of the reach. • Thomson Creek confluence located just above Ophir Bridge.	Moderate
Active bed- Bed Shape, incl modifications/ structures	• The bed is generally willow lined and confined in its location. • The bed in this reach is cobbly as opposed to gravel substrate. • Within the Lauder Gorge (approx 4km long, located below Lauder settlement) the river is naturally more confined. • The Manuherekia mainstem in this reach does not contain much fine sediment, but the tributaries do. • While clay pans are common in Reach 2, they do not occur within this reach. • Groynes are installed around water takes to collect and channel the flow.	Moderate
Active bed- Aquatic ecological health/ Water Quality	• The macroinvertebrate community index (MCI) at Ophir is good. • Water quality declines through the reach towards Omakau with D grade for E.coli at Ophir (LAWA). Thomson's Creek has poor water quality due to agricultural bywash discharges (LAWA), which impacts on the Manuherekia reach below the confluence. • The water quality becomes lower below the treatment plant and inflow from Thomson and Lauder Creeks (with low water quality at their confluence). • Periphyton is thick in places, but filamentous algae is limited. • No issue with finer sediments. • Brown Trout is found. • Some long-finned eels and upland bullies occur within this reach.	Moderate
Margin- Structures and Modifications	• Groynes are installed at the water takes. • Towns along the reach include Omakau and Ophir near the river corridor. • State Highway is located in close proximity to the margin, confining the floodplain. • Within Lauder Gorge the margins and bed remain intact.	Low-Moderate

Margin-Terrestrial ecology	• Shelterbelts and willows occur along the margins and encroach onto the bed in this section (fertile plains with intensive agriculture). • Erosions in adjacent paddocks. • Deer found throughout the floodplain/ margins.	Low
Context	• Rural land use dominates on the fertile plains. • State Highway is located in proximity of the river near Lauder. • SH bridge crossing at the top of the reach at Dunstan Creek confluence. Other bridges at Omakau, Ophir and historic bridge at Ophir Gorge (Daniel O' Connor Bridge). • Otherwise limited bridges (only Rail Trail bridge near Lauder). • The wider landscape context includes the Raggedy Range (SAL) with typical Central Otago high-country landscape values associated with extensive farming and rock outcrops.	Low
Experiential	• The overall level of modifications in terms of structures is relatively low. The river can however only be experienced at crossing points where modifications occur in clusters. • The willow lined banks have a moderately natural appearance with a relatively unmodified channel.	Moderate
RIVERSCAPE AND VISUAL AMENITY – Manuherekia Reach 3		**Values and Visual Amenity**
Nature of views, viewing audience	• This section is difficult to access, but some of the access points, in particular at the Rail Trail (above Lauder settlement) and Ophir gorge bridge has high scenic values. • The rail trail crossing of the river is highly frequented. • The historic bridge at Ophir is a point of interest for many visitors. • The SAL that encompasses the Raggedy Range and Blackstone Hill extends along the true left of the Manuherekia River, including the Ida Burn gorge.	Moderate

4.4 Ophir Gorge – Manuherekia: Reach 4

Entrance to Ophir Gorge from Ophir Bridge

This reach flows through the Ophir Gorge below the historic Ophir Bridge to the confluence with Chatto Creek. Here the river corridor becomes confined with very steep riverbanks, enclosing rock bluffs and boulders within the riverbed. The elevated rock tors above the river corridor are characteristic of the wider Raggedy Range. In this context, the river maintains high scenic and landscape values associated with the wider Central Otago high-county landscape.

Vegetation along the margins of the river throughout the gorge is dominated by exotic plants with a few willows perched along the river margin, and extensive briar and hawthorne in some areas. Grazing, including by pest animals, occurs. The margins of the gorge remain very inaccessible with access limited to a few narrow 4wd tracks with no public roads.

The substrate of the river channel is large and dominated by rocks, leading to the presence of several rapids. Such characteristics have become recognised by Whitewater paddlers who describe this section as a scenic canyon with technical, tight rapids. Prospective paddlers typically monitor optimal flows recorded at between 15 and 50 m^3/s with several steep, technical class III-IV rapids. Over 50 m^3/s the water is very turbulent and described as becoming solid class V (Charles, 2006).

A large 2 m^3/s take occurs in the central part of the gorge where the water gets diverted into a large hole and into the race operated by the Manuherikia Irrigation Co-operative Society which flows along the toe of the Merton and Clare Hills to the west of the Manuherekia River. Due to the large-scale water diversion in the central part of the gorge, it is understood that the flow that exits at the bottom of the gorge can be relatively low, exposing large open gravel banks.

A large wooden viaduct spans the southern edge of the gorge which provides access along the Central Otago Rail Trail. From here, willow trees enclose the margins of the river as it emerges in a semi-braided form from the gorge and continues towards the confluence with Chatto Creek.

Key Landscape Characteristics of Reach 4

- Ophir Gorge forms a rugged and remote section of river cut through the western toe of the Raggedy Range
- No public access is provided along the river margins
- Recognised by white water paddlers as a scenic canyon with technical, tight rapids
- A large water take currently diminishes low flows about halfway through the gorge
- The Central Otago Rail Trail provides views along the river at the bottom end of the Ophir Gorge where it maintains a willow-lined, semi-braided form with relatively low flows

NATURAL CHARACTER – Manuherekia Reach 4		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• Confluence of Thomson Creek above gorge • Generally flow is managed at dam to maintain enough flow at top of gorge to service Manuherekia Irrigation Scheme take • This is the biggest take in the catchment (1900l/s), located in a central part of the gorge (highest priority deemed permit) • Above the take hydrology is moderate, but due to the size of the take the natural character of flow below the intake is low. • Chatto Creek contributes some flow below the gorge	Moderate above Low below take
Active bed- Bed Shape, incl modifications/ structures	• Ophir gorge is approximately 12km long (between the Ophir bridge and the crossing of the Otago Rail Trail bridge) • Entire reach is in a gorge section • Within the gorge some bedrock and fine gravels are found with occasional larger boulders • Irrigation take is through a large hole in the bedrock wall as an intake structure in the central section of the gorge • The channel morphology is generally unmodified	High
Active bed- Aquatic ecological health/ Water Quality	• Some trout are found in the gorge • A few eels are present, but generally modified aquatic ecology • The Manuherekia Irrigation Scheme take in the gorge does not have fish screens that would prevent fish entry • High E coli bacteria, but water quality is generally acceptable (LAWA, Ophir Site). • Thomson's Creek has poor water quality due to agricultural bywash discharges (LAWA), which impacts on the Manuherekia reach below the confluence.	Moderate
Margin- Structures and Modifications	• Intake through hole in bedrock • No other modifications to the margins • High intactness of the banks morphologically • Bridge at bottom of gorge • Exposed cliffs and drops	High
Margin- Terrestrial ecology	• Willow and Elderberry can be found on the slopes • Some matagouri is present, but generally not a lot of native vegetation • Within the gorge a number of goats represent a grazing pest species	Moderate

Context	• Irrigation scheme supports stone fruit and grapes within the landscape context • The gorge is inaccessible and not visible from the highway, since the foothills of the Raggedy Range separate the visual catchments	Moderate
Experiential	• Very difficult to experience the gorge section • Can only be seen from the air or on the river • During high flows kayakers use the gorge section, containing challenging rapids • Secluded and inaccessible place along the Manuherekia River	High
RIVERSCAPE AND VISUAL AMENITY – Manuherekia Reach 4		**Values and Visual Amenity**
Nature of views, viewing audience	• The upper part of Ophir Gorge is identified as an Outstanding Natural Feature (ONF). • The SAL that encompasses the Raggedy Range extends along the true left of the Manuherekia River and includes the lower Ophir gorge. • Ophir bridge at top gorge is an historic attraction. • Bridge at the bottom of the gorge for the rail trail.	High

4.5 Ophir Gorge to Clutha/ Mata-Au– Manuherekia: Reach 5

Manuherekia River upstream from the Galloway Bridge

The lowest reach of the Manuherekia River commences at the confluence with Chatto Creek at the southern end of the Ophir Gorge and finishes at the confluence with the Clutha River / Mata-Au. The landscape associated with this reach undergoes a transition from a working rural landscape within the Manuherekia Valley into a more domesticated and settled character with increasing areas of exotic trees surrounding the township of Alexandra. The backdrop of the Raggedy Range retains a strong Central Otago character and high scenic associations along much of this reach.

Below Chatto Creek, the lower Manuherekia Valley is narrowed by the Merton and Clare Hills which extend east from the toe of the Dunstan Mountains. Pivot irrigators have been established along some of the flatter, more open terraces and gradually make way to increasing areas of planting. This includes horticulture and lifestyle development on the approach to the northern edge of Alexandra. Except for the area surrounding Alexandra and the Galloway Road approximately 4 km to the north, physical access to the river along this reach remains limited. The alignment of SH85 is located approximately 1km west of the river corridor beyond intervening farmland and views of the river are generally obscured by a dense ribbon of willow trees along the river margins.

The river corridor traces along the base of legible fluvial terraces, with some steeper eroding terrace scarps. The floodplain associated with the Manuherekia River has influenced the pattern of settlement with broad open paddocks retained in low lying areas, particularly adjoining Galloway, with increasing rural and lifestyle development established on terraces elevated above the river. The Manorburn Stream also drains into this reach from the Lower Manorburn Dam below Galloway, with established water races, including a significant water take at Galloway, providing irrigation and influencing the flow of the river through this area.

The river channel is predominantly single stem with few opportunities to braid as willows increasingly define the river corridor through this reach. Flow changes and low flows are evident through the exposure of shelving gravel banks. Gravel extraction, planted willows and stop banks are apparent above the Galloway Road bridge as clear signs of ongoing floodplain management.

The water quality of the lower Manuherekia River is impacted by E. Coli bacteria (C Grade, LAWA). Above the Galloway Road bridge, the channel is dominated by smaller gravels with a substantial amount of sand as fine sediment between the gravels. While little filamentous algae and no didymo was evident during the site visit, filamentous algae can be problematic in this reach with over 95% bed coverage during low flows and high summer temperatures. Habitat modelling for this reach suggests that there is sufficient fish habitat, but issues are evident in regards to the river's food producing capacity (lack of invertebrates), while some mayfly larvae and bullies were present during the site visit.

Near the confluence with the Clutha River / Mata-Au, the flow of the Manuherekia slows down resulting from the water backing up from the Clutha River / Mata-Au. Due to the flattening gradient between the Ophir Gorge and the Clutha River / Mata-Au, gravel is deposited in this reach and the bed is aggrading. Therefore, gravel extraction is necessary in order to maintain the bed height. At the very lowest part of the reach the banks are dominated by sand and even mud in some places which appears to be a backwash from the Clutha River / Mata-Au from recent floods.

The river provides a positive contribution to the amenity of Alexandra with its willows and aesthetic qualities of the rock outcrops and pools that line the riverbanks often framing the dramatic backdrop of the Raggedy Range. Two bridges cross the lower Manuherekia River at Alexandra including the historic Shaky Bridge. The Otago Rail Trail also passes through this area and follows terraces above the true left banks of the river. As with SH85, views from the Rail Trail entail extensive willow and poplar trees along the river margins seen below the hummocky and craggy silhouette of the Raggedy Range.

Key Landscape Characteristics of Reach 5

- Transition between working rural landscape and more domesticated and settled character of Alexandra along which the river contributes positively to amenity values
- Fluvial terraces with steep exposed scarps remain evident in association with the river along the valley floor
- The river corridor remains heavily willow-lined which typically obscures views into the river from surrounding rural areas
- Flood management measures become increasingly apparent including gravel extraction and stopbanks
- Increasing recreation use occurs in the vicinity of Alexandra including the Rail Trail and historic bridges affording views along the river corridor through this area.

NATURAL CHARACTER – Manuherekia Reach 5		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• A minimum flow of 900 l/s at Alexandra campground has been agreed in 2008, but this is not met in extreme dry conditions. • 26-28 hours of time lag for flow between Falls Dam and Clutha River / Mata-Au confluence means that exact flow rates in lower river are difficult to adjust. • One large take below the gorge: Galloway Irrigation Society Scheme water take diverts around 2/3 (and up to 80-90%) of flow. • Galloway Irrigation Society intake includes an around 700m long diversion of the flow where the required amount is taken and residual flow fed back into the river downstream. In the section between the intake and discharge point the river can dry out in low flows, forming a hotspot in terms of connectivity of flow.	Low and Very Low

Active bed-Bed Shape, incl modifications/ structures	• Flood banks at lower reach • The bed is generally willow-lined and has very little ability to move, but gravel banks shift within the channel. • Aggrading bed (up to 0.5 m) which is extending further upstream from Clutha River / Mata-Au confluence over time (since 1970s) due to Lake Roxburgh below. Galloway Bridge is currently upper limit of aggradation. • Gravel extractions in the lower reach help to counteract the flood risk from aggradation. • Short stop banks in place on true left to protect Galloway Bridge. • As the river becomes shallower, finer substrate is found below the gorge. Larger particles are only fist size. • Stopbanks within Alexandra are designed for very large flood events near the Clutha / Mata-Au confluence. • Channel morphology has low natural character. • Large gravel, sand and mud flats that are exposed at low flows at the Clutha / Mata-Au confluence.	Low
Active bed-Aquatic ecological health/ Water Quality	• Long filamentous algae and periphyton occurs with bed coverage up to 100% during low flows and warm temperatures. • Water quality can be low in this bottom reach. • Eels and bullies are present but Roxborough dam prevents migration of eels along Clutha River / Mata-Au. • Brown Trout present, Rainbow trout sometimes migrate up from Clutha River / Mata-Au to spawn. • Depth of flow on riffles is critical for trout migration for spawning.	Low
Margin-Structures and Modifications	• State Highway in relatively close proximity • Stop banks and township at Alexandra provides highly modified margins in places • Urban parks with floodplain forest along some stretches within Alexandra Township.	Low
Margin-Terrestrial ecology	• The land use of the hinterland of intensive pastoral grazing extends close to the river. • Willows line the entire reach, forming dense floodplain forests in places, such as at the Manorburn confluence.	Low
Context	• The demand for irrigation water in these lower reaches has increased as dairy support farming is becoming more common. Lower water availability is often reflected by higher efficiency of use.	Low
Experiential	• Sluffing algae has impact on swimming and amenity. • The sediment that is deposited near the Clutha confluence contains mud and can become unpleasant in terms of visual effects and smell.	Moderate to Low
RIVERSCAPE AND VISUAL AMENITY – Manuherekia Reach 5		**Values and Visual Amenity**
Nature of views, viewing audience	• Urban parks with walkways in the immediate context of the river • Otago Rail Trail starts in Alexandra and follows this reach. • Provides amenity and sense of place for to the township of Alexandra • Historic bridge in Alexandra	Moderate

4.6 Ida Burn: Reach 6

Idaburn Dam

The Ida Burn flows from the base of the Hawkdun Range to the confluence with the Pool Burn and predominantly flows through the Ida Valley between the Raggedy Range and North Rough Ridge. The Ida Burn then joins the Manuherekia River shortly after it emerges through the Poolburn Gorge into the Manuherekia Valley. The Hawkdun – Idaburn Water Race presently takes about a third of the total flow from the upper reach of the Ida Burn and diverts this into the Maniototo Plain. At the lower end, the Poolburn water race flows back into the Ida Burn just above the Poolburn Gorge.

The headwaters of the Ida Burn north of SH85 remain isolated with limited 4WD access. Here the river flows through open tussock terraces interspersed with occasional grey shrubs supporting dryland farming. Formative fluvial processes remain particularly legible on both sides of the river. Below SH85, where the Ida Burn continues through the Ida Valley, irrigated pasture and cropping becomes more prevalent. Here ribbons of willow trees and other exotic scrub have colonised the margins. As willows line the stream more densely, legibility of the river landforms becomes lower although near the entrance to Poolburn Gorge at Auripo the terraces remain quite pronounced.

The Idaburn Dam is located approximately midway along the Ida Burn and south of the small established settlement of Oturehua. The dam was built to contribute to the Hawkdun Irrigation Scheme in 1931 and store spring flows of the Ida Burn. The resultant lake provides high scenic values and expresses a strong Central Otago landscape character including reflections of the tawny and craggy backdrop of North Rough Ridge. Except for Idaburn Dam, there appears to be little modification along the riverbed through built structures although several bridges form pinch points where the river remains pinned to a certain path. The banks are generally gently shelving and only incised in very few areas such as below the Ida Burn dam and within the enclosure of the Poolburn Gorge.

Fencing separating the river margins from adjoining land use is sporadic with direct stock access to the river apparent in some areas. Younger willows and broom colonises the margins in the central part of the catchment, while mature willows line both banks lower down in the catchment, sometimes in open clusters with grassland at the entrance to Poolburn Gorge. Occasional briar and other exotic weeds are also present in the context. As the river cuts through Poolburn Gorge, the margins become lined with schist rock bluffs, within the steeper surroundings of the Raggedy Range, Views are regularly framed by tussock with hardy low-growing shrubs and jagged rock tors.

The active bed of the Ida Burn consists mainly of cobbles and gravels from fist size higher up in the headwaters down to approximately 2 cm diameter lower down. Issues with sedimentation are not particularly apparent despite the flow generally appearing low for the size of the bed. Water quality in the headwaters generally appears good. Below the Ida Burn dam, coverage of filamentous algae increases substantially, although shading from willows ensures the river corridor remains relatively cool. Around Auripo Road (Auripo meaning swamp in te reo Māori) abandoned wetlands occur that may have been connected to the main Ida Burn in the past.

The scenic values of the Ida Burn remain relatively high throughout although it is often difficult to see the river channel from public roads. The Otago Rail Trail runs in proximity along the lower reach of the river including through the Poolburn Gorge within the Raggedy Range and offers a strong sense of emersion within the broader Central Otago landscape, particularly when passing adjacent to the Idaburn Dam viewed against a backdrop of North Rough Ridge.

Key Landscape Characteristics of Reach 6

- High aesthetic values associated with wider Central Otago landscape, particularly in the tussock lined headwaters and in association with North Rough Ridge at Ida Burn Dam
- Increasing presence of willow and broom defining margins of the river, particularly through the upper part of the Ida Valley
- Wetland / swamp areas remain apparent along the margins near Auripo within the Ida Valley
- River extends through Poolburn Gorge which includes schist rock bluffs and steep slopes colonised by tussock and hardy low-growing shrubs
- Proximity of Otago Rail Trail in several areas including Poolburn Gorge and Idaburn Dam increase high scenic associations

NATURAL CHARACTER – Ida Burn		**Degree of Natural Character**
Active bed-Flow/ Water quantity	• Hawkdun - Ida Race takes water from the upper Manuherekia into the Ida Burn catchment. • The race also captures flows from the upper Ida Burn and Hills Creek (and the smaller tributaries the drain the Hawkdun Range slopes) along the way. • The deemed permit takes about 1/3 of the flow at low flows from Ida Burn (already consent to replace permit) • The Idaburn catchment is subject to the 800 l/s minimum flow at Ophir although this minimum flow is currently not being observed by Ida Valley users due to policy 6.4.5.[3] • The creek can dry out between Oturehua and Auripo • Poolburn enters Ida Burn just above the gorge, where it flows through the Raggedy Range	Low

[3] Policy 6.4.5 of the Regional Plan Water for Otago provides that minimum flows will not apply for the Manuherekia above Ophir, until there has been a collective review of consents in 2021.

Active bed- Bed Shape, incl modifications/ structures	• A few bridges, all of small scale, apart from the highway bridge in the upper reaches • Ida Burn dam just downstream of Oturehua • Auripo swamp has now been drained but some remnants of wetlands are visible near the river margins • Gorge emerges at Lauder settlement	Moderate
Active bed- Aquatic ecological health/ Water Quality	• Pockets of galaxiids in Hills Creek, while frequently found in the 1990s fewer now • Koura still occupy sections of the Ida Burn upstream of the Ida Burn dam. • *E.coli* in lower reach through gorge, as Poolburn contributes low water quality (stagnant in dammed lake) • Some large sized trout can be found and Ida Burn is used for spawning in the lower reaches • Generally low ecology values now in mainstem, apart from some pockets, but some tributaries are still in better condition.	Low (pockets of high)
Margin- Structures and Modifications	• Lined with willows in open areas • In the gorge no substantial modification has occurred • No wetland systems are connected anymore • The large race in the upper catchment captures a lot of the flows through a weir structure. • Some bridges along the central reaches are pin-points on the bed and confine the channel	Moderate – High
Margin- Terrestrial ecology	• Upper catchment contains tussocks and matagouri • Willows line the majority of the Ida Burn from the highway bridge downstream • Pasture often extends very close to the stream bed • Broom often occurs on the stream bed in the more open sections below SH bridge and above Oturehua	Low
Context	• The context of the headwaters includes conservation land with tussock land cover. • Extensive farming in upper sections with increase of modification in mid and lower Ida Valley • Few settlements with predominance of pastoral land use. • Roads are limited to local access • Relatively natural context through the Raggedy Range	Moderate to High
Experiential	• The headwaters have a highly natural appearance despite flow modification. • Gorge section is remote with very limited modification. • Majority of central Ida Burn Valley is dominated by agriculture and views to the river are often blocked by willow and other weeds.	Moderate

RIVERSCAPE AND VISUAL AMENITY – Ida Burn		Values and Visual Amenity
Nature of views, viewing audience	• Hawkdun Range has been identified as an ONL • High visual amenity in the upper catchment with impressive Central Otago landscape providing openness and views to the surrounding mountain range. • Raggedy Range and lower parts of North Rough Ridge are identified as SAL with tops of North Rough Ridge (above 900m contour) identified as ONL • Ida Burn dam just downstream of Oturehua is used for curling • High visual amenity in the Ida Dam area • Ida Burn Gorge is identified as ONF.	Moderate (central Ida Valley) High (headwaters and gorge)

4.7 Dunstan Creek: Reach 7

Dunstan Creek at St Bathans Loop Road Bridge

Dunstan Creek commences high up in the Dunstan Mountains between the Dunstan and St Bathans Ranges and connects with the Manuherekia at the SH85 Bridge. For the purpose of this assessment, this reach encompasses the lower end of the river as it flows into the part of the upper Manuherekia Valley near the northern end of Pauley Road. Here the creek flows into the Manuherekia Valley to the west of St Bathans and Blue Lake and is separated from the mainstem of the Manuherekia River below Falls Dam by the southern toe of the St Bathans Range.

The rural landscape surrounding the river is predominantly managed as pasture with some small conifer forestry blocks. The frequency of irrigation and greener pasture gradually increases below Cambrian Road in the vicinity of a substantial weir feeding the Dunstan Water Race take and intensifies further to the south of Beattie Road. Storage lakes are visible along St Bathans Loop Road with k-line and pivot irrigation established on open flat areas. Extensive willow trees outline the river course which traces along the toe of legible river terraces. Large grazed paddocks are often framed by conifer shelter belts, with such planting most typically established along the road verge.

The river corridor generally remains broad and supports a semi-braided channel with clear signs of erosion along the banks and evidence of shifting islands with varying levels of vegetation. It appears that the bed is relatively stable but retains the opportunity to shift in large flood events. The margins of the creek contain extensive areas of broom with some willow, although the bed generally remains wide within exposed gravel islands and banks. In the mid and lower sections, willow trees have become more established and appear very mature and fully shade the riverbed.

The riverbed is typically made up of large cobbles, generally up to fist size, with some slightly larger rocks. There is sign of didymo occurrence on some larger rocks, but the coverage is not extensive. The water quality generally appears good with fast flowing sections and natural appearance. Very little filamentous algae is apparent and the water is generally clear without odour. The water is comparatively cold and overall the stream seems to be in a relatively healthy condition.

Scenic values associated with Dunstan Creek become more limited in the lower reach as the river corridor remains barely visible from public roads due to the willows lining the banks and the distance to the road. Access to the river is only possible from the two road bridges, including SH85 at the confluence with the Manuherekia River where the flow appears relatively swift and the water quality appears relatively high, inviting recreation use.

Key Landscape Characteristics of Reach 7

- Headwaters commence high in the Dunstan Mountains alongside St Bathans Range
- The river adjoins a strong agricultural landscape character along the valley floor supporting increasing areas of irrigated pasture
- The river maintains a broad semi braided form which retains some mobility through extensive areas of broom and willow
- Exotic vegetation typically limits views of the river corridor with views and access into the river corridor limited to two road bridges
- The river flow appeared relatively swift and the water quality relatively high when observed at a flow of around 0.5 m^3/s on site.

NATURAL CHARACTER – Dunstan Creek		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• 14 water takes in total • Takes at the top are very small • First major take downstream from Loop Road bridge • The remainder of takes is small, and mostly from the tributaries • Around 30l/s is lowest flow in Dunstan Creek	High above Loop Road Takes Moderate below
Active bed- Bed Shape, incl modifications/ structures	• Bed is quite mobile and shifting gravel banks occur, in particular in the upper reaches. • Broom occurs on either side of the bed around Loop Road bridge, but the channel is still active and vegetated banks act as a buffer. • Generally the bed does not have much modification, apart from the bridges and intake structure • At the intake a large weir has been erected to direct water into the race. This acts as a barrier for fish passage.	High

Active bed-Aquatic ecological health/ Water Quality	• Dunstan Creek has high native fish values and instream ecology • Unconfirmed Alpine galaxias above Loop Rd • Central Otago roundhead galaxias occurs from Dunstan Gorge to Manuherekia confluence • Central Otago roundhead galaxiids can co-occur with trout in terms of habitat. • Best small stream trout fishery of Otago (Rainbow and Brown Trout) with large fish in low numbers.	High
Margin-Structures and Modifications	• Several road bridges, but most of them small in scale • Weir (2m high) and race at water intake structure • 4WD tracks along the river margins in some places • The State Highway bridge at the Manuherekia confluence confines the bed	High
Margin-Terrestrial ecology	• Native plants are mainly found above Loop Road • Broom and Willow line the bed in most places • The lowest part above the Manuherekia confluence is willow lined, but grassy margins are found in some places • A lot of wild deer graze in the river margins	Medium to Low
Context	• The headwaters are very natural before Dunstan Creek emerges from the Dunstan Mountains (above study reach) • The agricultural use becomes progressively more intensive along the lower catchment. • Paddocks, shelterbelt and small scale woodlots are located in proximity of the margins.	Moderate
Experiential	• The river is difficult to access and often not visible from the road due to dense willows • The river has a largely natural appearance with few structures in its vicinity • The relatively fast flow and high water quality provide for high experiential values	Moderate
RIVERSCAPE AND VISUAL AMENITY – Dunstan Creek		**Values and Visual Amenity**
Nature of views, viewing audience	• The Dunstan Mountains are an Outstanding Natural Landscape (outside study reach) • The upper catchment includes places with high amenity and historic values, such as St Bathans and Blue Lake • There are not many opportunities to view Dunstan Creek from the road, but when accessed (eg for fishing) it provides high amenity values within the river corridor.	Moderate

4.8 Thomsons Creek: Reach 8

Thomsons Creek looking south from Harvey Road Bridge

Thomsons Creek commences high in the Dunstan Mountains and has its confluence with the Manuherekia River just above Ophir Gorge. For the purpose of this assessment, the study reach encompasses the lower part of the creek as it flows into the Manuherekia Valley below approximately 500 masl (meters above sea level).

As Thomsons Creek emerges from the Dunstan Mountains, the surrounding landscape is predominately managed as dry stock tussock farmland with matagouri and some extensive areas of broom. Within the Manuherekia Valley the landscape context becomes increasingly modified with extensive irrigation on both sides. Some recent rural lifestyle subdivision and dairy farming with milking sheds also occur in the vicinity.

The alignment of Thomsons Creek typically bisects rectilinear paddocks and is crossed by several road bridges. At times the river corridor becomes enclosed by willow trees established along its margins. In other places it has a relatively open character with farming established right up to the banks, enabling direct stock access in places. At SH85 the channel is quite incised and old bridge abutments fix the banks of the stream in this location. Hardly any gravel banks were apparent throughout this reach and the flow can appear limited in this confined context.

The river channel emerging from the Dunstan Mountains maintains a rough substrate which contains rocks at about head size. The channel can dry in the upper section of the river below the Matakanui Water Race Take as it leaves the Dunstan Mountains[4]. Smaller cobbles and gravels occur along the base of an increasingly incised streambed with vegetated banks typically grassed up to the edge. At the Glassford Road bridge the channel has a degrading bed that is incised within the gravel banks. The water quality appears relatively high and there are clear gravel beds throughout the whole creek without evidence of filamentous algae or fine sediment. In the lower reaches finer sediment can be found in the creek bed.

[4] As observed during site visit on 25 February 2020. While the river was dry close to its headwaters it reappeared at Glassford Road.

Views along the stream are enabled from several bridge crossings as it passes through a modified rural setting with limited scenic amenities. There is also a popular picnic and rest spot at Thomson's Creek just before the township of Omakau along the Otago Rail Trail.

Key Landscape Characteristics of Reach 8

- Headwaters commence high in the Dunstan Mountains which are predominately managed as dry stock tussock farmland
- Through the Manuherekia Valley, the river corridor occupies a highly modified rural context through rectilinear paddocks and frequent bridge crossings
- The river flow often appears constrained by established water takes and the bed becomes increasingly incised between the banks as it approaches the Manuherekia
- Mixed willow and open pasture enclose the stream margins with frequent stock access from adjoining farmland

NATURAL CHARACTER – Thomson Creek		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• A large take is located at the upper reaches of Thomsons Creek which exacerbates a frequently and naturally occurring dry reach near Mawhinney Road. • A loosing reach where it emerges from the Dunstan Range • A gaining reach starts at Glassford Road (clay pans) and hydrology is neutral downstream. The flow does not fully recover due to the large take upstream. • Matakanui Race takes water from Thomson Creek and delivers it into the Chatto Creek catchment • Highly modified system due to historic gold mining	Very Low
Active bed- Bed Shape, incl modifications/ structures	• Single stem channel • Some fords and bridges, but otherwise not many structures • Some weirs at water takes • Flow recorders at top and SH85	Moderate
Active bed- Aquatic ecological health/ Water Quality	• Springs modified • Fine sediment issues • Water quality is low (E grade)[5] with *E.coli* issues as Omakau race discharges into Thomson Creek and due to intensive land use. Lower Thomson Creek also has poor water quality due to agricultural bywash discharges (LAWA). • Isolated pockets of galaxiids in adjacent wetlands/ springs • Trout from Manuherekia main stem spawn in Thomsons Creek	Low
Margin- Structures and Modifications	• Historic gold mining in upper reach • Sluicing ponds in proximity to the creek and creation of sludge channels.	Low

[5] Based on NPSFM, Appendix 2A, Table 9.

Margin-Terrestrial ecology	• Highly natural headwaters in the Dunstan Range • Tussock and matagouri in upper catchment where creek emerges from the mountains • Farmland starts to dominate below with increasing intensification and modification near the margins • Near Manuherekia channel is willow-lined • Some wetlands and springs on the sides of the creek with pockets of galaxiids occurring	Headwaters high Below Dunstan Range Low
Context	• Highly natural context in the mountainous headwaters, but increasing level of development • Goldmining in upper reaches until recently with sludge channels present. • Majority of context is dominated by farmland • In lower reaches some rural lifestyle development is found around Thomson Creek • Few country roads with regular small-scale bridges	Moderate
Experiential	• The naturalness of Thomson Creek within the Manuherekia Valley is perceived as relatively low due to the surrounding land use modifications and the low flow • Farming often extends to the channel	Moderate to Low
RIVERSCAPE AND VISUAL AMENITY – Thomson Creek		**Values and Visual Amenity**
Nature of views, viewing audience	• Dunstan Range is identified as an ONL (above the study reach) • Thomson Gorge Road connects as a 4WD track to Lake Dunstan (former connection for gold miners to Bendigo) and enables experience of headwaters • Within the Manuherekia Valley Thomson Creek flows through modified farm land and is a small feature within a broad landscape • Difficult to view the creek, as predominantly surrounded by farm land	Low

4.0 Chatto Creek: Reach 9

Chatto Creek near the historic Chatto Creek Tavern

Chatto Creek commences in the Dunstan Mountains and has its confluence with the Manuherekia River just below Ophir Gorge. As with Thomsons Creek, this assessment has only considered the section which flows through the Manuherekia Valley below approximately 500 masl.

As Chatto Creek flows into the Manuherekia Valley, it passes through modified landforms which result from former gold mining activity at Devonshire Diggings. At Devonshire Diggings surface flow is diverted from a small tributary into a water race, leaving its streambed dry while Devonshire Creek does not dry out. Below Devonshire Diggings the streambed continues through farmland to the west of Devonshire Road along which storage lakes and pivot irrigators are common.

In general, the creek is quite inaccessible, being separated from the larger Manuherekia Valley by the folded open landform of the Magdalen Hills. Between Devonshire Diggings and SH85, the only access is obtained at the bridge along Moutere Disputed Spur Road, also marking the confluence with Buster Creek which contributes about equal flow at this point. Further tributaries from the Dunstan Mountains flow into Chatto Creek to the west of the Magdalen Hills, the combination of which cover a broad area and create what is described as an ‘oak tree catchment’.

The alignment of Chatto Creek flows unconstrained through farmland, frequently with grass pasture right up to the edge of the creek. Ribbons of willow trees also border the margins of the creek as it sidles to the west of the Magdalen Hills and above the confluence with the Manuherekia River. At the SH85 crossing, it flows through a low but relatively confined gorge with large rock outcrops along the margins. A historic bridge is also located just below the current SH85 bridge and forms a local feature adjoining Chatto Creek Tavern.

Throughout the course of the creek the flow changes from sluggish to relatively fast flowing, depending on the gradient. Through the upper sections it typically forms a small incised channel through small boulders. Below this, fine sediment dominates the riverbed as it flows through areas of pasture with only a few gravels visible in the bed. Due to its sluggish flow, the water tends to be quite discoloured and brown in these sections. In the lower parts, Chatto Creek is faster flowing at a higher gradient which tends to support gravel beds defined by rock outcrops on either side.

The Otago Rail Trail follows the lower end of Chatto Creek where the waterway follows a lower terrace and traces alongside a ribbon of willow trees. The rail trail along Chatto Creek connects at the confluence of the Manuherekia near the viaduct below the Ophir Gorge.

Key Landscape Characteristics of Reach 9

- The headwaters commence in a broad 'oak tree catchment' within the Dunstan Mountains
- Much of the initial flow is intercepted by an established water race as it passes through former gold mine workings at Devonshire Diggings
- Mixed willow and open pasture enclose the stream margins with frequent stock access from adjoining irrigated farmland in upper areas
- Most of the river remains inaccessible above SH85 and separated from the broader Manuherekia Valley by the Magdalen Hills
- The alignment of Chatto Creek remains visible from the Otago Rail Trail as a ribbon of willow trees on a lowered terrace above the confluence with the Manuherekia River

NATURAL CHARACTER –Chatto Creek		**Degree of Natural Character**
Active bed- Flow/ Water quantity	• At Devonshire Diggings surface flow is diverted from a small tributary into a water race, leaving its streambed dry while Devonshire Creek does not dry out (while one of the small tributaries can dry out). • Young Hill Creek is a significant tributary. It connects with Chatto Creek about 300m above Manuherekia confluence and contributes about 1/3 of MALF. • Flow recorder located below Young Creek confluence, but some gauging occasionally carried out above. • Oak Tree catchment with numerous small tributaries • Small takes are located on most of the tributaries, which has a substantial cumulative effect on the flow in Chatto Creek, leading to a highly modified flow. • Flood irrigation occurs in the catchment • Chatto Creek flows parallel to Manuherekia Race (Burrow Race) • Due to the short catchment the flow is smaller than in Thomson Creek	Low
Active bed- Bed Shape, incl modifications/ structures	• In upper catchment bed often ill-defined and flowing through paddocks. • Lower reaches more incised bed • Some issues relating to fine sediment in the stream	Moderate to high
Active bed- Aquatic ecological health/ Water Quality	• Pockets of Central Otago Round Head Galaxias in main stem up to an elevation of around 820 masl. This species can tolerate higher water temperatures. • Not many trout in upper reaches, but some spawning in lower mainstem that is connected through water races.	High in upper reaches Moderate in lower reaches

Margin- Structures and Modifications	• Some gold mining in the context of the upper catchment • No flood mitigation structures within lower Chatto Creek • The creek flows mainly through plains and bridges are generally the only structures.	Moderate
Margin- Terrestrial ecology	• Mainly pasture in the immediate context with grazing in and along the stream and tributaries. • Banks and channel are trampled in places through stock access • Willow are more common further downstream • Many broken willows obstruct the bed	Low
Context	• Headwaters of the tributaries are within the Dunstan Mountain Range which provides high natural character • Headwaters Devonshire Gold Diggings in upper reaches • Irrigation used for pit and stone fruit in lower reaches • State Highway bridge at settlement and one other bridge in middle reaches • Farming use dominates the context • Pivot irrigation between Dunstan Range and Magdalen Hills • More extensive farming where Chatto Creek flows between Magdalen and Merton Hills.	Moderate
Experiential	• Difficult to access Chatto Creek but where visible from bridges stock trampling in and around the channel has led to modification in the reach above Magdalen Hills. • Willows line the bed in lower sections	Moderate to Low
RIVERSCAPE AND VISUAL AMENITY – Chatto Creek		**Values and Visual Amenity**
Nature of views, viewing audience	• Dunstan Range is identified as an ONL (above the study reach) • Access to the stream is difficult and not viewed by the public from many places • Contributes to the amenity at Chatto Creek settlement. • Small creek that becomes more incised in the landscape below the highway bridge.	Moderate to Low

4.0 Historic Values of Manuherekia River and Tributaries

4.1 Natural History

The Manuherekia River is remnant of the early Miocene Manuherekia paleolake, which stretched from the Waitaki River to the Nevis Valley South of Queenstown. The lake formed 18.7 to 15.1 million years ago during a period of basin subsidence in Central Otago, and was approximately 5,600km^2 in size, larger than all of New Zealand's modern-day lakes combined (Reichgelt et al., 2015). During this time, Central Otago was clad in sub-tropical rainforest species due to the warmer and wetter climate (Pole et al., 2003). This supported large conifer (including but not limited to *Dacrycarpus, Podocarpus, Prumnopitys, and Dacrydium)* and Eucalyptus species (Pole et al., 2003). Fossils of crocodilians and snakes have also been found within proximity of the lake.

The changes in the landscape surrounding Lake Manuherekia began when the Earth cooled during the Miocene Transition, approximately fourteen to thirteen million years ago(Worthy, 2011). During this period, the Earth's temperature dropped 8◦C and within the following ten million years during the Pleistocene glaciations there was a further 5◦C decline. Consequently, this eradicated the sub-tropical vegetation which surrounded the lake (Worthy, 2011).

While the habitat and ecology surrounding Lake Manuherekia began to change, so did the lake itself. Throughout time, Lake Manuherekia began to recede due to the tectonic uplift of the Southern Alps (Pole, 2015). This resulted in the lake water being concentrated into rivers, with the Manuherekia River being the final remainder of the lake.

4.2 Cultural History

The Manuherekia River catchment is of significance to local Kāi Tahu. The river is recorded as a kāinga nohoanga (encampments) and kāinga mahinga kai (food gathering), as determined by Kāi Tahu kaumatua (Te Rūnanga o Ngāi Tahu, 2018). Tuna (eels), pora ('Māori turnip'), weka, pārera (grey duck), pūtakitaki (paradise duck), and kōareare (edible shoot of raupō/bulrush) were all gathered along the river. It is also likely that the river was a welcomed stop when travelling between Moeraki to Makaroa along the Thomsons Saddle Route. This was used to navigate the Dunstan Mountains, overlooking the river from the west. Cultural values identified by Kai Tahu in relation to the Manuherekia Catchment have been assessed in a separate report (Clucas, R., 2017).

Following European settlement, the two major cultural influences that have shaped the Manuherekia and wider Central Otago landscapes were pastoral farming and the discovery of gold. Supplying the demand for water to support these endeavours has led to the establishment of long water races which obtain water directly from the surrounding ranges. Several water races, storage dams and diggings remain evident throughout the landscape and often are still in use. Part of the early mining infrastructure, including the Ida Water Race, has been adapted to supply ongoing irrigation for pastoral farming operations.

Settlement throughout the Manuherekia Valley includes several small towns which typically occupy elevated terraces close to the river and include several historic bridge structures which span the river corridor. The town of Alexandra marks the confluence between the Manuherekia and Clutha / Mata-Au Rivers. This provides a picturesque setting and strong association with the lower reach of the Manuherekia River which follows the toe of the Raggedy Range.

4.2.1 Pastoral Farming

With the arrival of Europeans, the landscapes of Central Otago were increasingly covered in sheep farms due to the success of wool exports (Central Otago District Council, 2020a). Scottish immigrants Watson and Alexander Shennan established the first of Central Otago's pastoral stations at Moutere and Galloway and Otago's first Merino flock (Central Otago District Council, 2020b). Exports from pastoral farming were not limited to wool however, with skins and hides, leather and livestock all coming out of Central Otago (McIntyre, 2007).

Farming began in Central Otago in the 1840s and initially involved the grazing of indigenous vegetation before moving to pastoralism. Much of the vegetation at this time was disrupted through previous fires (Guild & Dudfield, 2009). Grazing of Central Otago's landscapes expanded quickly during the 1850s and 60s, and farms were often situated near major river valleys, such as the Manuherekia River valley. Merino breeds being hardier were pushed up into the higher into the mountains, as they are more suited to the tawny expanse of high-country dryland tussock grassland (McIntyre, 2007).

4.2.2 Gold

During the 1860s the Manuherekia River became one of the centres of the Central Otago Gold Rush following the discovery of gold by Gabriel Read in 1861. The goldfields, which stretch the length of the Manuherekia River, originate at St Bathans in the north to Alexandra where the river converges with the Clutha River / Mata-Au. Gold was also discovered along the toe of the Dunstan Mountains, interacting with several tributaries (and associated water races) which feed the Manuherekia River from this area, including Chatto Creek.

At the peak in 1863, the goldfields across Central Otago supported a population of 24,000 people (Warlond, 2006). Goldfields near the Manuherekia River however were found in late 1863, and during the 1890s with many settlers arriving following the discovery of gold. Several townships sprung up and sustained populations as key commercial centres when the gold industry began to decline (Engineering New Zealand, 2020a).

4.2.3 Irrigation

Irrigation in Central Otago originated in 1873 when a Frenchman named Faraud was granted a water right for the irrigation of vegetables to sell to miners (Hinchey et al., 1981). Following the gold rush, water infrastructure was later repurposed and expanded for irrigation of pasture as its value for mining had fallen off.

The Ida Valley scheme came into operation in 1917 (Hinchey et al., 1981). The area was later proclaimed an Irrigation District by an Order in Council in 1926 (Hamilton, 2009). Around this time several additional water races not founded on the remains of mining were also established, particularly on the western side of the Manuherekia Valley. The Manuherikia Race, constructed from a take within the Ophir Gorge between 1917 and 1922, was the first such race in Central Otago to be constructed specifically for irrigation.

Historically, irrigation water was applied using overland flow systems such as flood and border dyke irrigation. In more recent years, technological advances have seen spray systems such as centre pivot and k-line become more common. Water availability is generally the main factor limiting irrigated land for many farms in the Manuherekia catchment and spray irrigation has advantages in terms of efficiency (Otago Regional Council, 2009)

4.3 Historic and Heritage Elements

Historic and Heritage elements identified from the following sources have been mapped in relation to the reaches assessed and included in Figure 5.

- Geo preservation Sites
- New Zealand Historic Places Trust Register
- New Zealand Archaeological Association (NZAA) ArchSite
- Central Otago District Heritage Values

The key heritage artefacts which influence and interact with rivers and waterways covered in this report are set out below:

4.3.1 Water Races

Gold mining was the driver for the first water races constructed in Central Otago from the 1860s (Hamilton, 2009). As the easy gold was won and the races abandoned by the miners, they were repurposed for domestic and stock water and then irrigation of pasture and horticulture. Many of the races are long, on steep hillsides, and construction was undertaken with limited resources.

The Mt Ida Race was constructed in the head of the Manuherekia catchment in 1876 and sidles the Hawkdun Range for 108km to Naseby where it provided miners a power source for sluicing as well as a water supply for the town. This was later repurposed for irrigation in the 1920s and continues to supply water for irrigation through the Maniototo Valley. A network of well-established races and associated irrigation schemes weave throughout the Manuherekia catchment including the Ida Valley, Manuherekia, Galloway and Omakau schemes, the first of which was completed in 1917.

The water races established for gold diggings and later other water users provided conduits for salmonids to travel and thereby providing an opportunity to invade and decimate non-migratory galaxiid populations along the base of the Dunstan and Hawkduns Mountains.

4.3.2 Dams / Storage Lakes

In support of the value of supplying irrigation to the district, several large dams and storage lakes were constructed in the 1930s. Two such dams occur along the course of the Manuherekia River and Ida Burn, namely Falls Dam and the Ida Burn Dam.

The Falls Dam and associated power station, forms a thirty-three-metre-high earth dam with a concrete spillway. It was first filled in 1935 to provide a reservoir for local irrigation systems (Bishop et al., 1984). The Ida Dam was built in 1931, capturing spring flows in the Ida Burn. The dam holds 0.23 million cubic metres of water. In the winter, the dam reservoir freezes which makes it popular for winter sports including curling, ice skating and ice hockey.

4.3.3 Historic Diggings

Historic diggings have created broadscale landform modification, often resulting from sluicing, as an enduring aspect of mining activity. Whilst several historic diggings are separated from the course of the river, including Blue Lake at St Bathans Lake, some continue to interact more directly with the Manuherekia and its tributaries. Devonshire Diggings remains particularly evident at the upper part of Chatto Creek along the toe of the Dunstan Mountains, where mining has occurred from the 1860s up until the 1980s (Hudson Institute of Mineralogy, n.d.).

During the 1890s, dredging also occurred directly along the course of the Manuherekia River, with fifteen dredges operating at the peak of this activity (McKinnon, 2015). These included the Chatto Creek Dredge which extracted a rich seam of gold from 1889-1901 before the Chatto Creek Dredge Company went into liquidation. This is now located near Chatto Creek Tavern, a couple of kilometres away from where the dredge previously was founded in the Manuherekia River.

Other diggings along the Manuherekia River include Blacks Diggings, and Tucker Diggings. Blacks Diggings were split into three areas and were situated at the base of the Raggedy Range near Ophir (formally known as Blacks). Gold was discovered here in mid-1863 on Charles and William Black's pastoral farm, causing nearly two thousand miners to come to the area for the short-lived gold rush (Hudson Institute of Mineralogy, n.d.). Tucker Diggings occurred just north of Alexandra on the side of Tucker Hill and were not as successful as other diggings. The gold found here only provided basic necessities for miners, hence the name 'Tucker' (Clyde to Chatto Creek, 2020).

4.3.4 Historic Bridges

Settlement throughout the Manuherekia Valley increased the need for access though the district including bridges connecting with several adjacent riverside towns. Along the Manuherekia River, the Daniel O'Connell Bridge crosses the river west of the township of Ophir. The construction of this bridge between 1879 and 1880 was not without its challenges, with locals campaigning for the bridge to be constructed to navigate across the hazardous Manuherekia River. The bridge stands at approximately 65 metres in length and was named after the Irish politician Daniel O'Connell, who allowed Catholics (the main population of Ophir) to become Members of Parliament. Today the bridge is recognised by Heritage New Zealand as Category 1 historic place (Engineering New Zealand, 2020a).

Further south, Shaky Bridge was constructed across the Manuherekia River between 1878 and 1879 for light traffic in response to the increasing need to connect areas east of the growing township of Alexandra (Engineering New Zealand, 2020b). During times of flood there was virtually no way of navigating the Manuherekia River through this area and with Alexandra being a key node in Central Otago during this time it was imperative for this connection to be permanent. After campaigning from locals, a 60-metre bridge was constructed across the Manuherekia River and today remains solely a foot traffic bridge leading up to the Alexandra Clock (Otago Central Rail Trail Charitable Trust, n.d.). It is considered a Category 2 historic place by Heritage New Zealand.

Another historic traffic bridge remains along Chatto Creek, near the Chatto Creek Tavern. Chatto Creek was predominantly a mining township, however workers were also employed to help build the railway which navigated the steep Tiger Hill nearby (Otago Central Rail Trail Charitable Trust, 2020a). The Chatto Creek Bridge was constructed as a road bridge and is now listed with the British Transport Museum (Chatto Creek in Central Otago, 2020).

4.3.5 Otago Rail Trail

The Otago Rail Trail follows the former course of the Central Otago railway line, constructed between 1891-1907 from Clyde to Middlemarch. The rail was a vital connection between the goldfields of Central Otago and Dunedin during the height of gold mining. However, during the 1930s when the economic prosperity of gold mining ceased, the railway line's use began to decrease and by the 1980s the railway line was redundant.

The alignment of the rail trail follows the true left bank along the lower reach of the Manuherekia River before traversing a viaduct below Ophir Gorge. It then extends alongside Chatto Creek to a crossing of Thomsons Creek and continues through the lower part of the Manuherekia Valley. From here it then extends through Poolburn Gorge along the lower part of the Ida Burn and continues through the Ida Valley, passing alongside the picturesque Idaburn Dam.

Several historic viaducts still remain along the rail trail including the Poolburn Viaduct, in Poolburn Gorge. At the time this was constructed, over three-hundred workers settled in camps west and east of both Poolburn tunnels, which were chiselled to allow the railway line to pass through (Otago Central Rail Trail Charitable Trust, 2020b).

5.0 Assessment of Flow Scenarios

5.1 Natural Character Effects

Natural character is a combination of the natural elements, patterns, and processes of a river system. When changes occur to elements (e.g. extraction of gravel), effects on natural character can be localised so that natural patterns and processes are able to essentially continue. When changes begin to affect natural processes (such as water flow/ quantity), natural character is likely to decrease more markedly across the whole system.

A reduction in flow can induce change in rivers that primarily has the potential to be reflected in the ecological integrity and quality of the waterway's ecosystems. River flow affects a range of habitat factors including current, water depth, wetted area, substrate, dissolved oxygen levels and water temperature. Indicators of impacts can be a very shallow water depth, a reduction in the wetted area or reduced water movement compared with what might be expected or for longer durations than might be expected. Changes such as these tend to be more noticeable in shallow, braided river sections than in single thread, incised river sections or streams.

In order to evaluate the effect on natural character of changing flows, the effects need to be considered separately for each of the river components, (i.e. active bed, margin, context) as change in flows affect these components in very different way and by varying degrees. Longer term effects of flow reduction such as vegetation encroachment onto the riverbed, are generally prominent and lead to effects on the natural patterns and processes of the river. The fine sediments deposited in the interstitial, water-filled space in the gravels of the riverbed change the habitat qualities for invertebrates, which need to be considered as part of the assessment of natural processes. This is covered in the Land and Water People Water Quality report prepared for ORC (see also 5.1.1)[6].

For these reasons, it is understanding the ecological impacts of reduced flows together with consideration of the maintenance flushing flows/floods and seasonal base flows that are most important in considering effects of flow thresholds on the natural character of the Manuherekia catchment. This aspect of the assessment relates to the ecological processes and water quality and therefore, specific findings in relation these aspects need to be sourced from the respective reports prepared for ORC.

The experiential aspects of natural character may also be impacted, however sometimes effects would have to be greater before a reduction in flow level would result in an adverse 'natural' experience. These experiential aspects of natural character are related to the amenity provided by a river.

Many factors play a role in maintaining, improving or reducing natural character, including flow levels. In addition to changing flows, the natural character of many of the reaches in the Manuherekia catchment is also susceptible to factors such as surrounding land use change (e.g. due to irrigation or subdivision), particularly by additional structural modifications to the river, its margins or adjacent context.

5.1.1 Active Bed

When considering the active riverbed in particular, a reduction in flow and especially the loss of flood flows, can reduce natural fluvial processes. This includes the movement and deposition of sediments and gravels that lead to the formation of river braids, bars, and islands.

In addition to lower flows, rapid, frequent, or large changes to flows (for example changing releases through Falls Dam) are not conducive to supporting fish habitat. If the flows are frequently reduced,

[6] LWP water quality report (2021), p.16 Fine sediment in water bodies occurs from soil erosion, riparian habitat loss, decreased bank stability, and changes in water flows. Deposition of fine sediments can result in population changes for example decreased diversity or decreased abundance in sediment sensitive (*Ephemeroptera, Plecoptera, Trichoptera*) and filter feeding organisms.

this can have negative effects in the slower/shallower margins of reaches. Low flows may also adversely affect benthic invertebrates, contributing to reduced food source availability for fish and birds. Conversely, invertebrate and fish taxa habitat quality and quantity can be highest at low to medium flows depending on the river system.[7]

Through extended low flows an accumulation of finer sediment can mean that less interstitial space is available, which reduces the overall ecosystem health due to impacts on the invertebrates that normally occupy this space. Effects on invertebrates have a ripple-on effect on the food chain of the river system and therefore macroinvertebrates are often used as indicator for the ecosystem health.

Physical habitat quality for cyanobacteria and algae, such as didymo and long filamentous algae are also predicted to be highest at stable flows without floods to clear the riverbed. This would lead to adverse effects relating to the presence of these nuisance algae. In this respect, not only low flows and water quality aspects influence the presence of algae but also the timing of low flows, in particular during extended low flows periods without freshes or floods.

It is likely that some sections of the Manuherekia River would be more susceptible to adverse natural character effects from low flows due to their location in relation to water takes and tributary inflows, as well as particular riverbed characteristics. In areas below water takes, where the riverbed is shelving and/or water is lost to ground, effects are likely to be worst, such as between the Blackstone intake and the Dunstan Creek confluence (at St Bathans Loop Road).

5.1.2 Margins

With regards to the margins, flow changes are important for abiotic features, such as gravel substrate banks as flood flows clear exotic weeds. These high flows that cover the margins are essential to maintain the quality of the gravel surface habitat for birds. From the photographic record (see photo 39) it is clear that the high winter flows of 10 m^3/s and above are required to maintain the extent of the gravel riverbed.

Values relating to terrestrial ecology in the riparian margins, eg vegetation and bird habitat, may be impacted by changes to flow when the extent to which these communities are within or out of the water changes so that their ability to adapt and survive is affected.

Vegetation on the margins of most reaches on the Manuherekia and lower tributaries is already modified so that effects of reducing flows on natural character are unlikely to be significant in terms of species composition. However, extended dry periods and frequently exposed riverbed would result in further colonisation of these dry river margin areas, in particular by fast-growing weeds. Once weeds become more established, larger floods are required to remove these weeds with established root systems.

5.1.3 Context

Effects of reduced flows are unlikely to impact on the natural character of the wider riverscape context, other than through experiential attributes. For similar reasons, low flows may reduce the visual amenity of a river, for example by resulting in large areas of exposed river margins covered with dry sediment or algae. In such an instance, people's appreciation of that river's pleasantness, aesthetic coherence and even its cultural or recreational attributes could be reduced.

Those areas most sensitive to a change in flow regime are likely to be sections where the river takes are located above a section with shallower, or more braided morphology, such as above the Dunstan Creek confluence.

[7] 2018. Ecological Flow Regime Assessment for The Upper Clutha River/Mata-Au: Complementing Hydraulic-Habitat Modelling With Drift-Feeding Trout Net Energy Intake Modelling. [1]Cawthron Institute and [2]National Institute of Water and Atmospheric Research. Prepared for Otago Regional Council

5.2 Riverscape and Visual Amenity Effects

The effects of flow change on visual amenity values is very closely linked to recreation values. The effects will be greatest at the most frequented locations where people come into contact with river margins for active or passive recreation. In particular, low flows expose greater extents of bare margin which can be less attractive due to the presence of sediment or algae. The effects will also be greatest in areas of high natural character/low modification where large exposed river margins can appear incongruent with the typical patterns and processes where the waterline adjoins vegetation.

Often fine sediment and algae increase as low flows occur over extended periods which can lead to adverse effects on the visual amenity and smell of the river. This reduces the usability of the river for activities and as a recreation resource. The awareness of water quality and depth is generally higher with regular users who have a frame of reference in relation to various flows encountered at different times of the year. In this respect locals who are familiar with the river environment are often more sensitive to low flows and the adverse amenity effects that can arise.

Since recreation values are closely related to the amenity of the river, the findings from the Manuherekia River and Dunstan Creek Recreation Values Assessment (Greenaway, Draft June 2020) and the related Manuherekia River Recreation Survey 2020 (May 2020) are relevant, the key findings are summarised as follows (Greenaway, May 2020, p.6) include:

- Poor water quality and low flows were the key issues for respondents who were dissatisfied with the recreation values of the Manuherekia River. Water quality and toxic algae were considered the top management issues, while water quantity was afforded a much lower priority.
- Low flow did not appear a determinant of recreation value by itself. Many respondents considered low and gentle flows a reason to describe the Manuherekia River as ‘safe’ and ‘family friendly’, although there were also many respondents who wanted deeper swimming holes. Concerns with flow may also be associated with the presence of algae and silt, which were frequently described as problems for recreational use.
- While most respondents (more than 80%) at the Blue Lake and the Lower Manorburn Dam thought the settings had improved or stayed the same over time, most respondents at the Manuherekia River thought the River had deteriorated (53%), and those with the longest experience of the River were more likely to consider it worse (72% for those with more than 41 years of experience). Low flows, poor water quality, mud and silt and algae were the main causes of a perceived deterioration.
- Respondents described the River’s best aspects to be its scenic qualities, its safety for family swimming, the peace and tranquility and its accessibility.

As part of the survey respondents were asked if their water-based activities were ever not possible due to low or high flows during the summer season (p.7). The majority of respondents (60%) had always been able to carry out their activity when the River was low, but 26% were affected ‘sometimes’ or ‘often’. Very few respondents (5%) checked the water quality or quantity before visiting. Respondents were asked if they preferred lower, higher or the same river flow experienced at the time that they were interviewed. There was a preference for higher flows than those encountered when flows were below 4m^3/s, and no respondents preferred the flows to be lower than 2 m^3/s – and few preferred it lower at any flow. Kayakers require high flows to use the Ophir Gorge (between 15 and 50 m^3/s), which are flows that are too high for fishing (preference for 5 m^3/s to 15 m^3/s). Poor water quality, mud and silt and algae were the worst three issues encountered at the Manuherekia.

Greenaway (June 2020, p.7) finds that the Manuherekia River is not nationally significant or outstanding for recreation, but it does have regionally significant values for angling and kayaking. In summary, the Manuherekia River can be described as regionally significant for recreation below Falls Dam.

5.3 Effects on Historic Values

Some of the historic values relate to structures that are closely associated with the river, such as bridges, water races and dams. Many of these structures are still in use today.

Within the wider Central Otago area several historic water races are now disused and serve as walking or biking tracks. Part of the early mining infrastructure including the Ida Water Race has been adapted to supply ongoing irrigation and support enduring farming operations. A track follows the race alignment through the Oteake Conservation Park and the race provides a degree of amenity despite the obvious man-made modification it presents.

Settlement throughout the Manuherikia Valley includes several small towns which typically occupy elevated terraces close to the river and include several historic bridge structures which span the river corridor. The river provides a picturesque setting where the historic buildings and structures form part of the amenity of the landscape (eg Dan O'Connell bridge). In this sense the river forms a focal point and connection to the past with this purpose-built structure associated with the early settlement/ gold mining history. Any changes in river flow would predominantly have an effect on the amenity of the setting for bridges and settlements. Effects on amenity are discussed in more detail under section 5.2.

Falls Dam and the associated power station, which are still in use today, were first used in 1935 to provide a reservoir for local irrigation systems. The Ida Dam was built in 1931 to supply land at the head of the Ida Valley, capturing flows from Ida Burn. These structures are closely linked to the presence of water within the Manuherekia River and Ida Burn. The lakes that have formed behind these dams have existing recreational value and form part of the sense of place associated with the cultural landscape in the area. While these structures have led to a reduction of natural character they provide for historic associations, as well as present uses. A reduction in water quantity in relation to these structures would impact on the visual and recreational amenity currently provided.

5.4 Flow Scenario Overview

The flow scenarios proposed by ORC for consideration are as follows (measured at the Campground flow recorder):

- Scenario 1: 911 l/s (Status quo)
- Scenario 2: 1,500 l/s
- Scenario 3: 2,500 l/s
- Scenario 4: 4,950 l/s (Proxy for Naturalised Flow)

The flows encountered during the first site visit were monitored prior to the on-site inspections (on 24/2/2020) on the ORC flow website and flow graphs were obtained on 27/2/2020. Based on the information available, the following flows were encountered on site as recorded at the various recorder sites:

- Manuherekia downstream of Fork: around 1,300 l/s
- Manuherekia Falls Dam 1000m downstream: around 2,650 l/s
- Manuherekia at Ophir: around 2,800 l/s
- Manuherekia Chatto Creek upstream: around 800 l/s
- Manuherekia Campground: around 1,800 l/s

The flows encountered during the second site visit (20/11/2020) were also obtained from the ORC website and were as follows:

- Manuherekia downstream of Fork: around 1,860 l/s
- Manuherekia Falls Dam 1000m downstream: around 2,560 l/s
- Manuherekia at Ophir: around 4,650 l/s
- Manuherekia Chatto Creek upstream: around 3,640 l/s
- Manuherekia Campground: around 2,512 l/s

The intention was to undertake two additional site visits at a higher and a lower flow in order to be able to draw conclusions about the effect of those flows on the values outlined above. Due to timing in relation to seasonal flows it was, however, not possible to view lower flows on site (see the Methodology Section 2.2).

The flows encountered during the first site visit on 24/2/2020 were similar to Scenario 2 (1,500 l/s), with the flow during the second site visit on 20/11/2020 similar to Scenario 3 (2,500 l/s). In order to assess the other two flows (Scenarios 1 and 4), photos were provided by ORC showing the Manuherekia River at a variety of flows. The two main locations that were used for the visual comparison of flows based on these photos are at the Alexandra campground and downstream of the Forks. Photo sheets for direct flow comparison were prepared and are attached to this report (see photos 24-54 of graphic attachment).

The extent of wetted surface can be different at the same measured surface water flow, depending if a flow is following an extended low flow period or a flood flow. This is due to the wetted gravels still holding water following a receding fresh/ flood flow.

It is acknowledged that flow assessments based on photos have limitations, since the parameters that visually change are mainly related to the width and (to some extent) depth of the water. Other flow parameters, in particular the velocity of flow, are difficult to assess based on photographs. The assessment is also solely based on visual aspects, while the sounds and smell associate with the river also change significantly with a change in flow.

5.5 Flow Scenario 1 - 911 l/s (Status quo)

Several photos for very low flows below 1,000 l/s were reviewed with the following flows measured at Alexandra camping ground (flows of 690l/s, 922 l/s and 978 l/s- see photos 25-28 and 40-43).

5.5.1 Visual Amenity Considerations

At the campground site (looking upstream from Little Valley bridge) the riverbed is wide and shelving which means that a reduction in flow is particularly visible in terms of wetted surface.

The photos used for the flow comparison (see photos 25-28) illustrate that the main channel in a braided river section can change through flood events which means that the channel outlines within the riverbed change over time.

While the photos only allow for a visual comparison, the differences appear relatively small between flows of 684 to 922l/s. At the flows of 700-900 l/s the riverbed appears to be approximately half empty with wide exposed gravel riverbanks and a very shallow flow at the campground bridge. The exposed riverbanks at these low flows show signs of dried out algae, which often cause issues relating to odour and reduction of visual amenity.

The visual amenity of this area is relatively high and the river in this lower section is frequented by a range of recreational users. It appears unlikely that swimming would be possible at these low flows due to the low water level.

5.5.2 Natural Character Considerations

The wetted riverbed shown in the photographs at low flows between 687 and 1,261 l/s (photographs 40-45) appears to contain a dense cover of filamentous algae. If extended very low flows are present (mostly in summer and early autumn) without the occurrence of large rainfall events, the lower reaches can experience long timeframes without any flushes or floods. The absence of flows that are large enough to clear the riverbed of algae can lead to excessive growth of algae that can negatively impact on the ecosystem (see LWP Water Quality report, 2021).

The dried-out algae forms a white cover on the dry riverbed, increasing the perception of low natural character relating to the flow and quality of the river bed. Odours associated with dried out algae would likely reduce the natural character and amenity experienced along this reach in low flows.

Other natural processes that are affected by extended periods of low flows relate to the accumulation of fine sediment in the interstitial spaces between gravels. These natural character effects have implications for the invertebrates which form an important part of the food chain (see LWP, 2021).

The dark water in this section appears relatively slow-flowing and shallow, which can lead to warm water temperatures. The effects on fish and invertebrates relating to water temperature and quality are covered in the LWP Water Quality report (2021). The recommendations from the water quality report and the ORC Ecology report[8] in relation to the ecosystem health/ habitat availability are the key considerations in relation to the natural processes that occur at these very low flows within the river. It is understood that habitat availability increases substantially up to flows of 1,000 l/s with low habitat availability for a range of macroinvertebrates that provide an important food source below this.

5.6 Flow Scenario 2 - 1,500 l/s

The first site visit for this project was undertaken at a flow that was similar to this scenario (1,800 l/s). While no photo was provided at a flow of 1,500 l/s, several photos are included in the graphic attachment for flows between 1,000l/s and 2,000l/s (see photos 29-31 and photo 44-46).

5.6.1 Visual Amenity Considerations

From the photo comparison it appears that a change in extent of wetted surface for the lowest river reach (where campground recorder is located) occurs around the 2,000l/s mark. While the wetted surface around 1,500 l/s appears relatively similar to the status quo (922 l/s) the water depth increases steadily to this point.

During the first site visit the flow encountered in several areas appeared to be too low to maintain a high amenity within the river. For example, at the confluence of the Manuherekia River with Dunstan Creek (at SH85 crossing) a relatively low flow was encountered, in combination with extensive algal cover in the wetted bed and on dried out rocks along the bank (see photo 8).

Visually the river still appears as a relatively narrow active channel within a wide riverbed with exposed gravel banks, both at the Dunstan Creek confluence and the lower reaches. The active channel only extends to the vegetated banks in few locations, which has implications for its visual relationship to the margin. The relative size of active river channels to the exposed, dry gravels is generally used by viewers to assess the flow of a river and one of the factors that influences the visual amenity of the river[9].

The change to the water surface through rocks or gravel close to the surface is another flow indicator, as run sections can show riffles in low flows if the water depth becomes too low to fully cover the gravels. During the site visit at a flow of 1,800 l/s riffles were more commonly

[8] Otago Regional Council. (2021). Draft Ecology and Habitat Report - Five flow scenarios

[9] See Boffa Miskell Ltd, & NIWA. (2009). Riverscape and Flow Assessment Guidelines.

encountered in the shallower sections of the river, such as at the Dunstan Creek confluence, Galloway bridge and Shaky bridge, than at flows above 2,500 l/s.

5.6.2 Natural Character Considerations

Based on the site investigations at a flow of 1,800 l/s, it is likely that there are some sections, such as those below irrigation intakes (eg Blackstone and Galloway Intakes), where the flow would be noticeably lower than in other sections (eg below Dunstan Creek confluence). While a flow of 1,500 l/s at the Alexandra Campground may provide for an adequate natural character in some of the confined single-channel sections, it may not be sufficient where water is lost to ground and in braided sections, such as at the Dunstan confluence. In terms of ecosystem health and river flow connectivity required from a fish and invertebrate perspective, the findings outlined in the Ecology/ Habitat report have to be relied on for natural character effects as they relate to natural processes in the river. Habitat availability for macroinvertebrates continues to increase (as shown in Table 4 of the Ecology report) above 1,000 l/s. The report states that "*with the macroinvertebrates the taxa vary in their percentage of habitat retention but key fish food species, Deleatidium, the caddis flies Aoteapsyche, hydrobiosids and Pycnocentrodes and Maoridiaesa all benefit from higher flows. This will have benefits for fish as these provide food and an increase in food supply has the potential to improve fish populations and/or fish condition.*"

5.7 Flow Scenario 3 - 2,500 l/s

A photo was provided at a flow of 2,540 l/s and the second site visit was undertaken at a flow of 2,512 l/s(see photo 48). In addition, several photos were supplied for flows between 2,000l/s and 4,000l/s for comparison (see photos 32-37 and photo 47-52).

The flow of 2,512 l/s during the second site visit followed an extended period of high flows over winter and spring (around and above 10m^3/s). It is evident from the photos that - in comparison to those taken at a flow of 2,540 l/s taken during the summer months (20/01/2017) - the same flow can lead to a different extent of wetted surface, dependant if the gravels of the river bed still contain water from a previous high flow. The photos below illustrate this;

Flow 2,540 l/s at campground on 20/01/2017

Flow 2,512 l/s at campground on 20/11/2020

Given that minimum flows would mostly be applicable during the summer months and to ensure comparability of flows, the photograph taken during the summer months were included in the graphic attachment (see photos 33 and 48).

5.7.1 Visual Amenity Considerations

It is apparent from the photographic record that flows in the range of 2,500l/s to 3,000 l/s lead to a wetted surface that provides for a higher amenity associated with the river than flows between 1,000-1,500 l/s. The dry riverbanks and areas of dried out algae are more confined around 2,500 l/s and the water depth and colour provide a healthier appearance. The active channels start to occupy a more substantial part of the riverbed at flows of above 3,000 l/s in the braided sections (see photos 50-53 and 34-37) and uninterrupted run sections without visible riffles are more common.

While these flows may not provide for recreational uses, such as swimming or tubing, this flow range leads to river amenity that is more inviting for passive recreation in the vicinity of the waterway. It would be less likely that odours from dried out algae impact on the amenity due to smaller areas of exposed gravel banks.

5.7.2 Natural Character Considerations

While it is difficult to judge from flow photos, the appearance of the river in terms of the water colour and depth is improved in comparison to the lower flows assessed above. It is unlikely that sediment transport would take place at these flows, but they may be sufficient to maintain the river's health between flood flows. While filamentous algae may still grow at these flows the photos indicate a much lower coverage. However, this mostly depends on freshes and floods that would clear out the river bed.

The Water Quality and Ecology reports provide more detail about the habitat availability in relation to the riverbed morphology and the effects of sediment on the interstitial areas. Table 4 of the Ecology Report (p.27) shows that the habitat availability is higher for a wider range of species at a flow of 2,500 l/s than at 1,500 l/s.

5.8 Flow Scenario 4 Assessment - 4,000 l/s (Proxy for Naturalised Flow)

A photograph was provided for 4,946 l/s (see photos 38 and 54) and several photos were supplied for flush and flood flows above 10m^3/s. Photo 39 was included showing a flow of 11,474 l/s for comparative purposes to illustrate that this flow would fill the entire river bed within a section that is braided at low flows.

Based on a review of the ORC flow record these high flows generally occur during the winter and spring months between June and November. The median flow of 11.60 m^3/s maintains the width of the gravel riverbed between the vegetated margins.

5.8.1 Visual Amenity Considerations

While the connection between the active channels of the waterbody and the vegetated margins is (partially) lost at the lower flows assessed above, the riverbed would be largely occupied by flowing water under the assessed flow of 4,500-5,000 l/s. The amenity of the river at this flow is high with a flow that matches the extent of the riverbed and no large exposed gravel areas. The flow appears swifter and the water is deeper with few riffles visible. The bed does not seem to display algal cover and the water colour is of a clear and healthy appearance.

Due to the increased water depth the use of the river for recreational pursuits, such as swimming or tubing, would be possible, providing an overall high amenity for active and passive users.

5.8.2 Natural Character Considerations

It is obvious that the natural character of the river could be best maintained under a naturalised low flow, ie a flow that would occur without water abstraction. Under this scenario the natural processes would occur as they would in an unmodified river. However, while this flow would naturally only occur for very limited times of the year, abstraction under this minimum flow would lead to a 'flat-lining' at this naturalised flow.

5.9 Flow Scenario Conclusion

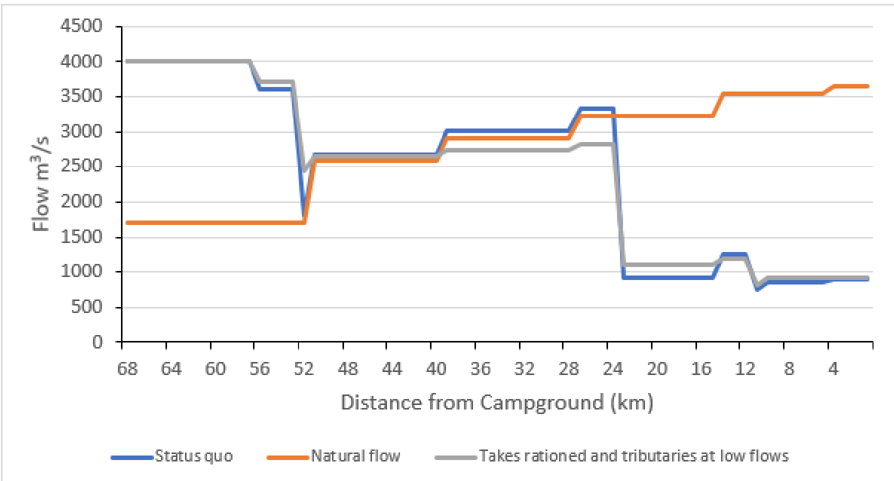
5.9.1 Visual Amenity Considerations

As outlined above, at a flow of around 1,500 l/s visually the river generally still appears as a relatively narrow active channel within a wide riverbed with exposed gravel banks. The active channel only extends to the vegetated banks in few locations, which has implications for the visual relationship of the waterbody to the margin. In the photographs the active channels start to occupy a more substantial part of the riverbed at flows of above 3,000 l/s in the braided sections. However, during the site visit on 20/11/2020 the river had a healthy appearance with high visual amenity throughout its course at a flow of 2,500l/s. Based on the flow photos taken during the summer months when low flows prevail, a flow of 2,500 l/s provides for a smaller wetted surface area than experienced during the second site visit following an extended period of high flows.

While a flow of around 3,000-3,500 l/s would achieve higher amenity outcomes, a flow as proposed under Scenario 3 (with 2,500 l/s) would lead to acceptable outcomes, if the minimum flows are confined to certain times of the year (ie when irrigation is required from November to April).

5.9.2 Natural Character Considerations

The ORC Ecology report provides findings in relation to habitat modelling, but it is unclear if the natural character effects are worse in particular river sections at flows around the status quo (922 l/s measured at campground). It is likely that in river sections where water is lost to ground, or immediately below abstraction takes, the flows would be lower than in the reach around the Alexandra campground where the flow is measured by a recorder. The Ecology report outlines (p.4): *"Combining the effects of water abstraction and tributary inflows leads shows that the flow in the Manuherekia River very strongly influenced by the Falls Dam water release and the downstream water abstraction. Under normal summer conditions flow decreases in a downstream direction. For the flow scenarios being assessed this longitudinal change in flow should be considered in conjunction with the flow and habitat provided at Campground."*



Refer to Figure 1 of Ecology Report: A longitudinal diagram of flow in the Manuherekia river under low flow conditions when mainstem abstraction is occurring.

Since the river functions as a system, the connectivity of the flow is an important factor. This means that it is important to maintain an appropriate minimum flow throughout all sections in order to ensure the health of the river ecosystem as a whole can be maintained. During the first site visit (at a flow of 1,800 l/s) the areas that displayed particularly low flows were below the Blackstone intake to the confluence with Dunstan Creek and below the Galloway Intake. In order to assess if experientially an appropriate level of natural character can be achieved at 2,500 l/s a second site visit was undertaken on 20/11/2020 at this flow. The river provided for a higher natural character at this flow than at 1,800 l/s, which would be appropriate from a perceptual perspective.

However, since the natural processes of the river ecosystem are the key consideration for natural character, the minimum flow requirements will need to be determined based on the findings from the Ecology report. The ORC Ecology Report[10] (2021) does not provide a definitive flow recommendation but outlines the following findings on the predicted habitat based on the modelling (p.15) for the Galloway Reach: "*The physical habitat parameters, water depth and river width increase rapidly from 0 m^3/s to 0.15 m^3/s. After the initial rise water depth increases only slowly as flow increases to 6 m^3/s and average river depth from a flow of 2 m^3/s to 6 m^3/s only increases from 30 cm to less than 40 cm over this flow increase. However, river width and water velocity increase more rapidly as flow increases and this leads to the riverine habitat subject to higher water velocities and organisms that prefer low water velocities will find the reach becomes less suitable. The rarity of pool habitat and the small increase in water depth also limits organisms that prefer deep water throughout the flow range." As outlined on p.19 of the report "Average river width and water depth increase very rapidly from 0 m^3/s to 0.5 m^3/s at the Omakau reach. Once the flow exceeds 0.5 m^3/s the rate of river width and water depth increase slows. Average water velocity has a steady rate of increase throughout the 0 m^3/s to 6 m^3/s indicate the increase in flow is being accommodated by the increase in water velocity rather than an increase in stream width or depth*." For the Blackstone Reach (p.22) *"the most notable pattern is that there is a gradual decline in channel width, depth and water velocity with declining flows down to 0.5 m3/s, below which width and velocity drop rapidly."* In Table 4 of the Ecology report (p 27) the predicted habitat available is outlined in comparison to the naturalised 7d MALF.

The Ecology Report (p 26) concludes that "*the percentage habitat retained when compared with the naturalised 7dMALF shows that all the fish species retain a high percentage of their habitat regardless of the flow scenario with the exception of the combined adult brown trout rainbow trout habitat. With the macroinvertebrates the taxa are vary in their percentage of habitat retention but key fish food species, Deleatidium, the caddis flies Aoteapsyche, hydrobiosids and Pycnocentrodes and Maoridiaesa all benefit from higher flows. This will have benefits for fish as these provide food and an increase in food supply has the potential to improve fish populations and/or fish condition. The key algal taxa, diatoms, are significantly reduced in the lower flow scenarios and even at the 3 m^3/s flow do not reach 80% habitat retention. As a key food source for macroinvertebrates this may represent a food web limitation for the lower Manuherekia River.*"

[10] Otago Regional Council. (2021). Draft Ecology and Habitat Report - Five flow scenarios

6.0 Conclusions

The Manuherekia River catchment is diverse and provides a wide range of natural character, landscape, visual amenity and historic/ heritage values described in this assessment for each river reach and tributary. While the natural values of the river and catchment generally decrease lower down in the catchment, the cultural values associated with the river are high throughout the catchment. The introduction of Falls Dam has modified the natural flow regime of the Mauherekia River in all but the top reaches through the attenuation of flood flows and the controlled release of flow throughout the year. The pressure on the water availability within the river and its tributaries from irrigation demands is clearly noticeable during the low flow months and flow recommendations will need to take into account the natural and cultural values of the waterways and weigh those up in relation to the economic value provided by the irrigation water for agriculture.

While the existing minimum flow of 900 l/s provides for low natural character and amenity values associated with the river channel, a flow of 1,500l/s – 2,500 l/s would improve these values as discussed in detail in the previous section of this report. In shallow riffle/ run sections and in sections below irrigation takes the effects of a low minimum flow set at the Alexandra Campground may be more noticeable (eg above Dunstan Creek confluence with large gravel banks covered in dried out algae). It is likely that ecological aspects, such as connectivity of the river system and habitat availability for particular species, such as macroinvertebrates that form part of the food source, are key considerations for the determination of an appropriate minimum flow to provide for an acceptable level of natural character.

Overall, the historic/heritage values are less likely to be sensitive to small changes in flow, while the natural character values, including those relating to the habitat requirements of particular species, are more likely to be a determining factor for flow recommendations. For these factors the findings in relation to the river's ecology need to be taken into account to determine appropriate flows that lead to acceptable environmental outcomes.

The wider landscape and visual amenity values of the river relate to the waterway, its margins as well as the wider context of the setting. The sensitivity of river users is likely dependent on their activity, familiarity with the river at different flows and their perception of naturalness. The river is an element perceived as part of its landscape context which means that the flow is often only one of a range of factors determining the overall amenity. Other modifications, such as man-made structures, land uses or exotic vegetation also influence a river's value; management of these aspects, including design of engineering works, setbacks of structures, fencing from grazing stock and native planting of the margins have the potential to adversely or positively influence the values of the river.

Water quantity is only one aspect that contributes to the landscape, natural character, visual amenity and historic /heritage values that are associated with the river and its tributaries. While the brief for this report had a focus on river flow in terms of assessment and recommendations, other aspects, such as water quality, management of the river margins and context are also key contributors to these values. There are a number of options for enhancement of these values that could include regulatory (including but not limited to recommendations for environmental flows/levels) and non-regulatory tools (such as incentives for riparian planting with native vegetation).

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