NZ TRANSPORT AGENCY
WAKA KOTAHI

Technical Report No 17

Christchurch Southern Motorway Stage 2 and Main South Road Four Laning

Aquatic Ecology Assessment

November 2012

Quality Assurance Statement			
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This Technical Report has been produced in support of the Assessment of Environmental Effects (AEE) for the Main South Road Four Laning and Christchurch Southern Motorway Stage 2 Project. It is one of 20 Technical Reports produced (listed below), which form Volume 3 of the lodgement document. Technical information contained in the AEE is drawn from these Technical Reports, and cross-references to the relevant reports are provided in the AEE where appropriate.

A Construction Environmental Management Plan (CEMP) has been prepared to provide the framework, methods and tools for avoiding, remedying or mitigating environmental effects of the construction phase of the Project. The CEMP is supported by Specialised Environmental Management Plans (SEMPs), which are attached as appendices to the CEMP. These SEMPs are listed against the relevant Technical Reports in the table below. This Technical Report is highlighted in grey in the table below. For a complete understanding of the project all Technical Reports need to be read in full along with the AEE itself; however where certain other Technical Reports are closely linked with this one they are shown in bold.

Schedule of Technical Reports for the AEE

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For further information on the structure of the lodgement documentation, refer to the 'Guide to the lodgement documentation' document issued with the AEE in Volume 1.

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Executive Summary

The Project is for the construction, operation and maintenance of the Christchurch Southern Motorway Stage 2 (CSM2), a four-lane median separated motorway. The Project also includes the widening, upgrading of Main South Road to provide a four-lane median separated expressway along this existing arterial route (MSRFL). Overall, these two components are known as The Project.

This report describes the existing environment, issues in relation to the aquatic ecosystem, the results of aquatic ecosystem investigations of the Project area, potential effects on the aquatic environment, including construction and operational effects and mitigation measures proposed to minimise any effects on aquatic ecosystems.

Existing Environment

The Project area contains no natural waterways or wetlands but does contain a number of manmade water races. The network of water races are used for stock water and irrigation and perform a land drainage function. As a result, they are an important local resource.

Field surveys carried out as part of this assessment indicated that the water races have poor overall riparian vegetation characteristics, with silt and fine sediment dominating the in-stream habitat. Pollutant tolerant species of aquatic macro-invertebrates are mostly found here, such as snails. Macrophytes are also present with pondweed (*Elodea Canadensis* and *Potamogeton ochreatus*) and watercress (*Nasturtium*) being the dominant observed species.

Three species of fish have been observed within the Project area; the native common and upland bullies (*Gobiomorphus cotidianus* and *Gobiomorphus breviceps*) and brown trout (*Salmo trutta*). Both common and upland bullies are found throughout New Zealand waterways.

The field surveys determined that there were no known species of conservation significance, no rare, regionally rare or threatened species in any of the water races traversed by the Project.

Context

The water races currently perform a land drainage function during heavy rainfall events. During or prior to such events, the upstream water race intakes are partially or completely closed / shut off, if necessary to increase the network capacity available to carry flood flows. In heavy rainfall events, runoff from the surrounding existing road network (including SH1) land drains to the race network.

The proposed alignment crosses nine existing water races and some of the races will become ineffective as a consequence of construction due to shortened lengths, isolation or alternative alignments being provided. These lengths are intended to be decommissioned as part of the proposed works and other sections of the race network will be piped beneath the motorway. This has the potential to impact on the aquatic ecosystems of the water race network.

Environmental Impacts

The effects of the Project on the aquatic ecosystems relate to both construction and operational activities and are primarily associated with the sections of water races that require piping and/or realignment. Potential effects include unforeseen discharges of water and contaminants into the race

network, sedimentation and erosion, habitat loss for aquatic ecosystems and impacts on fish passage. Although the proposed works may result in some loss of habitat in some areas, new areas of race will be created and proposed riparian landscaping for these areas will improve the habitat. In addition, the proposed stormwater system will improve the existing situation by reducing the amount of runoff that enters the race network and improving the quality via the proposed treatment. As a consequence, over time there may be an improvement in the water quality and habitat of the race network and downstream receiving environment.

Mitigation Measures

Mitigation measures are proposed to avoid or mitigate potential adverse effects discussed above. Such measures include the implementation of a Construction Environmental Management Plan, including sediment and erosion control measures, proposed landscaping along riparian margins of newly realigned sections of race, ensuring the provision of fish passage is maintained along the race network.

Summary

Overall, the environmental impact of the Project on the aquatic ecosystem will be minor or less than minor due to the proposed mitigation measures.

1. Introduction

The New Zealand Transport Agency (NZTA) is improving access to and from the south of Christchurch via State Highway 1 (SH1) to the Christchurch City centre and Lyttelton Port, by improving the capacity, safety and alignment of the Christchurch Southern Corridor.

This includes the proposal for the construction, operation and maintenance of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposal also includes the widening and upgrading of Main South Road (SH1) to provide for a four-lane median separated expressway along this existing arterial route (MSRFL). This is known as The Project.

This report has been prepared to describe the aquatic ecosystems of the Project area and wider downstream receiving environment and assess the impact that the Project has on that environment.

The scope of the aquatic ecology study includes an assessment of the waterways considered to be potentially affected by the Project (both during construction and operation), including those within the Project area and those forming part of the downstream receiving environment, outside the Project area.

The waterways within the Project area consist predominantly of man-made water races. Most of these form part of the Paparua Water Race Area (water races between Rolleston town up to and including Marshs Road) and are administered by Selwyn District Council (SDC). The races and drains in the Project area from north of Marshs Road to Halswell Junction Road (including Montgomery's Drain and the channel adjacent Springs Road and John Paterson Drive) are administered by the Christchurch City Council (CCC). The races and drains are shown on Figure 1. The area to the south-east (bottom right) of the dark blue dotted line on Figure 1 indicates the downstream environment.

1.1 Objectives

The objectives of this assessment are to:

- Describe the aquatic ecology (baseline) values of the potentially affected water races;
- Assess the effects of the Project on the integrity and functioning of those values, and;
- Provide recommendations as to appropriate remedial and mitigation measures.

1.2 Study area

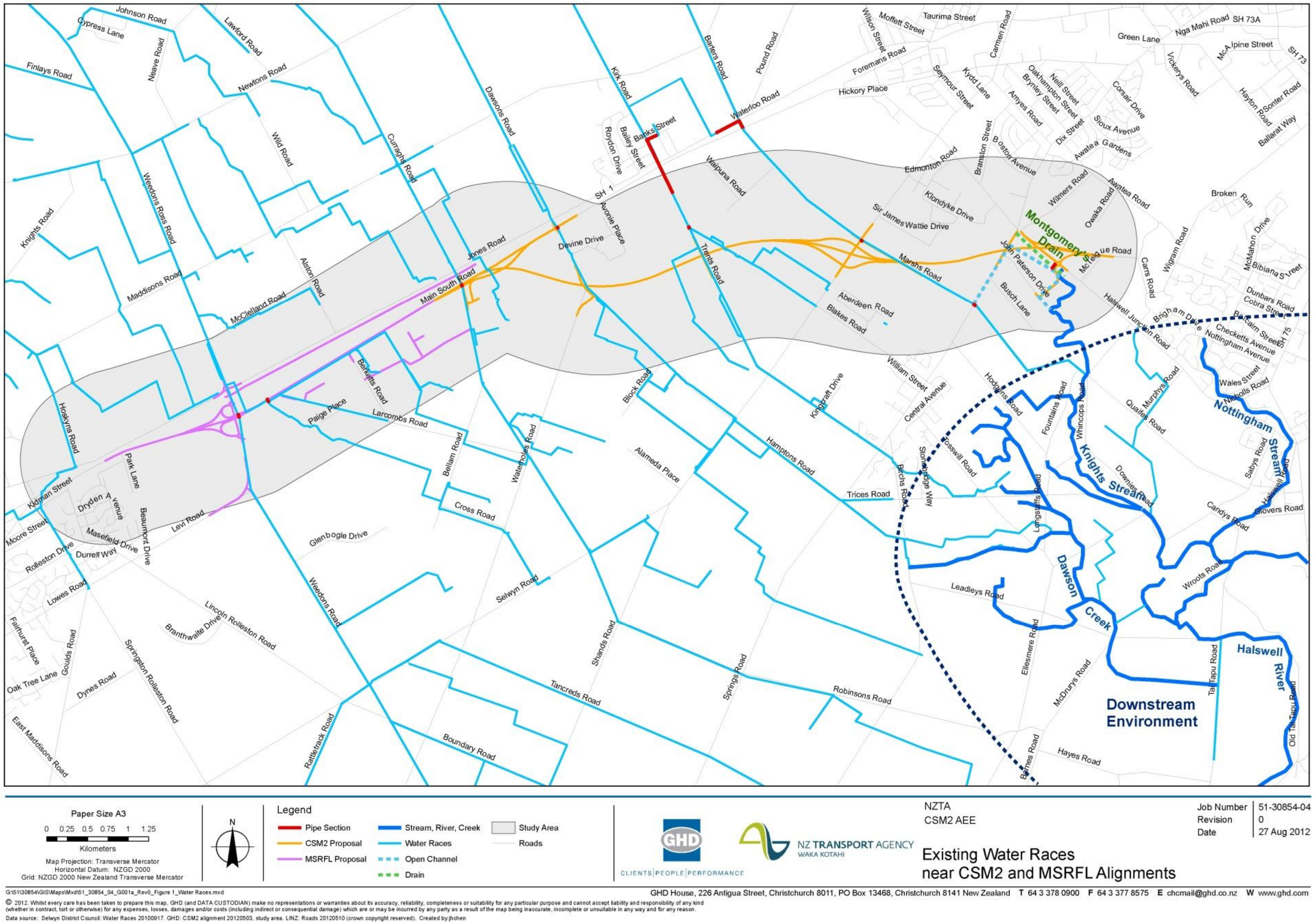
The study area is illustrated on Figure 1 and encompasses several water races and drains within the CSM2 and MSRFL alignments between Halswell Junction Road and Rolleston. The study area encompasses the designation area. Figure 1 also identifies the downstream receiving environment outside the alignment, including Upper Knights Stream and the Halswell River. It also shows some existing piped sections within the race network. It is noted that the water races are piped under the existing road infrastructure. A detailed description and location plan of the water races studied as part of the assessment is provided in section 6. A brief description of the downstream receiving environment is provided in Section 3.

1.3 Report structure

The report has been structured in the following manner:

- Section 1 provides a brief introduction, sets the assessment objectives, provides an overview plan of the study area and a brief report structure;
- Section 2 describes the proposal including local road connections and relevant statutory and planning context and includes a plan of the proposed alignment;
- Section 3 provides a description of the existing environment within the Project and wider area, including the downstream receiving environment;
- Section 4 provides some context of issues that may potentially affect the water races and receiving environment as a result of the Project;
- Section 5 describes the site survey methodology for the assessment;
- Section 6 provides the results of the field investigation, describing the aquatic ecology character of the affected area;
- Section 7 describes the risk assessment undertaken and effects of the Project on aquatic ecosystems;
- Section 8 discusses recommendations and proposed mitigation measures; and
- Section 9 forms the conclusion.

Figure 1 Study area, showing the existing water races and downstream receiving environment



2. Proposal Description

The NZ Transport Agency (NZTA) seeks to improve access for people and freight to and from the south of Christchurch via State highway 1 (SH1) to the Christchurch City centre and Lyttelton Port by constructing, operating and maintaining the Christchurch Southern Corridor. The Government has identified the Christchurch motorway projects, including the Christchurch Southern Corridor, as a road of national significance (RoNS).

The proposal forms part of the Christchurch Southern Corridor and is made up of two sections: Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (MSR), also referred to as SH1, to provide for a four-lane median separated expressway; and the construction of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposed construction, operation and maintenance of MSRFL and CSM2, together with ancillary local road improvements, are referred to hereafter as 'the Project'.

2.1 MSRFL

Main South Road will be increased in width to four lanes from its intersection with Park Lane north of Rolleston, for approximately 4.5 km to the connection with CSM2 at Robinsons Road. MSRFL will be an expressway consisting of two lanes in each direction, a median with barrier separating oncoming traffic, and sealed shoulders. An interchange at Weedons Road will provide full access on and off the expressway. MSFRL will connect with CSM2 via an interchange near Robinsons Road, and SH1 will continue on its current alignment towards Templeton.

Rear access for properties fronting the western side of MSRFL will be provided via a new road running parallel to the immediate east of the Main Trunk rail corridor from Weedons Ross Road to just north of Curraghs Road. For properties fronting the eastern side of MSRFL, rear access is to be provided via an extension of Berketts Drive and private rights of way.

The full length of MSRFL is located within the Selwyn District.

2.2 CSM2

CSM2 will extend from its link with SH1 / MSRFL at Robinsons Road for approximately 8.4 km to link with Christchurch Southern Motorway Stage 1(CSM1, currently under construction) at Halswell Junction Road. The road will be constructed to a motorway standard comprising four lanes, with two lanes in each direction, with a median and barrier to separate oncoming traffic and provide for safety.[1] Access to CSM2 will be limited to an interchange at Shands Road, and a half-interchange with eastward facing ramps at Halswell Junction Road. At four places along the motorway, underpasses (local road over the motorway) will be used to enable connectivity for local roads, and at Robinsons / Curraghs Roads, an overpass (local road under the motorway) will be provided. CSM2 will largely be constructed at grade,

[1] CSM2 will not become a motorway until the Governor-General declares it to be a motorway upon request from the NZTA under section 71 of the Government Roading Powers Act 1989 (GRPA). However, for the purposes of this report, the term "motorway" may be used to describe the CSM2 section of the Project.

with a number of underpasses where elevated structures provide for intersecting roads to pass above the proposed alignment.

CSM2 crosses the Selwyn District and Christchurch City Council boundary at Marshs Road, with approximately 6 km of the CSM2 section within the Selwyn District and the remaining 2.4 km within the Christchurch City limits.

2.3 Key Design Features

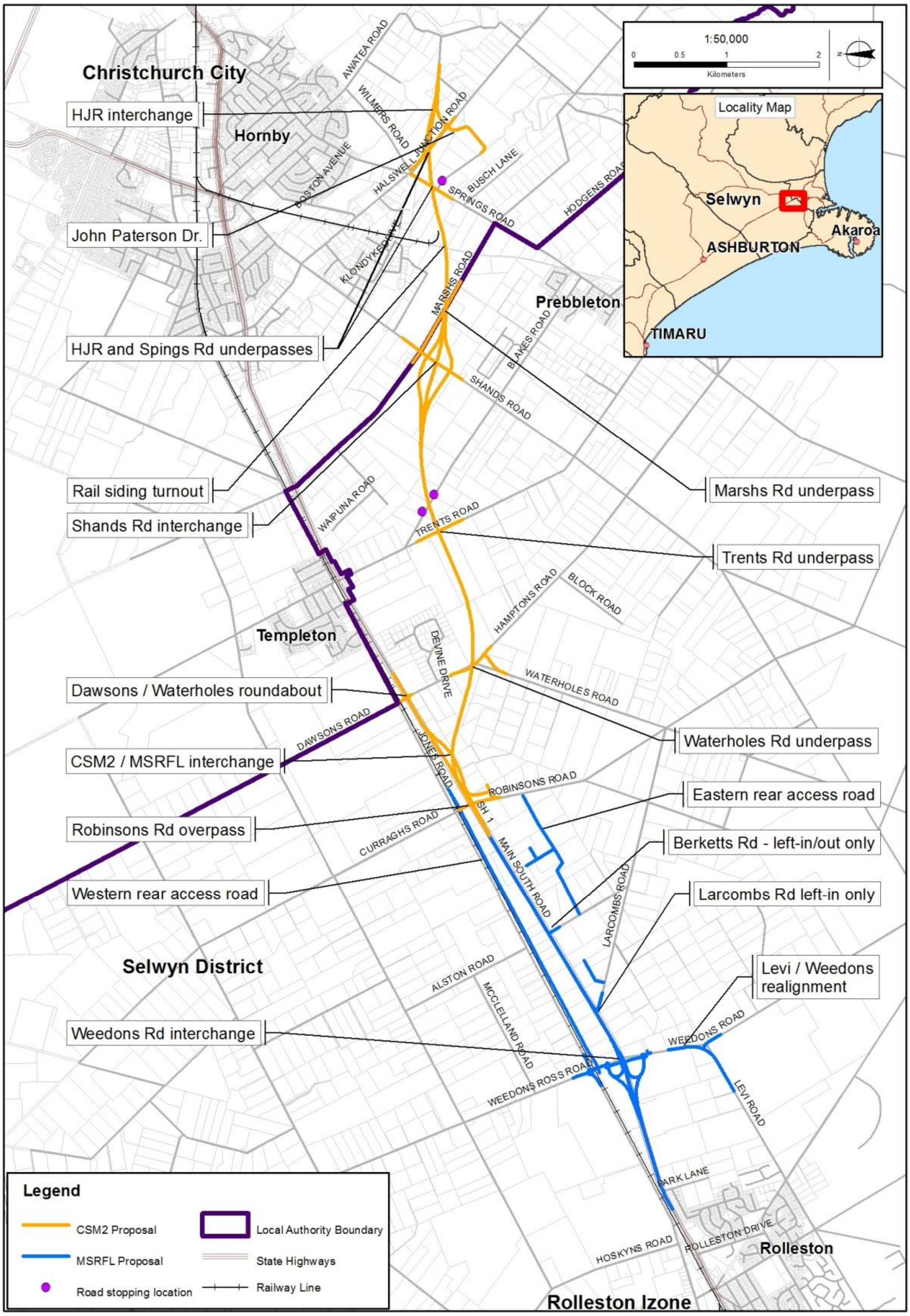
The key design features and changes to the existing road network (from south to north) proposed are:

- a new full grade separated partial cloverleaf interchange at Weedons Road;
- a new roundabout at Weedons Ross / Jones Road;
- a realignment and intersection upgrade at Weedons / Levi Road;
- a new local road running to the immediate east of the rail corridor, to the west of Main South Road, between Weedons Ross Road and Curraghs Road;
- alterations and partial closure of Larcombs Road intersection with Main South Road to left in only;
- alterations to Berketts Road intersection with Main South Road to left in and left out only;
- a new accessway running to the east of Main South Road, between Berketts Road and Robinsons Road;
- an overpass at Robinsons and Curraghs Roads (the local roads will link under the motorway);
- construction of a grade separated y-junction (interchange) with Main South Road near Robinsons Road;
- a link road connecting SH1 with Robinsons Road;
- a short new access road north of Curraghs Road, adjacent to the rail line;
- a new roundabout at SH1 / Dawsons Road / Waterholes Road;
- an underpass at Waterholes Road (the local road will pass over the motorway);
- an underpass at Trents Road (the local road will pass over the motorway);
- the closure of Blakes Road and conversion to two cul-de-sacs where it is severed by CSM2;
- a new full grade separated diamond interchange at Shands Road;
- an underpass at Marshs Road (the local road will pass over the motorway);

- providing a new walking and cycling path linking the Little River Rail Trail at Marshs Road to the shared use path being constructed as part of CSM1;
- an underpass at Springs Road (the local road will pass over the motorway);
- a new grade separated half interchange at Halswell Junction Road with east facing on and off ramps linking Halswell Junction Road to CSM1; and
- closure of John Paterson Drive at Springs Road and eastern extension of John Paterson Drive to connect with the CSM1 off-ramp via Halswell Junction Road roundabout (east of CSM2).

The proposed alignment is illustrated in Figure 2 and encompasses the MSRFL and CSM2 alignments between Rolleston and Halswell Junction Road.

Figure 2 Proposed Location Map



2.4 Strategic Planning Context

The following sections identify legislation relevant to aquatic ecology aspects of the Project. Consideration is given to the following legislation:

- Resource Management Act 1991
- Canterbury Natural Resources Regional Plan 2011
- Proposed Land and Water Plan 2012
- Canterbury Regional Policy Statement 1998
- Proposed Canterbury Regional Policy Statement 2011
- South-West Christchurch Area Plan
- Transit New Zealand Environmental Plan 2008
- National Policy Statement – Freshwater Management 2011
- Freshwater Fisheries Regulation 1983

2.4.1 Resource Management Act 1991 (RMA)

Purpose and Principles

Part 2 of the RMA is comprised of sections 5 to 8, and outlines the purpose and principles of the RMA. Section 5 states the purpose of the RMA is to promote the sustainable management of natural and physical resources where sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while:

> *a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and*
>
> *c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

Section 6 of the RMA contains 'matters of national importance' with which all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, *shall recognise and provide for* in achieving the purpose of the RMA.

The matters of relevance to the aquatic environment are:

> *a) 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; and*
>
> *c) The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna*

Section 7 of the RMA also states that *"all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to"* the following issues relevant to the proposed works associated with the construction of the motorway and the local aquatic environment:

a) Kaitiakitanga;

b) the efficient use and development of natural and physical resources

c) the maintenance and enhancement of amenity values;

d) intrinsic values of ecosystems; ..... and

f) maintenance and enhancement of the quality of the environment; .... and

h) the protection of the habitat of trout and salmon

Section 8 of the RMA states that all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi.

2.4.2 Canterbury Natural Resources Regional Plan 2011 (NRRP)

The NRRP contains objectives and policies relating to activities affecting fresh water bodies and the ones of particular relevance to this Project are identified below:

Chapter 4 – Water Quality

Issue WQL1 Surface water quality

Objective 1: *Water quality outcomes for rivers and lakes*

Policy WQL1: *Point source discharges that may enter surface water*

Policy WQl3: *Prevent the discharge of certain contaminants to surface water*

Policy WQL4: *Minor point source discharge to surface water*

Chapter 5 – Water Quantity

Objective WQN1: Surface water management

Chapter 6 - Beds of Lakes and Rivers

Chapter 6 of the NRRP is not considered to be relevant to the proposed water race closures and alterations, as section 2 of the RMA defines "river" as: *"river means a continually or intermittently flowing body of fresh water and includes a stream and modified watercourse but not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity generation and farm drainage canal)."*

This definition is also contained within section 6.2.2.3 of the NRRP. The fresh water bodies within the Project footprint are all artificial watercourses (water supply races) and as such do not meet the definition of "river".

2.4.3 Proposed Land and Water Regional Plan 2012 (PLWRP)

The Proposed Land and Water Regional Plan (PLWRP) was publically notified on 11 August 2012.

The PLWRP contains objectives and policies that identify the resource management outcomes or goals for land and water resources in Canterbury region, to achieve the purpose of the RMA. Details of these can be found within Chapter 30 of the Assessment of Environment Effects Report, contained within Volume 2.

2.4.4 Canterbury Regional Policy Statement 1998 (RPS)

The specific RPS objectives and policies relating to water bodies are found in the Water Chapter of the RPS and include:

Objective 3:

Enable present and future generations to gain cultural, social, recreational, economic, health and other benefits from the water quality in Canterbury's water bodies and coastal waters, while:

(a) Safeguarding the existing value of water bodies for efficiently providing sources of drinking water for people;

(b) Safeguarding the life-supporting capacity of the water.

Policy 9:

To manage point and non-point source discharge and set water quality conditions and standards and terms in plans, and conditions on resource consents, that achieve (a) to (h) of Objective 3. Adverse effects of discharges on existing water quality should be avoided, remedied or mitigated and, where appropriate, degraded water quality should be enhanced.

Policy 11

Promote land use practices which maintain, and where appropriate, enhance water quality.

2.4.5 Proposed Canterbury Regional Policy Statement 2011

Chapter 7 of the PRPS addresses adverse effects of activities on freshwater, the need for high quality fresh water for drinking and efficient use of water.

Objective 7.2.1 promotes the sustainable management of freshwater to safeguard its life-supporting capacity, to provide drinking water, to enable the exercise of customary uses and to preserve the mauri and natural character values of fresh water. Objective 7.2.3 sets further goals for how water will be sustainably managed in an integrated way to provide for these values, in particular and of relevance to this Project with respect to the effects of land uses on demand for water and on water quality.

Policy 7.3.5 seeks to avoid, remedy or mitigate adverse effects of land uses on the flow of water in surface water bodies or the recharge of groundwater while Policy 7.3.7 seeks to avoid, remedy or mitigate adverse effects of changes in land uses on the quality of fresh water.

It is considered that the Project will be consistent with the objectives and associated policies of Chapter 7 of the PRPS.

2.4.6 South-West Christchurch Area Plan (SWAP)

The CCC has proposed a vision for the development of a large area of land adjacent to the current South-Western limit of the city. The area includes from Halswell Junction Road and its surrounds (extending north almost to SH1 and to the South to the City administrative boundary) and includes the upper extent of the Halswell River Catchment (Montgomery's Drain and Upper Knights Stream). The South-West Area Plan (SWAP) (2009) highlights restoration and naturalisation of watercourses as the first goal to achieving the vision for the area.

There are numerous goals and objectives of the SWAP in relation to the water environment and ecology aspects[2]. These relate to improving water quality, restoring aquatic biodiversity and habitat restoration.

The Halswell River is classified as a "Class 1 Receiving Waterway"[3] and as such the recommended receiving environment objectives include[4]:

- Protect existing and otherwise enhance ecological values;
- Meet USEPA criteria for copper, zinc, and lead;
- Reduce nutrient levels;
- No ecological impacts from construction activities;
- Reduce existing flood levels;
- Protect springs that provide baseflow; and
- Protect and enhance existing baseflow conditions.

Knights Stream is classified as a "Class 2 Receiving Waterway" and as such the recommended receiving environment objectives include:

- Enhance ecological values;
- Meet USEPA criteria for copper, zinc, and lead where possible;
- Reduce nutrient levels;
- No ecological impacts from construction activities;
- Reduce existing flood levels;
- Protect springs that provide baseflow; and
- Protect existing baseflow conditions.

Montgomery's Drain is classified as a "Class 4 Network Waterway" and as such the recommended receiving environment objectives include ensuring Class 1 and 2 waterways downstream are not compromised.

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[2] Christchurch City Council. April 2009. South-West Christchurch Area Plan (Key Issues page 26).

[3] Waterways have been given classifications based on the current knowledge of the South-West Christchurch receiving environment via a series of workshops and meetings. Objectives have been set based on the classifications.

[4] Golders Associates (NZ) Limited on behalf of Christchurch City Council. May 2008. Integrated Catchment Management Plan for South-West Christchurch.

2.4.7 Transit New Zealand Environmental Plan 2008

This plan contains three Ecological Resources Objectives in Section 2.7:

E1. Promote biodiversity on the SH network.

E2. No net loss of native vegetation, wetlands, critical habitat or endangered species

E3 – Limit the spread of pest plants.

It is considered that these objectives can be met by the Project.

2.4.8 National Policy Statement – Freshwater Management 2011 (NPS)

The NPS (Freshwater Management) contains objectives and policies relating to water quality. Of particular relevance are the following objectives:

Objective A1

To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the use and development of land, and of discharges of contaminants.

Objective A2

The overall quality of fresh water within a region is maintained or improved while:

- *a) protecting the quality of outstanding freshwater bodies*
- *b) protecting the significant values of wetlands and*
- *c) improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated.*

It is considered that these objectives can be met by the Project.

2.4.9 Freshwater Fisheries Regulation 1983

Part 7: Use of electric fishing machines of the Freshwater Fisheries Regulation 1983 requires consideration. An electric fishing machine was used to identify the fish species present within the waterways of the Project area. As no freshwater fish species were intended to be taken (and were not taken) as a result of the proposed survey, it was not considered necessary to obtain an authority.

2.4.10 Summary

In carrying out this assessment of environmental effects in relation to aquatic ecology, consideration has been given to both positive and adverse effects of the Project in relation to the principles and outcomes sought and identified in the plans and policy documents discussed above. It is concluded that the relevant objectives and policies can be complied with and as will be discussed in detail in Section 7 of this report, the effects on the environment are minor or less than minor.

3. Description of the Existing Environment

The MSRFL extends for 4.5 km from the southern extent (adjacent to Park Lane) to the North-East where it joins with CSM2 approximately 400 m west of Robinsons Road. CSM2 is approximately 8.4 km long and extends from MSRFL east to the Halswell Junction Road / Springs Road intersection. This intersection is at the western extent of the CSM1 Project.

Refer to Figure 2 above for a location map of the Project area and alignment.

3.1 Landform and topography

The landscape along the proposed alignment is characterised by flat alluvial plains, and the overall setting is rural characterised by open space and dominated by pasture and shelterbelt vegetation. The plains are bordered by the Port Hills to the East and the Southern Alps further afield to the West. Land use in the surrounding area is predominantly rural and semi-rural, with a mixture of dairy farming, horticulture, cropping, lifestyle blocks and agricultural activities, with the exception of the eastern end of the alignment and the northern side of Main South Road, where some industrial land use exists. The landscape is organised around geometric patterns – roads, farm tracks, field patterns, shelter belts and woodlots, with these cultural elements contributing to a highly modified landscape. The built form consists mainly of scattered residential dwellings and associated buildings, horse training tracks and stables, and agricultural commercial buildings, often surrounded by well-established native and exotic plantings. There are also several townships in the wider surrounding area, including Prebbleton, Templeton and Rolleston.

3.2 Climate

The Project area has a dry, temperate climate typical of the wider Canterbury Plains, with mean daily maximum air temperatures of 22.5 °C in January and 11.3°C in July. The climate is broadly defined as oceanic. The summer climate is often moderated by a sea breeze from the Northeast. A notable feature of the weather is the north-westerly wind in summer; a hot föhn wind[5] that occasionally reaches storm force. In winter it is common for the temperature to fall below 0 °C at night. There are on average 70 days of ground frost per year, and snow fall occurs about once or twice every two years on the wider plains area.

3.3 Hydrology

3.3.1 Natural watercourses

The majority of the catchment subject to the proposed CSM2 and MSRFL alignment does not directly contribute to any natural watercourse (stream). Rather, surface water typically ponds in local depressions and then soaks away to ground. In larger events overland flows are likely to occur along old (filled in) river channels. The overland flow paths are often intercepted by field drains, irrigation channels and the stockwater race network.

[5] A dry down-slope wind that occurs in the lee (downwind side) of a mountain range.

The most northern section of CSM2 is part of the Halswell River Catchment. This area drains to the Halswell River via Montgomery's Drain and Upper Knights Stream. As such, the Halswell River and Upper Knights Stream are considered to form part of the downstream receiving environment of the Project area.

Halswell River

The Integrated Catchment Management Plan[6] states that the riparian vegetation within the Halswell River catchment has been reduced and highly modified and overall is of poor quality. Flow in the Halswell River is derived from springs sourced within Knights Stream and Marshs Road Drain. From the confluence with Knights Stream, the channel is quite uniform (about 5 – 6 m wide) and choked with aquatic macrophytes[7].

In a survey carried out by EOS Ecology et al.[8], results showed that over 80% of the invertebrate abundance in the Halswell catchment was represented by three pollutant tolerant species, however average taxa richness was recorded. In addition, freshwater crayfish have been caught in the middle reaches of the river[9].

Fish species diversity was found to decline significantly with distance upstream from Lake Ellesmere. Short and long-fin eels, upland bully and inanga were recorded, with the eels, upland bully and brown trout recorded in the upper reaches and the eels, common bully, inanga and brown trout recorded in the lower reaches.[10]

Knights Stream

Knights Stream headwaters are situated to the south of Halswell Junction Road, just downstream of Springs Road. The following extract is taken from the CSM1 Assessment of Environmental Effects by EOS Ecology[11]:

> *"At this point the river is a residual channel that is permanently dry, and in parts appears that it has been in-filled and regraded by farming. Periodic flow does not occur until approximately 2.3 km downstream of Halswell Junction Road (at Marshs Road), where flow is supplemented by McCarthy's Drain. However, permanent flow (sourced from springs) does not occur for a further 450 m."*

The upper reaches of Knights Stream were identified as low value for both fish and invertebrates. The waterway has been modified and the removal of riparian vegetation has reduced bank stability, causing bank erosion and sediment inputs into the waterway[12].

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[6] Golders Associates (NZ) Limited on behalf of Christchurch City Council. May 2008. Integrated Catchment Management Plan for South-West Christchurch.

[7] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[8] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[9] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[10] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[11] EOS Ecology. January 2008. Assessment of Environmental Effects: Christchurch Southern Motorway: Aquatic Ecology.

In a survey carried out by EOS Ecology et al.[13], pollutant tolerant macro-invertebrate taxa (e.g. snails) tended to dominate with more sensitive species such as mayflies, caddisflies and stoneflies only recorded in very low numbers. Upland bullies were recorded as being present in the stream. The stream in its upper reaches has large amounts of aquatic macrophytes, mainly *Elodea*, with some watercress at the margins. In the downstream reaches, the *Elodea* is covered in long strands of filamentous algae and at the confluence with the Halswell River, emergent watercress dominates.

Based on the River Environment Classification (REC) classes[14], Upper Knights Stream is classified as having urban land cover and the following parameters: Climate: cool-dry; Geology: alluvium; Valley-landform: low-gradient; Source of flow: low-elevation.

3.3.2 Water Races

The network of water races within the majority of the Project area are operated by SDC, with some discharging to urban watercourses in Prebbleton approximately 3 km south east of the proposed alignment where they have been landscaped and form an important aesthetic function for the residents of the town. The races and drains to the north of Marshs Road are operated by the CCC. The larger races discharge to streams in the Upper Halswell River Catchment while the smaller races drain to soak pits. The water races are used for stock water and irrigation and are an important local resource for this purpose.

The proposed route crosses nine existing water races (seven along CSM2 and two along MSRFL - noting that a water race runs parallel to MSRFL on the South Eastern side within the road reserve for approximately 2100 m which currently collects road run off).

In response to large rainfall events, SDC typically closes the inlet to the water race network to increase the network capacity available to carry flood flows. This helps to reduce flooding of the race network and highlights the land drainage function of the network.

3.3.3 Stormwater systems

The Project area features few dedicated stormwater systems, with the exception of isolated soak pits along Main South Road. The water race network within the Project area is considered a part of the existing storm water system, particularly in winter months as it assists with land drainage. Further details can be found in the Assessment of Stormwater Disposal and Water Quality (Technical Report No. 3).

3.3.4 Groundwater

Well log records from Environment Canterbury (ECan) show the water table is between 3 m and 5 m in the CSM2 portion of the Project closest to Christchurch, falling deeper towards Rolleston to a depth of between 12 m to 20 m. Further details can be found in Technical Report No. 3 and the Geotechnical Engineering and Geo-hazards Assessment (Technical Report No. 11).

[12] Golders Associates (NZ) Limited on behalf of Christchurch City Council. May 2008. Integrated Catchment Management Plan for South-West Christchurch.

[13] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[14] The NZ River Environment Classification system (REC) groups rivers into classes at a variety of levels of detail and scales. Rivers with the same class are expected to have similar physical environments and ecosystems, similar environmental and economic values and similar responses to human disturbance despite the possibility that they are geographically separated.

3.4 Ecology

3.4.1 Terrestrial ecology

Details of the terrestrial ecology of the Project area can be found in the Terrestrial Ecology Assessment (Technical Report No. 18).

3.4.2 Aquatic ecology

There are no natural water courses or sites of aquatic ecological significance noted within the Project area. As previously explained, there is a network of water races with several running adjacent to the existing roads that intersect with the CSM2 alignment, and along parts of SH1.

The water races have poor overall riparian vegetation characteristics, with silt and fine sediment dominating the in-stream habitat. Pollutant tolerant species of macro-invertebrates are mostly found here, such as snails. Macrophytes are also present with pondweed (*Elodea Canadensis* and *Potamogeton ochreatus*) and watercress (*Nasturtium*) being the dominant observed species in the races. The slow flow at all sites is also a likely contributor to the growth of macrophytes.

Three species of fish have been observed within the Project area; the native common and upland bullies (*Gobiomorphus cotidianus* and *Gobiomorphus breviceps*) and brown trout (*Salmo trutta*). Both common and upland bullies are found throughout New Zealand waterways. Upland bullies (along with shortfin eels) were found to be the most common and abundant species in a survey of the waterways associated with CSM1[15] and within the SWAP ecology study[16]. In addition, the waterways, wetland and drainage guide[17] developed by CCC, identifies these species as being common in Christchurch waterways.

[15] EOS Ecology, 2008, Assessment of Environmental Effects: Christchurch Southern Motorway: Aquatic Ecology

[16] EOS Ecology et al., 2005, Appendix 4: Aquatic Values and Management. South-west Christchurch Integrated Catchment Management Plan. Technical Series. Report Number 3.

17 Christchurch City Council. 2003. Waterways, Wetlands and Drainage Guide, Part B – Design.

4. Context/Issues

This section provides a brief overview of the nature of the potential effects to the water race network including changes to the water race network and discharge of contaminants to the receiving environment.

As already noted the only surface water features within the proposed alignment area and designation boundaries are water races (used for stock water, irrigation and land drainage) and drains. Some of the affected race and drain systems (e.g. Montgomery's Drain along Halswell Junction Road) flow into streams downstream of the alignment area, such as the Halswell River via Upper Knights Stream.

The existing State Highway and local road network in the vicinity of the Project provides little in the way of stormwater quality treatment. Untreated runoff can easily enter the environment via the water race network. The stormwater design philosophy (refer to Technical Report No.3) includes separation of runoff from the Project, from the surrounding environment, via treatment as it flows through the grass verge and along the treatment swale, prior to soakage to land. It is not proposed to discharge stormwater into the water races or drains.

The exception being the discharge of treated stormwater from the Maize Maze Pond and Ramp Pond into Montgomery's Drain which will occur in a 1 in 100 year 24 hour rainfall event. Given that this discharge would be infrequent and involve treated stormwater, it is not anticipated that there would be an impact on water quality (refer to Technical Report No. 3).

In addition, there is a requirement to mitigate for the effects of high groundwater in combination with the effects of the Central Plains Water (CPW) proposal. As such, at some time in the future (post construction of both this proposal and CPW) there may be an artificial lowering of the groundwater beneath the ponds. A system of interconnected extraction wells and/or in combination with a pipe drainage network beneath the ponds will act to artificially limit ground water level rise. The outlet of this system is proposed to continue along the realigned portion of John Paterson Drive then deviate southeast and discharge to the Upper Knights Stream. This discharge will be infrequent and will be of clean groundwater and as stated may not commence for some time.

During construction of the Project swales and pits, measures will be in place to ensure that any sediment or contaminants resulting from the works are directed away from water races. In addition, during construction of the Project, temporary stormwater systems (typically designed for a 1 in 10 year rainfall event) will be in place to collect stormwater runoff from the Project area with permanent structures in place for the operation of the Project.

During both construction and operation, land drainage will continue to enter the races from the same contributing areas as existed prior to the Project. In addition, during exceedingly large or large and long rainfall events (typically 1 in 100 year 24 hour event), at Weedons Ross Road there is potential for treated water to spill out of the system to the existing overland flow path downstream of the alignment. There are two emergency spill points proposed to the stockwater race system. These will be from the inside of the clover leaf interchange where extended soakage systems are proposed.

Any de-watering water (clean groundwater) that is encountered during construction or operation will be discharged to land or into Montgomery's Drain. Measures will be in place as part of the CEMP and Erosion and Sediment Control Plan to ensure that the drain banks and bed are not eroded or result in any sedimentation into the drain as a result of this activity.

Refer to Figure 1 which shows the existing location of the water races (Section 1 of this report). Further details of the proposed changes to these races are contained in the following sections and can be seen in Figure 4 below.

Some of the races will become ineffective as a consequence of construction due to shortened lengths, isolation or alternative alignments being provided. These lengths are intended to be decommissioned as part of the proposed works and others will be piped beneath the motorway. SDC has confirmed[18] that several of the water races could be permanently closed with landowner agreement or if NZTA purchased the properties as part of the Project, otherwise they will be siphoned, closed or realigned.

The sections below provide a brief overview of the proposed works to the water race network. This should be read in conjunction with Technical Report No. 3 and Drawing No's: 62236-A-C401 to 62236-A-C406 and 62236-B-C401 to 62236-B-C417 (contained within Volume 5 of the application). Exact details and dimensions of changes to water races are still being determined and may also alter during the detailed design phase from those outlined below.

4.1 MSRFL

4.1.1 Southern extent of works to Weedons Ross Road

North of Jones Road, there are two races in this area, one on either side of Weedons Ross Road. The east stock water race is proposed to be realigned and piped (a distance of approximately 250 m) from immediately north of the Jones Road intersection, below Jones Road and the railway, to the Digga-Link property entrance culvert. This race is currently piped under Jones Road and the railway for a distance of about 120 m. The existing race on the west side of the road will be realigned. (Refer to Drawing No: 62236-A-C403, contained within Volume 5 of the application.)

4.1.2 Weedons Ross Road to CSM2

Subject to agreement with the property owner, it is proposed to terminate the Weedons Ross Road water race that flows through the Digga-Link site at a new soak pit. (Refer to Drawing No: 62236-A-C403, contained within Volume 5 of the application.)

Along SH1, approximately 2 km of the existing water race system will be piped from about 50 m north of Weedons Road to about 450 m north of Berketts Road along the south side of SH1.

The existing road contributes runoff to the existing Weedons Road water race leading to potential flooding downstream. It is proposed that this race will be piped for approximately 50 m under the new MSRFL. It is currently piped under the existing SH1, for a distance of approximately 20 - 25 m. A 130 m section of the race between SH1 and the proposed rear access road will be realigned slightly retaining its open race structure. (Refer to Drawing No: 62236-A-C403, Volume 5.)

In addition as outlined above, two soakage basins will be located within the middle of the clover leaf at Weedons Road. There will be a piped discharge into each soakage basin from Weedons Road to take embankment runoff. However in the very unlikely event that the soakage becomes full these pipes

[18] Email from Vicki Rollinson, SDC Water Race and Land Drainage Coordinator to Tom Parsons, GHD, dated 13-09-2010.

could act in reverse and discharge or spill to the Weedons Road water race. Any discharge will be infrequent and be of treated stormwater.

4.2 CSM2

4.2.1 MSRFL/CSM2 to Blakes Road

The existing water race on the west side of Robinsons Road will be passed below SH1 and piped for a length of approximately 380 m and continue flowing south on the other side. The existing race running along Robinsons Road in this section will be in-filled (about 120 m to the north-east of SH1 and 120 m to the south-east of SH1). Minor realignment will be required to bypass the embankments required for the intersection renewal. The land drainage and stock water function of the race will be maintained. The existing water race at the intersection to be formed between SH1 and CSM2 will also be passed below the proposed road alignments. (Refer to Drawing No: 62236-B-C401, Volume 5.)

Approximately 350 m to the east of Robinsons Road, in a paddock to the south of SH1, approximately 125 m of the existing water race system will be in-filled and a new 200 m piped section installed to travel under CSM2. Approximately 25 m of this section is currently piped under SH1. (Refer to Drawing No: 62236-B-C402, Volume 5.)

Approximately 140 m of the existing water race running adjacent to Waterholes Road will be piped under SH1. Approximately 25 m of this section is currently piped under SH1. (Refer to Drawing No: 62236-B-C403, Volume 5.)

Approximately 140 m of the existing water race at the proposed Waterholes Road underpass will be passed below the proposed CSM2 road alignment and about 150 m realigned to suit the extents of the proposed embankments for the underpass. The land drainage and stock water function of the race will be maintained. (Refer to Drawing No: 62236-B-C404 and 62236-B-C405, Volume 5.)

Trents Road will cross CSM2 by means of an underpass and modifications to the Trents Road water race will be required as part of these works. The water race will pass below CSM2 (approximately 100 m piped section) and continue along the new alignment for a length of approximately 170 m upstream of CSM2 and 150 m downstream to the proposed embankment end. This will allow the race to recommence its original alignment. (Refer to Drawing No: 62236-B-C406 and 62236-B-C407, Volume 5).

On the south corner of the intersection of the proposed CSM2 and Trents Road, a branch departs the main water race and heads west before turning south. This branch connection point will be removed as part of the underpass works and it is proposed that this branch be infilled subject to landowner agreement. A new 350 m open race branch will connect up the existing and newly aligned sections of water race. (Refer to Drawing No: 62236-B-C406, Volume 5.)

On the north side of Trents Road a new section of water race approximately 300 m long will connect the Trents Road race with that running along Blakes Road. The Blakes Road race will be piped beneath the CSM2 motorway for a distance of approximately 100 m. (Refer to Drawing No: 62236-B-C407, Volume 5.)

4.2.2 Blakes Road to before Springs Road

Modifications to the water race network will be required as part of the works. An existing water race flows down the north side of Marshs Road. It is proposed to divert this water race to the south side of Marshs Road at the intersection with Shands Road (for a piped length of approximately 60 m). The water race will then pass below CSM2 (for a piped length of approximately 100 m) on the south side of the underpass, and at the southern extent of the underpass embankment, pass back over to the north side of Marshs Road to connect into the existing race alignment, where it will continue to flow south. The existing race on the north side will be infilled (a distance of approximately 760 m) and the new race alignment (a distance of approximately 660 m) will be on the south side of Marshs Road. The land drainage and stock water function of the water race network will be maintained. (Refer to Drawing No: 62236-B-C409 and 62236-B-C410, Volume 5.) The realigned water race inside the Marshs Road intersection will be protected against overland flow.

4.2.3 Before Springs Road to CSM1

The existing open channel running along Springs Road that heads south-east into a paddock between John Paterson Drive and Halswell Junction Road, connecting with Montgomery's Drain and eventually Upper Knights Stream will be in-filled for a distance of approximately 485 m. A new realigned section, approximately 410 m long, will be created which will join up with the existing channel in the same paddock. The race will be piped under Springs Road as it currently is for a distance of approximately 50 m. (Refer to Drawing No: 62236-B-C412 and 62236-B-C414, Volume 5.)

The SWAP includes a stormwater treatment pond on the east side of the proposed CSM1 alignment known as the Owaka Basin. Construction of the Owaka Basin is underway on behalf of CCC as part of the CSM1 scope. This treatment facility has been designed to capture overflows from the Halswell Junction Quarry pond (via Montgomery's Drain) and provide additional stormwater treatment. Once the capacity is exceeded, the system will overflow south under Halswell Junction Road into Montgomery's Drain and Upper Knights Stream (design is for a 50 year ARI design storm event).

Montgomery's Drain collects flows from the existing Halswell Junction roundabout stormwater retention basin and eventually discharges into the Halswell River. Realignment of Montgomery's Drain will be required. (Refer to Drawing No: 62236-B-C412, Volume 5.)

The CSM2 motorway will cross the existing Montgomery's Drain. As such the drain will require piping beneath the CSM2 motorway via a siphon. The drain will also be diverted to the CCC proposed Owaka Basin at a higher level beneath Halswell Junction Road. This will be undertaken to maintain the function of the SWAP proposals. (Refer to Drawing No: 62236-B-C414, Volume 5.)

As part of the CSM2 Project, the stormwater treatment system is proposed to spill into Montgomery's Drain in events exceeding the 100 year ARI design storm event. These flows will eventually reach the Halswell River but adoption of the high design standard will mitigate any flooding effects.

In order to mitigate for the potential of high groundwater in conjunction with heavy rainfall and associated runoff when the Maize Maze and Ramp Ponds will fill (as designed), a programme of controlled emptying is to be employed. This system includes controlled discharges to the Upper Knights Stream, outside and downstream (approximately 500 m) of the Project area (refer to Drawing No. 62236-B-SK4010, Volume 5)

4.3 Other Matters

The flow in all the water races can be controlled by a series of upstream flood gates in high rainfall events. This enables the races to perform one of their functions of carrying flood flows. The races are sourced from the Waimakariri River and there are fish screens at the control gates at the Waimakariri River end of the race network.

Water race management carried out on the main races (Weedons Road, Robinsons Road and Trents Road) is undertaken by SDC and/or its contractors. Works in the lateral and local races (Waterholes/Hamptons Road, Blakes Road and Marshs Road) is managed by the land owner/s. Works include managing bank vegetation to ensure it is tidy and does not obstruct water flow. The water race banks are generally sprayed or weed-eaten as required (up to twice per year). Race cleaning is also carried out and involves removing silt/spoil that has settled on the race bottom. During this routine cleaning, a digger removes weed and silt from the races and this is either left on the bank or trucked away. The flow in each race determines how quickly they silt up and thus how often they require cleaning.[19]

Cleaning is done with the races flowing, and the contractor is responsible for ensuring that any fish inadvertently removed are returned to the race. Water race shutoffs are timed around demand, except in the case of an emergency. Shutoffs longer than 24 hours must be publicly notified 14 days prior to the event. ECan and Fish & Game are always notified separately in regard to a shutoff longer than 24 hours. The shutoff time is largely determined by the work being carried out, ideally three days maximum.[20]

In addition to the alterations to the race network outlined in sections 4.1 and 4.2 above, the following areas adjacent to the Project area have been identified, as they provide some context of the existing race network and the assessment of potential effects in later sections of this report.

At the intersection of Trents and Blakes Road (about 400 m upstream of the CSM2 alignment), a physical barrier to fish migration is present, in the form of a weir (refer to Figure 3 below). The weir is elevated by 0.55 m above the bed level and 0.25 m above the water level on the day surveyed, probably restricting fish access upstream in times of low flow. In addition to this weir structure, the Trents Road race is currently piped for a distance of approximately 870 m at the intersection with SH1.

[19] Vicki Rollinson, SDC Water Race and Land Drainage Coordinator, pers comm

[20] Vicki Rollinson, SDC Water Race and Land Drainage Coordinator, email dated 25 July 2012.

Figure 3 Weir at the intersection of Trents Road and Blakes Road

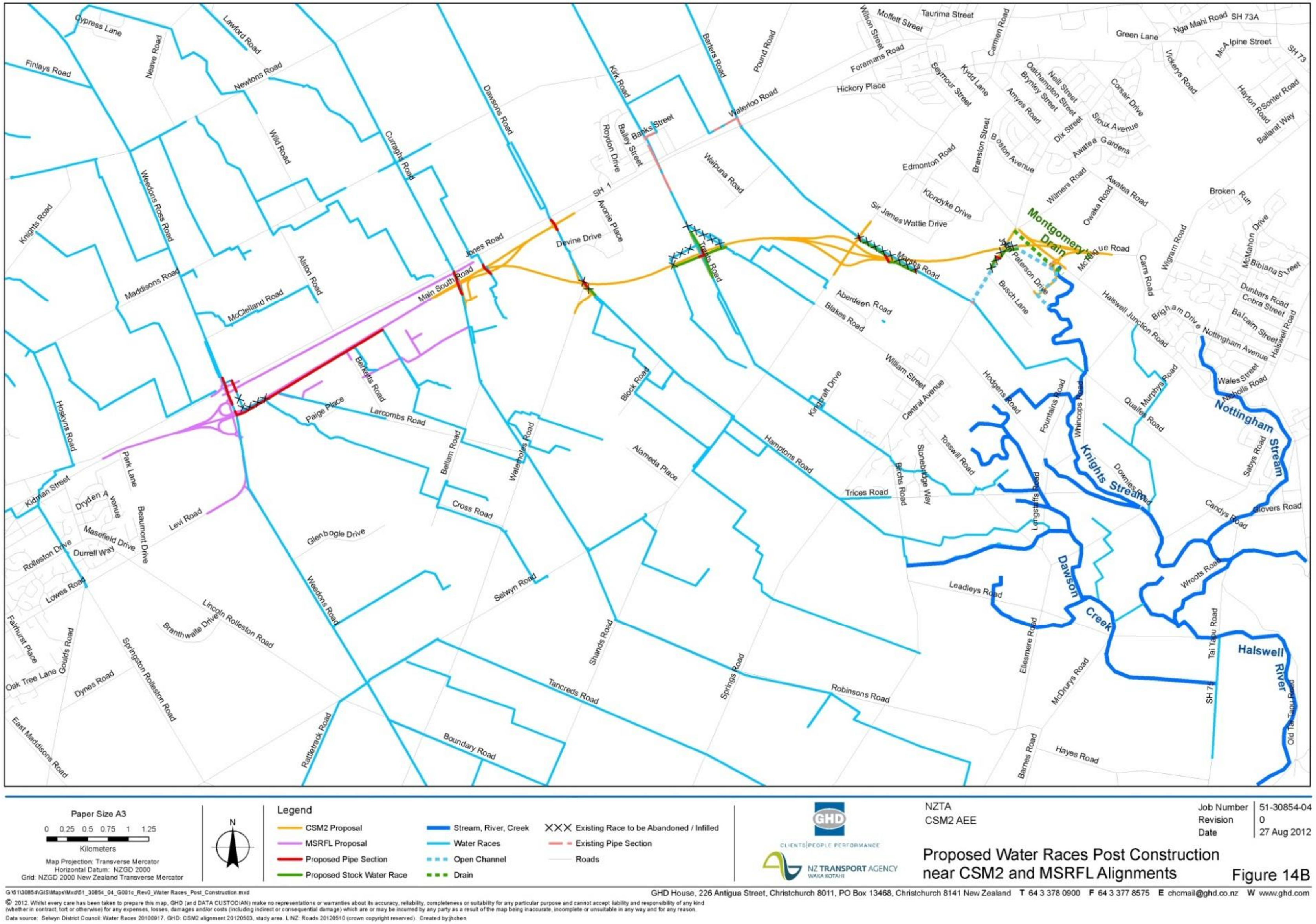
The Marshs Road race is also piped for a distance of approximately 420 m at the intersection with SH1 (outside of the proposal area) thus forming a potential barrier to fish migration. Both the Trents Road and Marshs Road existing piped sections are much longer than those proposed for the crossings under CSM2 (approximately 80 m and 60 m, respectively).

It is noted that all the water races are currently piped at numerous locations along the race network, including under the roads and driveways that they traverse. These pipes are typically approximately 350 mm diameter pipes.

4.4 Summary

The potential impacts of the Project include those related to the construction and operation of the motorway and the matters discussed in the above sections provide context for these impacts. A detailed discussion of potential and actual effects can be found in section 7 of this report.

Figure 4 Plan showing proposed water race alignments



5. Site Survey Methodology

5.1 Approach

A range of survey methodologies have been used including various national protocols (e.g. Harding et al. 2009[21] and Stark et al. 2001[22]) and methodologies used within the region by ECan. The following section is an overview of the sampling strategy, the sites and areas sampled, and methodologies employed for collection of the data. More detailed aspects of the methodologies are discussed in subsequent subsections of this report.

Sampling of stream reaches was carried out on the 5th and 6th July, 2011. Sampling was carried out following a period of no significant rainfall within two weeks preceding sampling (i.e. no increase in waterway flow).

Several sets of data were collected to describe the aquatic habitats and their assemblages to allow the importance of data to be assessed. These were:

- Physical habitat data (i.e. substrate type, riparian condition etc);
- Water quality; and
- Flora and fauna (primarily aquatic macro-invertebrates, fish and aquatic macrophytes data).

Sampling and analysis methods were chosen that would:

- Describe the existing aquatic physical habitat (including water parameters);
- Describe the existing fish communities;
- Describe the existing aquatic macro-invertebrate communities;
- Describe the existing aquatic flora present;
- Identify any rare or threatened species within the waterways; and
- Enable identification of potential and actual effects and mitigation to be proposed.

Initial site walkovers were carried out in July and October 2010 to identify environmental constraints for the Project. During these site visits it was concluded that the physical habitat types within the Project area were very similar being modified water races of a typical width, depth and flow, limited riparian environment and similar substrate type. These walkovers identified that several of the water features contained no flow.

In addition to the initial site walkovers, the following components were completed to gain an understanding of the existing environment and identify potential ecological risks associated with the construction of the Project:

[21] Harding et al., 2009. Stream habitat assessment protocols for wadeable rivers and streams of New Zealand.

[22] Stark, J.D. et al., 2001. Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment.

- desk top review including database and record searches to identify areas of aquatic ecological value (eg, significant waterways, fish and other fauna species) within the Project area; and
- the NIWA Freshwater Fisheries Database (FFDB) was searched to determine the known presence of fish species in the Project area. This would provide a picture of the likely species that may be found whilst electro-fishing.

The above searches found that very limited information was available on the aquatic ecosystems of the water race network within the Project area.

Sampling effort was focussed on the five main water race systems that were likely to be affected to the greatest extent by the Project.

5.2 Scoping of sampling locations

Five main water races were selected to be sampled (these are referred to as Sites 1 to 5). This was based on the initial site walkover and discussions with Tom Parsons (GHD Stormwater Design Engineer for the Project – refer Technical Report No. 3) and Vicki Rollinson (SDC Water Race and Land Drainage Coordinator) about the drainage features of the Project, such as siphoning, piping, realigning or culverting of the existing water races. These main water races link to four smaller sections of water race that will also be altered in some way by the Project and are considered to provide representative data of these races.

The water races selected to be sampled, will remain (in an altered form) with the construction of the Project so it is necessary to obtain data to enable mitigation measures to be recommended if required. Refer to Figure 5 and Table 1 for location of sampling sites. Four other sites were observed and photos were taken as part of the site survey, however these sites were not surveyed for physical habitat, flora and fauna or water quality (these are referred to as Site A to D). Two of the sites were dry (Montgomery's Drain and the open channel along Springs Road) at all site visits and the other two sites (Blakes Road and SH1) were considered to be sufficiently represented by the five main sites surveyed. Refer to Table 2 for the types of sampling undertaken at each site.

The following sites were selected to provide baseline data for the Project:

MSRFL – Southern extent of works to Weedons Ross Road

- Weedons Road (immediately downstream of Main South Road) (Site 1).

MSRFL - Weedons Ross Road to CSM2

- A site visit and photos were taken along the SH1 race in the vicinity of Berketts Road (Site A).

CSM2 - MSRFL/CSM2 to Blakes Road

- Robinsons Road (approximately 130 m downstream of Main South Road) (Site 2).
- Hamptons Road (approximately 200 m downstream of Waterholes Road/Hamptons Road intersection) (Site 3).
- Trents Road (approximately 300 m downstream of Blakes Road/Trents Road intersection) (Site 4).
- A site visit and photos were taken at Blakes Road (Site B).

CSM2 - Blakes Road to before Springs Road

- Marshs Road (approximately 150 m downstream of Shands Road) (Site 5).

CSM2 - Before Springs Road to CSM1

- Montgomery's Drain was unable to be surveyed given that it had no flow however photos were taken at this site (Site C).
- Springs Road open channel was unable to be surveyed given that it had no flow, however photos were taken at this site (Site D).

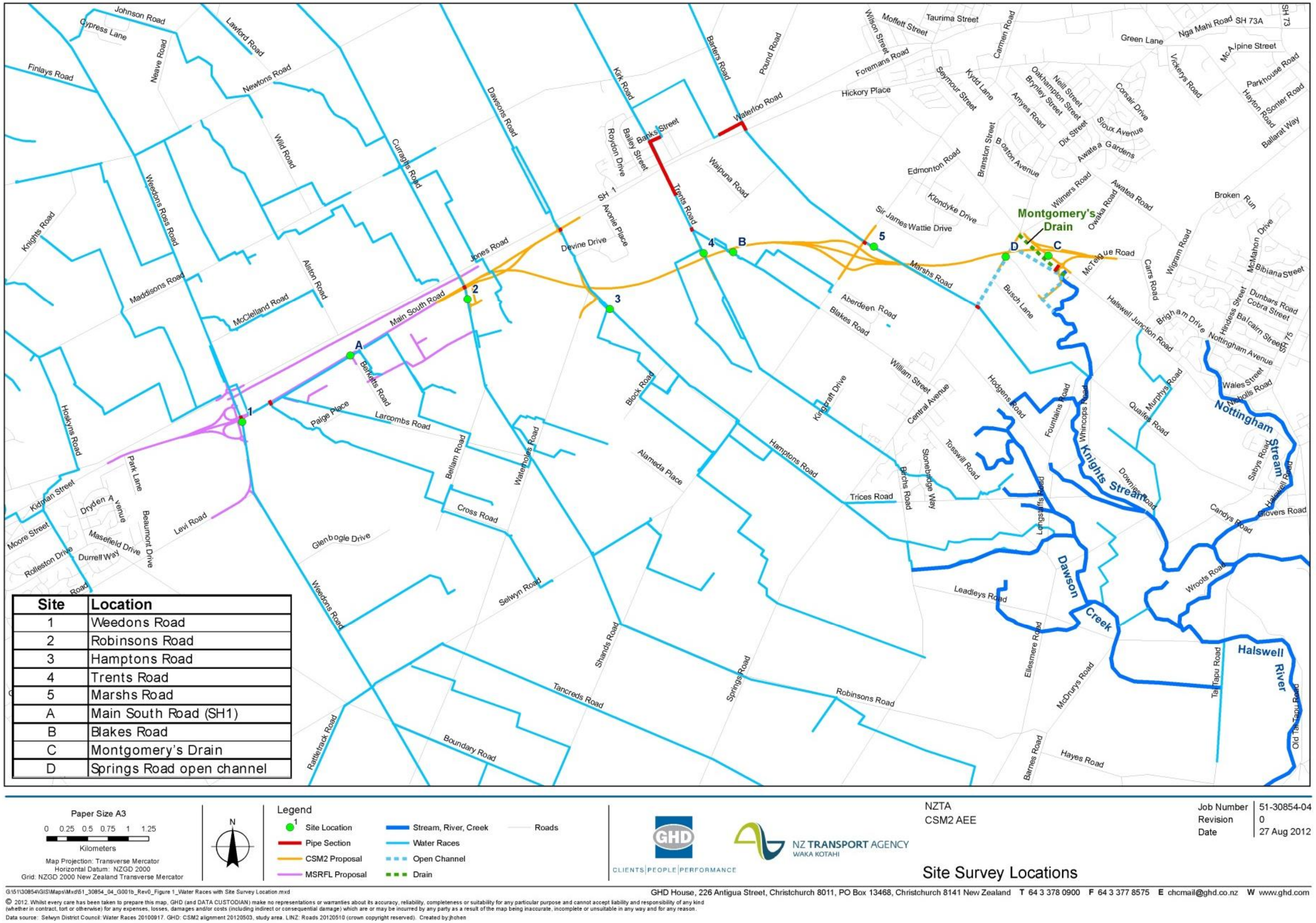
Table 1 Location of sample sites

Site No.	Name	Northing (NZTM)	Easting (NZTM)	Altitude a.s.l
1	Weedons Road	5174314.5	1552393.7	50
2	Robinsons Road	5175843.1	1555157.6	45
3	Hamptons Road	5175749.2	1556896.0	40
4	Trents Road	5176437.1	1558044.5	35
5	Marshs Road	5176518.1	1560131.8	30
A	SH1 (in vicinity of Berketts Road)	5175181.3	1553717.2	50
B	Blakes Road	5176473.8	1553880.0	35
C	Montgomery's Drain	5176406.3	1562274.0	20
D	Springs Road open channel	5176393.3	1561746.2	20

Table 2 Type of sampling at each site

Ref No.	Name	Physical habitat (including water quality)	Electric fishing	Macro-invertebrates	Aquatic flora (macrophytes)	Other (photo, site visit)
1	Weedons Road	Y	Y	Y	Y	Y
2	Robinsons Road	Y	Y	Y	Y	Y
3	Hamptons Road	Y	Y	Y	Y	Y
4	Trents Road	Y	Y	Y	Y	Y
5	Marshs Road	Y	Y	Y	Y	Y
A	SH1					Y
B	Blakes Road					Y
C	Montgomery's Drain					Y
D	Springs Road open channel					Y

Figure 5 Location of the water race sampling sites and additional observation sites



Site	Location
1	Weedons Road
2	Robinsons Road
3	Hamptons Road
4	Trents Road
5	Marshs Road
A	Main South Road (SH1)
B	Blakes Road
C	Montgomery's Drain
D	Springs Road open channel

5.3 Field and analysis methods

5.3.1 Aquatic physical habitat assessment

Aquatic physical habitat parameter measure methods were based on those of Environment Canterbury in Meredith et al. (2003)[23] and now also promoted as a “national protocol” by Harding et al. (2009)[24]. The original methods developed by ECan were based on the Plafkin et al., 1989[25] and Barbour et al., 1998[26] (US EPA protocols) protocols. Catchment scale features, riparian and bank features, reach scale and in-stream habitat quality was assessed using habitat field sheets provided by ECan. This assessment provides a rating for habitat features (optimal, sub-optimal, marginal or poor). These overall ratings are derived by adding together the scores for each habitat parameter scored. These sheets record such information as physical characteristics, vegetation, land-use, human influences and other general observations.

Further physical details were also recorded, including flow (measured using a portable unit – the Global Water FP111), channel shape, bed substrate and organic matter. These observations were recorded as per Harding et al (2009) using the P2 stream habitat assessment protocols[27]. It is noted that some features were not able to be recorded as they were not present in the modified water race environment. However, it is considered that the parameters recorded using a combination of the Meredith et al. (2003) and Harding et al. (2009) methods provide a good description of the habitat present at the surveyed sites.

Physical habitat assessments provide overall information relevant to other analyses (such as water chemistry, macro-invertebrate composition, fish communities) that can be used to describe the existing aquatic environment. The River Environment Classification (REC) classes[28] were used to provide a brief description of the water races.

A reach length of approximately 60 m was sampled at each site. Sampling was carried out following reasonably stable weather conditions (i.e. no recent rainfall events affected the races) on 5 and 6 July 2011.

It is noted that in areas in the North Island, the Stream Ecological Valuation (SEV) methodology is sometimes used to assess the potential effects of a proposal on the freshwater environment and to provide an indication of whether compensation for freshwater losses is required. This tool has not been developed for Canterbury waterways and such methods are not used in Canterbury[29]. Given this and that the majority of the water features within the proposed alignment are controlled water race systems it was not possible to assess the effects of the Project using the SEV methodology. As outlined

[23] Meredith, A.S; Cottam, D; Anthony, M; Lavender, R. 2003. Ecosystem health of Canterbury Rivers: Development and Implementation of biotic and habitat assessment methods 1999/2000. Report No. R03/3. Environment Canterbury.

[24] Harding, J. et al. 2001. Stream habitat assessment protocols for wadeable streams

[25] Plafkin et al., 1989. Rapid bioassessment protocols for use in streams and rivers: nebthic, macroinvertebrates and fish. EPA 444/4-89-001. US Environmental Protection Agency, Washington DC.

[26] Barbour et al., 1998. Rapid bioassessment protocols for use in wadeable streams and rivers: Periphyton, benthic, macroinvertebrates, and fish. EPA 841-B-98-001., Washington DC.

[27] Harding et al., 2009. Stream habitat assessment protocols for wadeable rivers and streams of New Zealand.

[28] Snelder et al., 2004.New Zealand river environment classification user guide. Ministry for the Environment, Wellington, NZ.

[29] Michelle Stevenson ECan Water Quality Scientist pers comm.

above, a combination of the methods developed by Meredith et al. (2003) and adapted by Harding et al. (2009) was used and considered sufficient to assess the aquatic physical habitat of the Project area.

5.3.2 Aquatic Macrophytes and Periphyton

Aquatic flora diversity is a visual aspect of rivers and can affect the waterways aesthetic and amenity values. Typically low river levels in conjunction with dominant bed sediments, amount of shading, source of flow (for example, mountains, foothills, lowland) and nutrient inputs, can contribute to excessive periphyton and macrophyte coverage.

Aquatic macrophytes (in moderation) can be particularly important as a habitat in streams which are dominated by fine sediments and where other stable substrates are uncommon as they can provide a food source in these environments and also a refuge for fish to hide. In contrast, excessive macrophyte beds can smother benthic habitats and trap more fine sediments. Such habitats are typically dominated by pollutant tolerant species such as worms, chironomids and snails[30].

It is noted that water races are typically not considered to be an aesthetic or amenity feature. However the presence of macrophytes at each site was assessed to give an overall picture of the aquatic environment.

At each sampling site macrophyte species type and percentage cover was recorded during the physical habitat process. Five transects along the sample reach were assessed for vegetation cover and species recorded as a percentage of submerged or emergent plants[31] The methodology used was based on that provided by the Environment Waikato Guidelines which are a method commonly used in the Canterbury region.

During aquatic surveys, periphyton sampling is often undertaken to measure species richness and cover. The presence of periphyton was absent from the water races and as such no particular survey was undertaken to describe their presence and abundance.

5.3.3 Water quality

Baseline monitoring was carried out to collect water samples from each of the five sampling sites and analysed in the ECan laboratory for the following parameters: faecal coliforms; total nitrogen (TN); Ammonia Nitrogen (NH_3N); Nitrate + nitrite nitrogen (NNN); Nitrate-Nitrogen (NO_3N); Nitrite-Nitrogen (NO_2N); dissolved reactive phosphorous (DRP); total phosphorous (TP); total suspended sediment (TSS); conductivity; pH; dissolved oxygen; and turbidity.

The ANZECC (2000) guidelines for fresh and marine water quality outline default trigger values for slightly disturbed New Zealand lowland river ecosystems. These values have been derived to trigger a management response should they be exceeded. Where regional guideline trigger values have been developed these should be used. The data has been compared against these trigger values.

This data provides an overall picture of water quality for the different water races which is able to be used as a baseline for assessing effects in the future.

[30] Collier, K., Kelly, J. & Champion, P. 2007. Regional Guidelines for Ecological Assessments of Freshwater Environments – Aquatic plant cover in wadeable streams. Environment Waikato Technical Report 006/47.

[31] Collier, K., Kelly, J., Champion, P. 2007. Regional Guidelines for Ecological Assessment of Freshwater Environments – Aquatic Plant Cover in Wadeable Streams. Environment Waikato Technical Report 2006/47

5.3.4 Fish

Fish populations, including trout and whitebait, provide important recreational and amenity values (e.g. recreational fishing and nature appreciation). Like macro-invertebrates, their presence/absence is also a commonly used indicator of high ecological value. For example, high fish density or the presence of rare or locally uncommon species is an indication of high ecological value.

Upland bullies (along with shortfin eels) were found to be the most common and abundant species in a survey of the waterways associated with the CSM1 Project (EOS Ecology, 2008) and within the Southwest Christchurch area study (EOS Ecology et al., 2005). In addition, the waterways, wetland and drainage guide[32] developed by CCC, identifies these species as being common in Christchurch waterways.

In determining the methodology, the above data was considered. Further, the significance of individual species was assessed using conservation threatened species lists prepared by Allibone et al. (2010) and by evaluating their presence within the Project area using the New Zealand Freshwater Fish Database (NIWA 2007).

No records of fish species were recorded on the database within the Project area. The species known to be common to the area had a threat classification of “Not Threatened” or “Introduced and naturalised”[33].

As such, a stream reach of approximately 60 m at each site was electro-fished using a Kainga 300 backpack electro-fishing machine. This was carried out in six sections of 10 m length. The stream wetted width of each 10 m length was recorded (width on average at all sites was 1 m) and the approximate area sampled at each site was 60 m^2. Cover features such as macrophytes and undercut banks were targeted. Fish were captured in a stop net positioned 1 -2 m downstream and transferred into a bucket for identification and measuring. They were then returned to their habitats. It has been demonstrated that electric fishing is an effective method to detect the presence of most native fish species.[34]

It is noted that other fishing methods such as night spot-lighting and baited trapping are also common methods to ensure a full range of species are caught. However based on data for other races within the Christchurch south-west area it was considered that the effort and catch was sufficiently representative of the species present.

Given the above assessment and fish species observed in this survey (refer section 6.1.6), no further assessment was considered necessary.

5.3.5 Aquatic Macro-invertebrates

Aquatic macro-invertebrates are commonly used as indicators of high ecological value, including the presence of high invertebrate diversity and an invertebrate community dominated by pollution-

[32] CCC. February 2003. Waterways, wetlands and drainage guide.

[33] Allibone, R., et al. (2010). Conservation status of New Zealand freshwater fish, 2009. New Zealand Journal of Marine and Freshwater Research. First published on 27 September 2010.

[34] Jowett, I.G., Richardson, J. & McDowall, R.M. 1996. Relative effects of instream habitat and land use on fish distribution and abundance in tributaries of the Grey River, New Zealand. New Zealand Journal of Marine and Freshwater Research 30: 463-475.

sensitive species. Stark & Maxted (2007)[35] noted that macro-invertebrates do not move great distances and are therefore largely confined to the area of stream being sampled. Therefore, the macro-invertebrate community of a stream lives with the stresses and changes that occur in the surrounding environment, including reduction in the extent of riparian margins, urbanisation resulting in reduced water quality.[36]

Macro-invertebrates were surveyed to provide information on the ecological health of the water races.

Macro-invertebrate communities were sampled using a 0.5 mm D-net following guidelines as specified by Ministry for the Environment Protocol C2 for soft bottomed streams.[37] This semi-quantitative method is considered suitable given that the metrics to be assessed (MCI and EPT%) can be analysed using this method. In total, an area of approximately 3 m^2 (ten unit efforts of approximately 0.3 m^2) of combined bank margins, submerged woody debris and aquatic macrophytes were sampled[38] . The ten sampling efforts were pooled to create the sample.

Samples were then transferred to a labelled container and preserved in isopropyl alcohol for transport to the laboratory. Ministry for the Environment Protocol P2[39] was used to obtain a 200 individual fixed count with a scan for rare taxa for each macro-invertebrate sample in the laboratory. Samples were processed and identified by Stark Environmental Limited.

5.3.6 Aquatic Macro-invertebrate Data Analysis

As well as summarising taxa richness (calculated by the number of different taxa identified in each sample), a range of biotic indices were calculated to measure stream pollution and its effects on the biology of the respective water race. Biotic indices included the number of Ephemeroptera-Plecoptera-Trichoptera taxa and the Macro-Invertebrate Community Index (MCI) and Quantitative MCI (QMCI). These biotic indices are described below. All regional councils that undertake State of Environment (SoE) monitoring use the MCI and/or QMCI for reporting results[40].

The number of Ephemeroptera-Plecoptera-Trichoptera taxa (% EPT taxa and % EPT abundance).

The Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa are the total number of distinct taxa within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). This value summarises taxa richness within the insect orders that are generally considered pollution sensitive. The exception to this is the hydroptilid caddisflies (e.g., Oxyethira spp. and Paroyethira spp.), which are often found in high numbers in nutrient enriched water.

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[35] Stark, J.D. & Maxted, J.R. (2007). A User Guide for the Macroinvertebrate Community Index. Cawthron Report No. 1166 – Prepared for the Ministry for the Environment.

[36] Stark, J.D. & Maxted, J.R. (2007). A User Guide for the Macroinvertebrate Community Index. Cawthron Report No. 1166 – Prepared for the Ministry for the Environment.

[37] Stark, J.D. et al., 2001. Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment.

[38] Stark, J.D. et al., 2001. Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment.

[39] Stark, J.D. et al., 2001. Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment.

[40] Stark, J.D. & Maxted, J.R. (2007). A User Guide for the Macroinvertebrate Community Index. Cawthron Report No. 1166 – Prepared for the Ministry for the Environment.

The percentage density of Ephemeroptera, Plecoptera and Trichoptera (% EPT Taxa) is a commonly used metric based on the percentage of the total number of pollution sensitive invertebrates in a sample that are within these insect orders. % EPT taxa are highest in unimpaired sites little affected by eutrophication or nutrient enrichment. Milne and Perrie (2006) defined "Very good" instream habitat for aquatic macroinvertebrates is associated with greater than 60% EPT Taxa: "Poor" instream habitat is associated with less than 10% EPT Taxa and "Moderate" instream habitat is associated with 10 to 60% EPT Taxa[41].

.The Macro-invertebrate Community Index (MCI) and the Quantitative MCI (QMCI); including MCI-sb / QMCI-sb.

The calculated MCI and QMCI rely on prior allocation of scores (tolerance values range from 0 to 10) to freshwater macro-invertebrates based upon their pollution tolerances. Taxa that are characteristic of pristine conditions score more highly than taxa that may be found in "polluted" conditions. The MCI and QMCI have been developed as a means of detecting organic pollution in communities inhabiting rock or gravel riffles and MCI-sb and QMCI-sb for soft-bottomed waterways[42]. It should be noted that many stream habitats support invertebrate communities with low MCI values because of reasons other than pollution, including reduction in current speed, increase in stream temperature, decrease in dissolved oxygen, smothering of bed by fine sediment and reduction in quality of riparian habitat[43].

MCI values greater than 119 indicate "excellent" instream habitat for aquatic macro-invertebrates. "Poor" instream habitat for aquatic macro-invertebrates is associated with MCI values of less than 80. "Good" and "Fair" instream habitat for aquatic macroinvertebrates is associated with MCI values of 100 to 119 and 80 to 99 respectively (Stark 1993)[44] .

QMCI is similar to MCI but also takes into account the coded abundance of each species. QMCI values greater than 5.99 indicate "excellent" instream habitat for aquatic macroinvertebrates. "Poor" instream habitat for aquatic macroinvertebrates is associated with QMCI values of less than four. "Good" and "Fair" instream habitat for aquatic macroinvertebrates is associated with QMCI values of 5 to 5.99 and 4 to 4.99 respectively[45].

The MCI-sb / QMCI-sb comparable index was developed for soft-bottomed streams and is applicable to the five sites surveyed for this assessment.

[41] Milne, J. And Perri, A. 2006. Freshwater Quality monitoring technical report. Prepared for Greater Wellington Regional Council.

[42] Stark, J.D. 1993. Performance of the Macroinvertebrate Community Index; effects of sampling method, sample replication, water depth, current velocity, and abstraction on index values. New Zealand Journal of Marine and Freshwater Research: 32: 55-66.

[43] Auckland Regional Council. 2008. State of the Environment Monitoring – Freshwater Invertebrate Monitoring; 2003-2007 analysis and evaluation. TR 2008/010.

[44] Stark, J.D. 1985. A macroinvertebrate community index of water quality for stony streams. Water and Soil Miscellaneous Publication No. 83, 379pp. Ministry of Works and Development, Wellington.

[45] Stark, J.D. 1998. SQMCI: a biotic index for freshwater macroinvertebrate coded-abundance data. New Zealand Journal of Marine and Freshwater Research: 27: 463-475.

6. Results – Description of the water race systems

Using the REC classes, the five water races surveyed, the additional four sites observed and Upper Knights Stream all exhibited similar classification features as identified with the following parameters:

Climate: cool-dry; Geology: alluvium; Valley-landform: low-gradient; Source of flow: low-elevation. The land cover for the five sites surveyed and Springs Road race (Site D) was classed as pastoral, however the section of Montgomery's Drain (Site C) within the Project area and Upper Knights Stream was classed as urban land cover. The SH1 race (Site A) was classed as pastoral land cover for most of its length, with a small area classed as urban in the mid reach.

Below are the results of the field investigations. Site specific summaries of the five sites surveyed and the additional four observations sites can be found in Appendix B attached to this report.

6.1 Field Investigation - Physical Habitat

Stream habitat is affected by in-stream complexity (eg. pools, rapids, cascades, cobble and boulder substrate, and large woody debris) and topographical features (eg. stream margins). Both the quality and quantity of available habitat affect the structure and composition of resident macro-invertebrate and fish communities. The physical habitat of streams is a major determinant of aquatic community potential and is regularly measured to assess the quality and health of a site.

All five sites surveyed were soft-bottomed streams, although some had small intermittent patches of small cobbles they were largely surrounded by fine sediments. All sites were approximately 1 m wide and 10-50 cm deep, with a constant "run" environment, lacking riffles or pools at each site. The flow in the races varied little between sites with lower flows observed at the water's edge compared with the middle of the race. Site 5 had the least flow of all sites, being 0.1 m/s consistently across the race from bank to bank. Site 2 also had little flow variation, ranging between 0.1 m/s and 0.2 m/s, with the slightly higher flow in the middle of the race. Sites 1, 3 and 4 ranged from 0.1 m/s to 0.4 m/s, once again with the slightly higher flows observed mid race and lower flows towards the edge where typically the depth of water was also lower.

Sites 1, 2 and 3 had some riparian cover in the form of tree shelter belts, providing partial shade to the races. Organic matter input from leaf fall from overhanging riparian vegetation can potentially cause significant water quality issues at these sites (eg. eutrophication), but this was minimal at sites 2 and 3 as the riparian trees were evergreens. Lack of shade and slow flows (present at all sites) may contribute to the macrophyte growth and lack of organic inputs may reduce habitat and food availability for instream ecosystems. Sites 1 and 4 had greater available in-stream habitat and diversity than the other sites. This was mainly due to the presence of undercut banks and snags (ie. fallen tree branches, overhanging grasses) and a more diverse substrate heterogeneity (ie, mix of silt/sand and a few areas of small cobbles). The flow at all sites was a constant run, with pools and riffles largely absent, limiting flow pattern variation.

All sites had an overall rating of "marginal" based on the parameters assessed (refer to Appendix A for an example of the habitat assessment sheet). Table 3 summarises the habitat characteristics for each of the five sites.

All sites ran adjacent to an existing road with modified vegetation cover (i.e. mown grass), with the opposite bank consisting of pastoral land (sites 2, 3, 4 and 5) or rural-residential land (site 1). So while all sites had a relatively complete riparian vegetation cover, the actual canopy and in-stream cover provided was minimal. These results are consistent with a general survey of water races within the Paparua Water Race System carried out by Lincoln Environmental in 1997[46,47]. Table 3 provides a summary of the habitat parameters.

Figure 6 to Figure 10 below shows photos of the five sampling water races.

Table 3 Summary of habitat parameters recorded at each site

Habitat ParameterP1.[48]	Site				
	1 – Weedons Road	**2 – Robinsons Road**	**3 – Hamptons Road**	**4 – Trents Road**	**5 – Marshs Road**
Predominant surrounding land-use	Pastoral land-use, rural-residential, road	Pastoral land-use, rural-residential, road	Pastoral land-use, rural-residential, road	Pastoral land-use, rural-residential, road	Pastoral land-use, road
Dominant substrate composition	Silt/sand	Silt/sand	Silt/sand with a few small cobbles	Small cobbles surrounded by silt/sand	Silt/sand
Embeddedness (substrate surrounded by fine sediment)	Poor (greater than 75 %)	Poor (greater than 75 %)	Marginal (55 to 75 %)	Marginal (55 to 75 %)	Poor (greater than 75 %)
Riparian vegetation	Mown grasses, some trees and shrubs (residential garden)	Mown grasses, conifers along right bank	Mown grasses, conifers along left bank	Mown grasses and pastoral land	Mown grasses and pastoral land
Extent of riparian cover	Marginal (6-12 m cover) (left bank), poor (right bank)	Poor (<6 m cover) (left bank), marginal (right bank)	Poor	Poor	Poor
In-stream	Submerged/ Emergent	Submerged/ Emergent	Submerged/ Emergent	Submerged/ Emergent	Submerged/ Emergent

[46] McMurtrie, S., Milne, J., Ward, J. and Meurk, C. 1997. Assessment of ecological values of the Paparua Water Race System. Lincoln Environmental Report Number 2759/2 prepared for Christchurch City Council.

[47] In the Lincoln Environmental 1997 survey, 15 sites across the scheme were surveyed. One site (site 15) was located approximately 2 km downstream of our site 1; site 14 was located approximately 220 m upstream and site 7 approximately 820 m downstream of our site 3; and sites 6, 8 and 3 were located approximately 1.8 km, 1.4 km and 900 m respectively upstream of our site 5.

[48] Refer to Habitat Assessment Example in Appendix A.

Habitat ParameterP1.48	Site 1 – Weedons Road	2 – Robinsons Road	3 – Hamptons Road	4 – Trents Road	5 – Marshs Road
vegetation	macrophytes - bed cover 18%	macrophytes - bed cover 26%	macrophytes - bed cover 10%	macrophytes - bed cover 12%	macrophytes - bed cover 8%
In-stream habitat diversity and abundance (e.g. from logs, vegetation)	Suboptimal (40-70% cover available)	Marginal (20-40% cover available)	Marginal	Suboptimal	Marginal
Overall habitat grading	Marginal (113)	Marginal (105)	Marginal (118)	Marginal (124)	Marginal (85)

Figure 6 Site 1: Weedons Road

Figure 7 Site 2: Robinsons Road

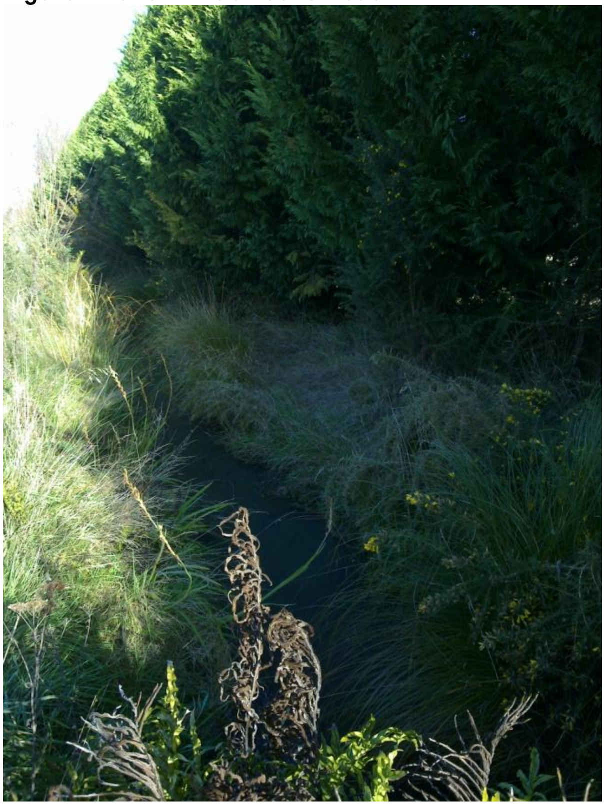


Figure 8 Site 3: Hamptons Road

Figure 9 Site 4: Trents Road

Figure 10 Site 5: Marshs Road

6.2 Field Investigation - Macrophytes

Aquatic macrophytes were present at all five sites, with pondweed (*Elodea Canadensis*) and watercress (*Nasturtium*) being the dominant species at sites 1, 2, 4 and 5 and the pondweed (*Potamogeton ochreatus*) dominant at site 3. These species were primarily present along the edges of the water race and did not extend across the whole water race width and therefore, did not choke the water race and only restricted the flow in some small areas around the edges of the races. Water race beds were dominated by fine sediments at all sites and this, along with the slow flow at all sites, is a likely contributor to the growth of macrophytes at all sites.

6.3 Field Investigation - Water quality

The nutrients most often responsible for water quality degradation are nitrogen (N) and phosphorus (P). Nutrients are essential for the growth of algae and other plants. Aquatic plant and algal growths are important in waterways as they provide food for both invertebrates and fish. However if they become excessive, due to an oversupply of nutrients (especially N and P), the quality of the waterway deteriorates.

The ANZECC (2000) guidelines for fresh and marine water quality outline default trigger values for slightly disturbed New Zealand lowland river ecosystems. These values have been derived to trigger a management response should they be exceeded. Where regional guideline trigger values have been developed, these should be used. For the purposes of this assessment, the default lowland trigger values for total phosphorus (0.033 mg/L), total nitrogen (0.614 mg/L), oxides of nitrogen (0.444 mg/L) and ammonical nitrogen (0.021 mg/L) were used.

Changes in the pH value of water affect the organisms that live there. Most natural waters fall within the pH ranges 6.5 to 8.0 (ANZECC, 2000). Lowland default trigger values to assess risk of adverse effects due to pH in various ecosystems indicate a lower limit of pH 7.2 and an upper limit of pH 7.8 as being acceptable (ANZECC, 2000). All five water races have pH values within this range (Table 4).

Dissolved oxygen (DO) is a basic requirement for a healthy aquatic ecosystem and under low levels, the aquatic environment can become stressed and the lack of oxygen can kill aquatic plants and animals. Most desirable fish species (such as indigenous species and recreational fish such as trout) suffer if DO concentrations fall below 3 to 4 mg/L and stoneflies suffer with levels below about 6 mg/L. Other species such as carp and chironomids can survive at levels as low as 1 mg/L[49]. The DO levels at all five sites are about 12 mg/L[50], well above the limit required to sustain a healthy ecosystem for water quality classes: aquatic ecosystems, fisheries, (fish spawning) of 6 mg/L (as per the Third Schedule of the RMA 1991). It is noted that fish were caught at four of the five sites sampled, although diversity was low.

Suspended sediment (SS) (eg. fine clay particles/silt) in the water column can be a nuisance to aquatic ecosystems through smothering of benthic organisms and affecting fish respiration (ie. gill damage). Excess silt and soil can enter aquatic environments during heavy rainfall events particularly in areas where vegetation cover has been disturbed, resulting in reduced soil stabilisation. Consequently,

[49] University of Wisconsin. Dissolved Oxygen - Water Action Volunteers – Volunteer Stream Monitoring Factsheet, 2006. Accessed from the internet August 2011.

[50] Consistent with the Lincoln Environmental 1997 survey results.

proposed earthwork activities associated with the development of the proposed motorway may result in land clearing surrounding each of the water races. During heavy rainfall events the exposed sediment has the potential to be transported to the adjacent water races thereby increasing suspended sediment loading. Appropriate sediment control measures (e.g. silt fences, settling ponds) should be included in a Construction Environmental Management Plan (CEMP) (Volume 3 of the application) to minimise impacts to the respective water race. Refer to Technical Report - Construction Environmental Management Plan for details of the sediment and erosion controls proposed.

Increased water turbidity, caused by suspended sediments, can affect benthic algae and macrophyte growth by reducing light penetration throughout the water column. Further fine sediments can smother aquatic flora and other aquatic life if they settle out. All sites, except for site 5 (Marshs Road) reported turbidity values less than the ANZECC (2000) trigger value of 5.6 NTU (Table 4). The high turbidity value and low habitat score at site 5 is probably a contributing factor in the lack of fish collected (and released) in the stream and the low percentage of EPT taxa present (Table 4).

Conductivity varied little between sites and values were consistent with those observed in drains and races surveyed for the south-west Christchurch catchment study[51] and the Paparua Water Race System survey[52].

Table 4 Water quality parameters at each site

Water Quality Parameter	Site					Trigger value[53]
	1 – Weedons Road	2 – Robinsons Road	3 – Hamptons Road	4 – Trents Road	5 – Marshs Road	
Turbidity (NTU)	2.4	4.6	2.4	2.1	8.2	5.6 NTU
Total Phosphorus (TP) (mg/L)	<0.008	<0.008	0.008	<0.008	0.04	0.033
Dissolved Reactive Phosphorus (DRP) (mg/L)	<0.001	<0.001	<0.001	<0.001	0.01	0.01
Total Nitrogen (TN) (mg/L)	<0.08	<0.08	<0.08	<0.08	0.13	0.614

51 EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

52 McMurtrie, S., Milne, J., Ward, J. and Meurk, C. 1997. Assessment of ecological values of the Paparua Water Race System. Lincoln Environmental Report Number 2759/2 prepared for Christchurch City Council.

53 ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy.

Water Quality Parameter	Site					Trigger value[53]
	1 – Weedons Road	2 – Robinsons Road	3 – Hamptons Road	4 – Trents Road	5 – Marshs Road	
Ammonia Nitrogen (mg/L)	0.007	0.006	<0.005	0.006	0.017	0.021
Nitrate Nitrite-Nitrogen (NNN) (mg/L)	0.054	0.047	0.053	0.077	0.078	0.444
Dissolved oxygen (DO) mg/L	12.6	12.6	12.5	12.2	12.1	> 6[54]
pH	7.8	7.8	7.8	7.7	7.7	7.2 – 7.8
Conductivity mS/m	6.9	6.9	6.9	7.1	7.0	ND

Figures in red exceed the trigger values, ND – No Data

Generally, the majority of water chemistry results at all sites were within the ANZECC (2000) guidelines for nutrients, except for an exceedance in turbidity and total phosphorus at site 5 (Table 4).

6.4 Field Investigation – Aquatic Macro-invertebrates

Macro-invertebrate data is summarised in Table 5 below. A complete list of taxa recorded from the streams is contained in Appendix D.

Taxa richness for invertebrates reflects the "health" of instream communities and generally increases with increasing water quality, habitat diversity and or habitat suitability. The percentage contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance (diversity) at the lowest positive taxonomic (species) level. A community dominated by relatively few species would indicate environmental stress.

[54] Water quality classes: aquatic ecosystems (AE), fisheries (F), (fish spawning (FS), and gathering or cultivation of shellfish for human consumption SG), as specified in the Third Schedule of the RMA 1991.

Table 5 Macro-invertebrate data recorded from each site

Macro-invertebrate Parameter	Site				
	1 – Weedons Road	2 – Robinsons Road	3 – Hamptons Road	4 – Trents Road	5 – Marshs Road
Total number of taxa (taxa richness)	15	18	22	24	24
Total number EPT taxa (excl Hydroptilidae)	7 (7)[55]	5 (3)	9 (8)	6 (5)	5 (3)
MCI-sb	99 (fair)[56]	69 (poor)	94 (fair)	79 (poor)	76 (poor)
QMCI-sb	1.80 (poor)[57]	2.03 (poor)	6.38 (excellent)	2.38 (poor)	2.05 (poor)
% EPT taxa (excl Hydroptilidae)	46.67 (46.67) (moderate)[58]	26.32 (15.79) (moderate)	40.91 (36.36) (moderate)	25.00 (20.83) (moderate)	20.83 (12.50) (moderate)
%EPT abundance (excl Hydroptilidae)	4.37 (4.37)	7.37 (5.99)	67.81 (67.81)	6.14 (6.14)	4.58 (4.23)

Species diversity in the five sites is reasonably high, with sites 4 and 5 having the highest diversity of taxa (Table 5). However all sites are numerically dominated by pollutant tolerant species (snails[59]) as is reflective of the low EPT taxa numbers. This is likely reflective of the habitat of these water races, being predominately soft-bottomed, with poor instream cover and marginal in-stream diversity supporting a wide range of species. The most diverse invertebrate group were the caddisflies followed by the true flies (diptera). This is consistent with surveys carried out in 2008 of the waterways associated with CSM1[60] and 2005 within the Southwest Christchurch area study[61]; immediately

[55] The figures in brackets refer to the total number of taxa excluding Hydroptilidae which are an EPT taxa but considered to be pollutant tolerant so are other removed from this metric.

[56] The reference in brackets refers to the MCI category that each score receives, as detailed in Section 5.3.6 of this report.

[57] The reference in brackets refers to the QMCI category that each score receives, as detailed in Section 5.3.6 of this report.

[58] The reference in brackets refers to the % EPT category that each score receives, as detailed in Section 5.3.6 of this report.

[59] Snails were also the most abundant species in the Lincoln Environmental survey.

[60] EOS Ecology. January 2008. Assessment of Environmental Effects: Christchurch Southern Motorway: Aquatic Ecology.

[61] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

adjacent the CSM2 Halswell end of the Project. Taxa richness scores from the five water races sampled were moderate to high (Table 5) and consistent with the EOS Ecology et al (2005) study.

EPT taxa richness generally increases with increased water and habitat quality[62]. EPT taxa at the five sites are relatively low with sites dominated by pollutant tolerant species. This is likely a reflection the marginal habitat at each site.

Many EPT taxa prefer stony substrata to attach egg sacs, as a food source (ie, biofilm grazing) and shelter (i.e. stable stones during flood events)[63]. Soft bottom sites typically do not provide these requirements.

EPT taxa tend to prefer cool water, high dissolved oxygen levels, varied habitat diversity and hydrological heterogeneity (diversity in stream flows – riffles, runs, pools) which are conditions not present at the five sampling sites or observed along the reaches not sampled. The percentage density of EPT taxa is a commonly used metric based on the percentage of the total number of pollution sensitive invertebrates in a sample that are within these insect orders. Percentage EPT taxa are highest in sites minimally affected by eutrophication or nutrient enrichment.

The percentage EPT taxa are poor to moderate at all sites and is a likely a reflection of marginal habitat lacking in-stream heterogeneity). However, all five sites are rated as "poor" or "fair" based on their MCI-sb value, consistent with the results of the Lincoln Environmental survey[64].

Except for site 3, which is rated as "excellent", all other sites are rated as "poor" based on their QMCI-sb value. Further investigation of site 3 resulted in the identification of an extremely large number of the caddisfly taxa, *Hudsonema*, contributing to the high quantitative rating. The overall poor rating at each site is likely a reflection of a soft bottomed stream, minimal stream shading, and minimal riparian complexity resulting in a pollutant tolerant, EPT poor taxa. Therefore MCI and QMCI are more appropriately considered a measure of general water and habitat quality.

The MCI-sb and QMCI-sb results are consistent with other studies of drains and water races in this area[65,66].

Community composition at all sites, except site 3, is dominated by molluscs (snails). As already discussed, site 3 is dominated by the caddisfly, *hudsonema*. Snails are often present in waterways with macrophyte presence as they feed off the plants.

6.5 Field investigation - Fish

Fish presence at each of the sampling sites is recorded in Table 6 below. The fish communities at the five sites sampled were depauperate (lacking species diversity) and limited to three species, the native

[62] Meredith, A.M., Cottam, D., Anthony, M., Lavender, R. 2003. Ecosystem health of Canterbury rivers: Development and implementation of biotic and habitat assessment methods 1999/2000. Environment Canterbury Report R03/3.

[63] Auckland Regional Council. 2008. State of the Environment Monitoring – Freshwater Invertebrate Monitoring; 2003-2007 analysis and evaluation. TR 2008/010.

[64] McMurtrie, S., Milne, J., Ward, J. and Meurk, C. 1997. Assessment of ecological values of the Paparua Water Race System. Lincoln Environmental Report Number 2759/2 prepared for Christchurch City Council.

[65] EOS Ecology. January 2008. Assessment of Environmental Effects: Christchurch Southern Motorway: Aquatic Ecology.

[66] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

common and upland bullies (*Gobiomorphus cotidianus* and *Gobiomorphus breviceps*) and brown trout (*Salmo trutta*). No fish were caught at site 5. Brown trout were caught at sites 1 and 2, upland bullies at sites 2, 3 and 4 and common bullies at sites 1 – 4. Both common and upland bullies are common throughout New Zealand waterways. Upland bullies (along with shortfin eels) were found to be the most common and abundant species in a survey of the waterways associated with CSM1 (EOS Ecology, 2008) and within the Southwest Christchurch area study (EOS Ecology et al., 2005). In addition, the waterways, wetland and drainage guide[67] developed by CCC, identifies these species as being common in Christchurch waterways. Upland bullies can be found above substantial in-stream obstructions as it is a non-migratory species and therefore does not require access to the sea.

In the study carried out by EOS Ecology et al. (2005), it was found that fish species diversity declined significantly with upstream distance from the main channels in the Halswell catchment, with only the non-migratory upland bully found at the most upstream sampling sites[68]. Fish surveys were limited as part of the Lincoln Environmental survey, however of the sites surveyed, upland bullies and brown trout were the numerically dominant species[69].

Table 6 Fish presence recorded from each site

Fish Species Presence	Site				
	1 – Weedons Road	2 – Robinsons Road	3 – Hamptons Road	4 – Trents Road	5 – Marshs Road
Fish present	Yes	Yes	Yes	Yes	No
Fish species	Brown trout	Brown trout	No	No	No
	Common bully	Common bully	Common bully	Common bully	No
	No	Upland bully	Upland bully	Upland bully	No
Fish caught	4	1	N/A	N/A	N/A
	1	5	47	14	N/A
	N/A	4	3	4	N/A
Average fish length (cm)	10.3	15	N/A	N/A	N/A
	3	3.4	3	2.7	N/A
	N/A	5.25	5	4.5	N/A

[67] CCC. February 2003. Waterways, wetlands and drainage guide.

[68] EOS Ecology et al. 3 July 2005. Appendix 4: Aquatic Values & Management. South-west Christchurch Integrated Catchment Management Plan Technical Series. Report No. 3.

[69] McMurtrie, S., Milne, J., Ward, J. and Meurk, C. 1997. Assessment of ecological values of the Paparua Water Race System. Lincoln Environmental Report Number 2759/2 prepared for Christchurch City Council.

Fishing area (m^2)	60	55	60	60	60

Instream cover is an important component for fish as it provides a refuge from predators and high flows. Cover, such as larger substrate, undercut banks and overhanging vegetation was marginal at most sites and may reflect the low diversity of fish species caught in the survey. Upland bullies will tolerate a variety of habitats from stony-bedded rivers to weedy streams hence why they are able to tolerate the habitat conditions of the water races sampled. In addition, they are non-migratory, spending their whole lives in freshwater. Brown trout are also primarily a freshwater species. Common bullies can spend some of their lives in the marine environment, but land-locked populations are known to occur.

6.6 Summary

The overall aquatic ecosystem of the water races was quite poor and reflective of other race systems within Christchurch and the Canterbury Plains.

All sites had a relatively complete vegetation cover, but actual canopy and water race cover was minimal, providing little or no shading to the in-stream environment. In addition, in-stream cover (e.g. from logs, vegetation) was minimal and substrate diversity was very low, consisting largely of silt and mud. Further, water width and depth and flow varied little across all the races surveyed.

Macro-invertebrate species diversity in the five sites was reasonably high, however all sites were dominated by pollutant tolerant species as is reflective of the low EPT taxa numbers observed. Fish species presence and diversity was depauperate and only common fish species observed in other water races in the area were observed.

No rare or threatened species were identified within any of the water races.

As outlined at the start of Section 6, site specific summaries of the five sites surveyed and the additional four observations sites can be found in Appendix B attached to this report.

7. Assessment of effects on aquatic ecosystems

As outlined in Section 4 above, the flow in the race network can be controlled and the water quality in the system often reflects the stormwater runoff of the surrounding area. No consideration is given to timing of such events (e.g. avoidance of potential fish spawning times) and they can occur at any time[70]. Further, SDC also carries out maintenance activities such as clearing out of the weed, macrophytes and silt in the races as these reduce the capacity to carry flood flows. This type of activity disturbs the bed and banks of the races as it has the potential to scour out the bed substrate and likely contributes to sedimentation. Further, the banks are often sprayed or weed-eaten which reduces riparian cover for in-stream ecosystems and may decrease bank stability. In addition, with the agreement of the land owners, SDC can close off or entirely terminate a section of the race network. As a result of such activities, the race network is considered to be a highly modified and controlled environment.

The potential effects of the Project on the aquatic environment are likely to be related to both construction and operational activities. Construction effects will relate primarily to earthworks for the construction of the motorway, realignment and construction of the piped sections of the races and the resultant sedimentation, habitat disturbance and potential water quality impacts. Operational effects relate to the on-going effects of altered waterway habitat, changes to fish passage, potential altered hydrology as a result of pipes, culverts and siphons and potential for altered water quality. These effects are discussed in detail in the following sections.

7.1 Environmental Risk Assessment

An environmental risk assessment was undertaken for aquatic elements within and immediately adjacent to the Project area only. The aquatic environments within the Project area are modified (ie, water races) and are representative of the local area only. Given the modified state of these environments, it is unlikely these are ecologically significant within the regional area. It is unlikely that these environments are representative of the wider regional area and as such, the risk assessment is constrained to the Project area and the immediate adjacent area.

In this section, the risk assessment process and a summary of the methodology are described and each of the risk assessments is included. A detailed description of the risk assessment methodology is contained in Appendix C to this report.

7.1.1 The Risk Assessment Process

No international standard exists for risk management, and as a result, the risk assessment methodology employed for this AEE is based on the Australian Standard AS/NZS 4360: 2004 *Risk Management* (the Standard) and the HB 203:2000 *Environmental Risk Management – Principles and Process* (the Guidelines). The Standard and Guidelines set out a generic framework for establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating risks. The Transit New Zealand (2008)[71] Environmental Plan provides a process to develop approaches and

[70] Vicki Rollinson, SDC Water Race and Land Drainage Coordinator, email dated 25 July 2012.

[71] Transit NZ (2008). Improving environmental sustainability and public health in New Zealand. Version 2.

implementation plans for each category of environmental and social impact. The NZTA has accepted the Transit NZ Environmental Plan which is incorporated into this risk assessment.

This risk assessment is specific to the outcomes of the aquatic ecology assessment.

7.1.2 Risk Assessment Methodology

The objective of a risk assessment is to filter the minor acceptable risks from the major non-acceptable risks. It involves consideration of the sources of risk, the consequences and the likelihood that those consequences may occur.

Risk analysis may be undertaken to various degrees of refinement depending upon the risk information and data available. Analysis techniques include qualitative assessment, semi-quantitative assessment, and quantitative assessment.

The risk assessment methodology for this AEE uses a semi-quantitative process for determining risk. The detailed methodology used for this assessment is contained in Appendix C of this report.

The following table contains the risk assessment undertaken for the Aquatic Ecology elements of this Project. It is intended that if/when aspects of the Project change, these risk assessments would be revisited, as part of the management review, to ensure significant risks are properly addressed.

Table 7 Water Quality Risk Assessment

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Construction Phase				
Construction of culverts and piped sections	Water quality impacts (including from altered hydrology and siltation/sedimentation regimes) that may have potential flow on effects for trophic groups including aquatic flora and fauna associated with this habitat i.e. fish and macro-invertebrates.	(2, 4) Medium	Construct culverts and pipelines in line with stream hydrology regimes and SDC guidelines to minimise changes to flow rates, hydraulic capacity and reduce ecological impacts.	(2, 3) Low
Construction of Project	There is the potential for spillage (either minor through drips or major through a leak/accident) of oils and fuels from construction equipment to impact on freshwater quality.	(3, 2) Low	No planned refuelling or maintenance of construction equipment to occur, nor equipment to be parked adjacent to freshwater environments for a significant time. Readily available spill kits for land and water to be kept on site with trained personnel. Emergency response procedures will be established. Adherence to waste management controls identified in the CEMP for this Project.	(2, 2) Low
	Potential for de-watering water to enter Montgomery's Drain.	(1, 3) Low	De-watering water is clean water and as such no impacts on water quality are anticipated. The CEMP includes measures to ensure scouring potential at release points in freshwater environments within the Project area is minimal.	(1,2) Very low
	Increased turbidity and decreased light on benthic aquatic flora and fauna.	(2, 4) Medium	Program construction activities to avoid where practicable excavation of soils adjacent to freshwater environments during heavy rainfall and flood events. Races to be closed off in sections to enable work to proceed in localised areas.	(2, 2) Low
Operational Phase				
Water quality impacts	Impacts to freshwater quality from increased water temperature in adjacent freshwater environments leading to reduction in species diversity.	(2, 3) Low	Implement a riparian planting plan in conjunction with SDC and its planting guideline and plantings as proposed in Technical Report Number 7 and associated plans to maintain water races.	(2, 1) Very low

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
	Impacts to freshwater quality from stormwater inputs from the Maize Maze Pond or Ramp Pond into Montgomery's Drain during a 1 in 100 year 24 hour rainfall event, including increased erosion.	(2, 3) Low	Stormwater will be treated prior to discharge. Discharge will only occur on an infrequent basis as the system is designed for a 1 in 100 year 24 hour rainfall event. The CEMP includes measures to ensure scouring potential at release points in freshwater environments within the Project area is minimal.	(1, 3) Low
	Impacts to freshwater quality from embankment runoff from Weedons Road ponds located on the inside of the cloverleaf interchange into Weedons Road race during a 1 in 100 year 24 hour rainfall event, including increased erosion.	(2, 3) Low	Stormwater will be treated prior to discharge. Discharge will only occur on an infrequent basis as the system is designed for a 1 in 100 year 24 hour rainfall event. The CEMP includes measures to ensure scouring potential is minimal.	(1, 3) Low
	Impacts to freshwater quality from high groundwater under the Maize Maze and Ramp Ponds in combination with the effects of CPW requiring an artificial lowering of groundwater via discharge of groundwater to Upper Knights Strream on an infrequent basis inputs and possibly not commencing for a considerable time, including increased erosion.	(2, 3) Low	Discharge will be of clean groundwater and will only occur on an infrequent basis as the pond system is designed for a 1 in 100 year 24 hour rainfall event. The CEMP includes measures to ensure scouring potential at release points in freshwater environments within the Project area is minimal.	(1, 3) Low
Waste management	There is potential for an increased amount of waste to enter the freshwater environments leading to blockages, indirect smothering of habitats and release of contaminants to the waterways.	(2, 3) Low	Monitoring and clearing waste in freshwater environments is to be carried out in accordance with the CEMP. Where appropriate, implement waste management devices at outflows to reduce waste loads entering freshwater environments.	(2, 2) Low

Table 8 Sediment Quality Risk Assessment

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Construction Phase				
Construction of culverts and piped sections	Sediment re-suspension and subsequent contaminant re-suspension and or desorption and re-entry into the water column during construction of culverts and placement of pipelines.	(4, 4) Major	Disturbance of soft sediments to be limited immediately within the closed sections of the races (work in dry bed) required for construction. As detailed in the CEMP a contingency plan should be developed to deal with the discovery of contamination.	(2, 3) Low
	Erosion of water race banks during construction activities.	(2, 3) Low	Construction activities to be limited to designated areas within the culvert/pipeline construction sites. Heavy machinery should be placed away from the banks to minimise potential for bank instability and potential collapse. Construction sites immediately adjacent to freshwater environments will be bunded to reduce potential for fines moving into the freshwater environment, measures in place as outlined in the CEMP.	(2, 1) Very low
	Spill from digger during relocation of excavated sediment.	(2, 1) Very low	Operate within safe weather conditions.	(2, 1) Very low
	Alteration of habitat sediment quality arising from run-off from the construction area resulting in increased fine sediment loads and potential for contaminant exposure.	(3, 4) Medium	Construction areas to be remediated immediately after completion of construction activities. Remediation plans as detailed in the Landscaping Technical Report Number 7. Measures outlined in the CEMP to address sediment and run-off matters.	(2, 2) Low
Operational Phase				

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Sediment quality impacts	Alteration of sediment quality in adjacent habitats from land run-off resulting from poor sediment quality. Potential reduction in water race biodiversity.	(3, 4) Medium	As part of stormwater treatment, manage stormwater retention pond discharge to maintain water quality. Appropriate design and construction of culverts and pipelines, including lining with geotextile fabric where appropriate to reduce potential for fines to be moved into the surrounding environment.	(2, 2) Low
	Scouring of river bed and banks in association with the outfall point into Upper Knights Stream and the potential remobilisation of contaminated sediments	(3, 4) Medium	Appropriate design and construction of pipe outfall including bed and bank protection (rip rap etc) to reduce potential for erosion of banks and scouring of the bed. Where possible, minimise potential race bank collapse by positioning machinery away from the banks. Replant any bank vegetation removed with like vegetation immediately after completion of works.	(2, 2) Low
	Remobilisation of contaminated sediments within culvert/pipeline construction areas. Potential reduction in freshwater biodiversity.	(4, 4) High	Appropriate design and construction of culverts and pipelines, including lining with appropriate material where possible to reduce potential for fines to be moved into the freshwater environment. Program construction activities to avoid where practicable excavation of soils adjacent to freshwater environments during heavy rainfall and flood events. Where possible, minimise potential race bank collapse by positioning machinery away from the banks.	(2, 3) Low

Table 9 Aquatic Flora and Fauna Risk Assessment

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Construction Phase				
Construction of culverts and piped sections	Direct mortality of flora and fauna associated with vehicular traffic and construction activities.	(2, 4) Medium	Educate Project employees of environmental responsibilities during inductions, as per CEMP. Establish appropriate access corridors and ensure employees and vehicles do not leave the designated corridors.	(2, 1) Very low
Construction of Project	Disturbance to aquatic flora and fauna (mainly fish) behaviour due to noise, light and vibration.	(2, 4) Medium	No ability to control noise/vibration impact. Fauna may occur in proposed culvert construction and pipeline placement and impacts are expected to be temporary. Employ directional lighting pointed towards Project area and away from surrounding habitat. Ensure plant and equipment are maintained.	(2, 3) Low
	Indirect degradation of habitats due to pollution. Weed and pest species.	(2, 3) Low	Install appropriate rubbish disposal facilities on site (including recycling option), as per the CEMP. Include, as part of the CEMP, procedures for managing the spreading of weeds from construction vehicles.	(2, 2) Low
	Impact upon flushing regime and health of the freshwater ecosystem. Potential impacts on sedimentation/scouring of the benthic habitat and riparian vegetation associated with the siphons, culverts and pipelines.	(3, 3) Medium	Design infrastructure placement to reduce any long-term scouring potential. Pipe inverts to be level with or below bed level to reduce potential for scouring. Undertake remediation activities in accordance with the CEMP.	(2, 3) Low
Water race bank construction	Loss of riparian vegetation and loss of bank side stability.	(3, 3) Medium	Undertake activities in accordance with the CEMP to ensure no impact on bank stability. Proposed riparian planting plans (Volume 5 of the application) are included in Technical Report Number 7. Riparian planting where appropriate to promote ecological linkages and provide potential fish spawning habitat.	(2, 2) Low

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Operational Phase				
Operation of Project	Indirect degradation or change in adjacent and surrounding water race habitats as a result of changes in water race hydrology. This includes potential for scour and/or sediment deposition changing suitability for existing benthic (fauna forage resource) and freshwater plant communities.	(4, 3) Medium	Design of culverts and pipelines will need to consider appropriate sizes to retain stream bank integrity or other measures to guard against scour. The proposed pipe diameters are consistent with the existing piped sections of the race network and follow the SDC guideline on this matter. Pipe inverts should be level with or below bed level. The races are routinely scoured out by machines to clear vegetation to maintain capacity for flood flows.	(2, 3) Low
	Indirect degradation or change in adjacent and surrounding water race habitats as a result of changes in water quality. This may change suitability for existing benthic (fauna forage resource) and freshwater plant communities.	(3, 2) Low	Use appropriate management techniques and/or devices to reduce potential for continuing negative water quality impacts to the adjacent area. Proposed stormwater treatment systems will reduce existing runoff to water races. Where appropriate use geofabric in culvert construction and pipeline placement.	(2, 2) Low
Fish passage	Alteration of habitats from construction of culverts and pipelines. Potential to act as a barrier to fish passage and migration.	(4, 4) High	The alignment of the piped sections will be consistent with the water race environment and will not include any steep drops or perched sections. Pipe inverts will be level or below bed level. Numerous piped sections already exist along the race network. Consider retaining the 2 km SH1 race and using a wire rope barrier to fence off from traffic. Alternatively consult with SDC over diverting the SH1 race into lateral races and removing the requirement for the 2km piped section along the proposed MSRFL. Use of light wells and resting areas for fish along the piped sections (approximately every 40 - 60 m where possible), use of baffles.	(3, 3) Medium

Activity Description	Potential Impacts and their Consequences	Preliminary Risk Assessment (C, L) Score	Additional Control Strategy	Residual Risk with Control Strategies Adopted (C, L) Score
Habitat fragmentation	Loss of riparian vegetation leading to increased habitat fragmentation and loss of ecological corridors.	(4, 3) Medium	Re-vegetation plans to be underpinned by ecological principles and scientific advise ensuring stream quality and habitat integrity is maintained and enhanced. Technical Report Number 7 provides for riparian landscaping.	(2, 2) Low

7.2 Construction Effects

The main activities to be carried out during construction which relate to the water races will be the piping, realignments and temporary closure of the system to enable sections of the network to have pipes, siphons and culverts installed. It is considered that these adverse effects can be mitigated as recommended in section 8 to the extent that the Project will have a minor effect on aquatic ecosystems.

The activities have the potential to affect the freshwater ecosystem via stormwater runoff and other contamination, the effect of habitat disturbance on the ecosystems and sedimentation.

It is recommended that any construction work in the vicinity of the water race system (an appropriate distance should be identified in the CEMP), including as part of the realignment works should incorporate sediment and erosion control practices to avoid addition of silt-laden and potentially contaminated water to these systems. The CEMP includes an Erosion and Sediment Control Plan, which has been prepared in accordance with:

- The NZTA's Draft Erosion and Sediment Control Standards for State Highway Infrastructure; and
- The ECan guidelines[72] on erosion and sediment control.

7.2.1 Effects on freshwater ecosystem

Stormwater runoff and other contamination

Stormwater runoff or accidental spills may contain a range of contaminants including nutrients, heavy metals and hydrocarbons. This in turn can lead to nuisance growths of algae and toxicity of biota. These factors can lead to a reduction in in-stream biota or a change in the community structure favouring more pollutant tolerant species. Direct stormwater discharge to the water races within the Project area is not proposed as part of this Project and therefore contamination from this source is not a relevant consideration.

The construction of the motorway and associated culverts and piped sections of the water race will not result in any planned discharges of sediment or contaminants to the water races. The CEMP includes processes to guard against this happening. However, it is possible in extreme unforeseen circumstances such as accidental spill events, exposed sediment and associated contaminants are mobilised during construction and enter adjacent waterways. During heavy rainfall events, surface flow may also exacerbate erosion via uncontrolled transport and deposition of sediment. Both wind and movement of heavy machinery can further exacerbate this effect.

In addition, construction activities including wash-down facilities, fuelling stations and mechanical workshops may contribute fuel and machinery oil to stormwater discharges. The CEMP provides details of erosion, sediment and dust control measures to be implemented during the construction phase to mitigate these impacts. It incorporates procedures including all refuelling to be done well away from water races and drains to minimise environmental impacts and also contains procedures for accidental

[72] Environment Canterbury (ECan) 2007. Erosion and sediment control guidelines. ECan Report No. R06/23.

spills. The proposed stormwater system (swales, soak pits and basins) will provide suitable containment for spills of contaminants and ensure that any such spills are not directed towards the race network and are contained within the treatment system during both construction and operation. There will be emergency management procedures in place to ensure that any spills have less than minor effects on the receiving waterways.

Any de-watering water (clean groundwater) that is required to be discharged during construction (as a result of high water tables) will be discharged to land or into Montgomery's Drain. Measures will be in place as part of the CEMP and Erosion and Sediment Control Plan to ensure that the drain banks and bed are not eroded or result in any sedimentation into the Drain as a result of this activity. As the discharge would be of clean groundwater and with the proposed erosion and sediment controls in place, it is expected that there will be no impact on the water quality in the Drain.

Habitat disturbance

Construction activities have the potential to affect freshwater habitats and fauna communities by degrading the habitat through physical and chemical disturbance (e.g., increased contaminants into the water column and increased suspended solids). Although, as already noted in Section 4, habitat disturbance occurs on a regular basis in the water race network.

Permanent diversions, which are proposed in some Project areas, may cause the infilling and loss of habitat reaches. In most instances, diversions will be put in place where infilling has occurred. The exact design will be refined at the detailed design phase of the Project.

It is recommended that construction of new water race diversions occurs at the start of the Project to minimise disturbance to the aquatic environment. Early construction of diversions will enable works to occur in confined areas without flowing water impeding construction and will allow unobstructed flow in the re-diverted race channel. Observations should be made of the old race channel to ensure no fish are trapped in the confined section. Where fish are located, they should be captured and relocated into the diverted race channel. To minimise disturbance to the habitat and ecosystems, it is proposed that any works within the races to install the pipes, culverts, siphons and carry out diversions will be undertaken in the dry bed. This will reduce the potential for sedimentation of downstream wetted channels.

Creation of new habitat in the diverted sections can be achieved by including in-stream features such as rocks and cobbles that provide in-stream heterogeneity (i.e., variation in flow). Remediation of race banks to encourage the colonisation of a healthy in-stream community can be achieved by riparian planting. A planting plan underpinned by ecological principles (i.e., promotion of stream shading) is recommended to enhance ecological integrity along the water races. Riparian planting is proposed as per Technical Report Number 18 and Number 7 and Drawing No's 62236-A-L011 to L018 and 62236-B-L011 to L024 (Volume 5). Once established, the riparian vegetation may provide an ecological bridge for fauna species to neighbouring areas, provide a sediment and erosion control facility and provide a buffer for land runoff before it enters the water race.

Figure 11 Claremont Estate, just upstream of the entrance

Figure 12 Gainsborough Estate, West Melton

An example of an area where some in-stream habitat has been included within the race network is at the entrance to the Claremont Subdivision (refer to Figure 11) and the Gainsborough Subdivision (West Melton) (refer to Figure 12). Both these race systems are within the Paparua Water Race Network. The Claremont Subdivision example shows the Waterholes Road water race, approximately 400 m upstream of the Project area and 700 m upstream of sample site 3. In these areas, the race banks have been flattened and the race is less incised. This has the potential to provide connectivity for spawning fish to the banks, also boulders and stones have been incorporated into the race bed and banks, and some riparian vegetation has been planted, enhancing the habitat.

Culverts and piping which are proposed for sections of the water races, can potentially impede fish passage by creating velocity traps for upstream migratory fish. The reduction in light and riparian vegetation along the culverted/piped sections may reduce spawning habitat, reduce bank stability, increase suspended sediments, alter the existing biological communities and reduce the availability of food sources. It is noted in Section 4 that there are already sections of piped water races and drains within the Project alignment and also elevated weir structures. In particular these are around road and rail crossings and driveways and are between 20 to 30 m long (but up to 870 m long) with pipe diameters of about 350 mm. Some of these existing piped sections are much longer than those proposed for this Project and likely form barriers to fish migration.

If the culverts/siphons and piped sections are designed with the invert at or under the level of the water race bed, fish passage can be maintained at the road crossings. However consideration should also be given to pipe diameter and the length over which the water race will be piped to ensure that where practicable they do not form a barrier for fish migration races. As noted in section 4 of this report, the proposed piped lengths may be between 50 m to 250 m long (and 2 km along SH1) and pipe diameters between 350 to 450 mm (600 mm along SH1). The flows in the road crossing pipes are not expected to increase significantly from the existing flows (about 0.3 to 0.4m/s) however the flows in the SH1 pipe may increase to about 0.8 m/s (refer to Technical Report No. 3 for further details) but water will not entirely fill the pipe. The 2 km section of pipe will provide a barrier to fish passage and remove aquatic habitat currently available to the resident communities. However as already noted the actual function of the race network itself forms an existing barrier, as the flow downstream of the races is controlled by flood gates and there are large piped sections of race network already. There are alternative routes up and down the race network for the fish inhabiting the races.

Whilst the piping may form a barrier to fish passage in some areas, it also has the potential to create a safe haven for fish on the upstream site of the barrier as the existence of such structures means that upstream fish habitats are likely to be virtually free of predators. In addition, some fish species may find protection by hiding just inside the pipe and with riparian vegetation proposed at the ends of some of the piped sections this has the potential to provide desirable habitat for fish as they enter and exit the pipes. This provides a benefit to the non-migratory species such as upland bully and non-migratory brown trout.

Further to this, it is proposed to install light wells and resting places (where possible) for fish at intervals of approximately 40 – 60 m along the piped sections of water race (including the Weedons Road, SH1, Robinsons Road piped sections and section north of Robinsons Road) and include baffles in these and all other piped sections of water races (including Waterholes Road under SH1 and CSM2, Trents Road, Blakes Road under CSM2, Marshs Road under Shands Road and CSM2 and Springs Road open channel under Springs Road).

The presence of a structure such as the baffles will provide variation in hydrology through the pipes and create eddys, backwaters and resting places for fish. The longer piped sections allow for the inclusion of light wells and resting places at the manholes to assist with fish passage.

In summary it is considered that the aquatic ecosystem present within the race network is highly adapted to the changing environment that is present including changes in water hydrology, water quality and physical habitat disturbance. Although, the physical habitat is not of a high quality, the race network does support a macro-invertebrate and fish population. It is noted that this is considered to be largely lacking in species diversity and abundance however it requires consideration and protection. In particular, in areas where the race network contributes to a more significant downstream receiving environment such as Upper Knights Stream and the Halswell River.

The proposed piping represents a loss to the aquatic habitat within the immediate proposal area. However there are other areas where new sections of race are being created and also riparian margins at each end of proposed piped sections and these areas provide an opportunity to minimise the loss of habitat by enhancing the riparian and instream habitat for the aquatic ecosystem. In such areas, it is recommended that riparian planting be incorporated. This is addressed in Technical Report No. 7 and indicated on Drawing No's 62236-A-L011 to L018 and 62236-B-L011 to L024 (contained within Volume 5 of the application). Such plantings should be consistent with the SDC Planting Guide for Water Race Margins and should be incorporated as part of the proposal to mitigate effects on aquatic values.

Overall it is considered that the effects of the Project will not adversely affect the wider existing aquatic system with the recommended landscaping including riparian plantings, alternative routes for fish passage and other mitigation proposed in Section 8.

Sedimentation

Fine sediments can smother aquatic flora and other aquatic life living on the bed of the races/drains. Suspended sediment also has the potential to affect fish and invertebrates by interfering with their gills and changes in the visual clarity of the water can affect the ability of fish to see their prey. The reduced light penetration throughout the water column can affect benthic algae, periphyton and macrophyte growth and in turn can reduce the food sources for many freshwater species.

It is noted that at Marshs Road where the turbidity levels exceeded the ANZECC (2000) guideline levels, no fish were caught and the macro-invertebrate community was typical of a pollutant tolerant environment.

The Project's CEMP including the Erosion and Sediment Control Plan is expected to control and minimise the volume of sediment entering the races to such an extent that negligible (if any) adverse effects on freshwater ecology are predicted from the proposed activity. In addition, riparian plantings recommended as per Technical Report No. 7 and Drawing No's 62236-A-L011 to L018 and 62236-B-L011 to L024 (contained within Volume 5 of the application) have the potential to provide some stabilisation to the race banks in those areas further reducing sedimentation and bank erosion.

Temporary increases in turbidity from storm events or construction activities are unlikely to occur due to sediment and erosion control measures proposed in the CEMP. If any effects as a result of construction activities do occur, it is not expected to negatively affect the freshwater ecosystems. Given that they are already modified and subject to activities that create sedimentation and increase turbidity in the water column, such as cleaning of silt and weeds in the races as part of routine maintenance. Biological communities in these environments are tolerant to a wide range of environmental events including increased flood flows and as such have good tolerance to a variable habitat.

7.3 Operational Effects

The operational effects include those on-going effects associated with the freshwater ecosystem and downstream receiving environment as outlined in the sections below.

7.3.1 Effects on freshwater ecosystem

The three main potential long-term effects from the on-going operation of the Project on freshwater ecosystems include:

- Reestablishment of habitat and adaption of fish to modified habitat resulting from the required water race realignments;
- Loss of habitat due to piping of sections of some of the water races; and
- Sedimentation and contamination in stormwater runoff from road surfaces.

Habitat disturbance in relation to construction effects is detailed in Section 7.2.1 above. These matters and proposed mitigation are also relevant to operational effects. During the operation of the motorway, aquatic ecosystems will have to re-establish within and adapt to the newly created race sections. In essence this would be similar to the temporary adaptation that the existing ecosystem must make during times of race closures and routine maintenance. Given this regular temporary disturbance, it is likely that the ecosystems are adapted to such changes and are able to find alternative routes along the race network as/when required.

As a result of piping sections of water races, there is likely to be loss of physical habitat, including loss of riparian vegetation which may impact water temperature. There may be changes to flow regimes (i.e. water volumes and velocities) through the piped sections and these sections may form impediments to fish passage and reduce the quality of spawning habitat. However it is noted that given the incised nature of the water race banks, spawning habitat within the Project area is assumed to be limited. In addition, existing maintenance works carried out by SDC does not take into account fish spawning times with the activities being carried out whenever required. As such it is not anticipated that the water race network provides a desirable spawning habitat.

It has been identified that there will be some loss of physical habitat as a result of piping sections of the races. As such, proposed landscaping is recommended as detailed in Technical Report No. 7, Drawing No's 62236-A-L011 to L018 and 62236-B-L011 to L024 (contained within Volume 5 of the application). The creation of new habitat in the diverted sections should provide improvements to the physical habitat and encourage the colonisation of a healthy instream community over time through riparian planting. Once established, the riparian vegetation may provide an ecological bridge for fauna species to neighbouring areas, provide a sediment and erosion control facility and provide a buffer for land runoff before it enters the water race.

Furthermore, improved stormwater systems will result in a reduction of runoff into the race network and over time the water quality and ecosystems in the system may improve and this will go some way to mitigating against the habitat loss. In addition, an improvement in water quality is particularly important for the downstream receiving environment and this meets the requirements of the SWAP and the community aspirations for the Halswell River catchment.

The piped sections may form a barrier to fish migration, however such piped sections already exist within the race network and in addition the extensive network allows for alternative routes, meaning fish can still move freely upstream and downstream and should not become trapped in a particular area of race. Mitigation such as light wells, resting areas and baffles within the pipes will assist with fish passage along the pipes. The alignment of the piped sections should be consistent with that of the natural water race environment and not include any steep drops or perched sections which would make the system impassable to most fish species and may result in fish being trapped either upstream or downstream of the piped section.

It is recommended that an alternative alignment or diversion of the SH1 race into adjacent lateral races should be investigated further if the race cannot maintain its open nature (with wire rope barrier). If no alternative is possible then light wells and resting areas should be included along the pipe lengths to assist with fish passage.

It is not considered that freshwater ecosystems within the Project area will be affected by sedimentation and contamination and the discharge of stormwater during operation. As part of the Project design, stormwater discharge will be via land and not directly to the water race network. This is an improvement on the current situation where the stormwater discharges directly to the race network.

Embankment runoff from the ponds located within the Weedons Road interchange may run down the new embankments and into Weedons Road water race. The runoff will be treated and only occur on an infrequent basis (1 in 100 year 24 hour rainfall event). As noted, these races currently received untreated runoff from the adjacent road and banks and it is not expected that any treated runoff will effect water quality and instream ecosystems.

In addition, clean de-watering water may be discharged into Montgomery's Drain. However, the only phase where there is potential for stormwater to enter a waterway is in the exceedence of a 100 year ARI design storm event at the Maize Maze (adjacent to Halswell Junction Road) pond. Following treatment, water may be discharged into Montgomery's Drain. However, this discharge would be treated and diluted having gone through the first flush and the detention basin system. Currently Montgomery's Drain receives stormwater runoff from Halswell Junction Road and as part of the CSM1 Project it will also receive runoff.

7.3.2 Effects on downstream receiving environment

The key effect on the downstream environment relate primarily to contamination and water quality issues as a result of the Project stormwater system.

As described in Section 4, the highly modified and controlled race network feeds into the Upper Knights Stream via Montgomery's Drain. Activities that occur upstream have the potential to impact on those waterways and adversely affect the ecological values.

As part of the Project, there is no direct discharge (and no indirect discharge expected) to any water race or drain except in exceedence of a 100 year ARI design storm event into Montgomery's Drain, or clean de-watering water into this Drain. However this discharge will be infrequent (exact frequency is uncertain, more work is currently being carried out as part of Technical Report No. 3, however in essence this is likely once every 100 years) and is of treated stormwater. As such the water quality is expected to be of a quality that will not impact on the receiving environment and will comply with the standards specified in the NRRP. The drain currently receives untreated stormwater runoff from Halswell Junction Road and will also receive runoff as part of CSM1. As part of this Project any runoff will be treated and as such water quality in the receiving environment should over time improve.

If water quality is poor in the upper catchment then the potential for good water quality further down the river is reduced as cumulative effects of discharges moving downstream tend to worsen rather than improve water quality. The downstream reaches of the Halswell River have the potential to be affected by discharges from the motorway if adequate treatment is not provided. With the Projects proposed stormwater treatment system in place (which is an improvement on the existing "no treatment" situation), there is potential for the downstream water quality to improve over time. Improving water quality in the Halswell River may in turn improve the ecological health in the river, both of which are aims of the SWAP and an aspiration of the community.

Furthermore, the water race network coming off Springs Road that currently feeds into Montgomery's Drain and then Upper Knights Stream will be diverted away from the road and will retain an open channel structure. This provides an opportunity for landscaping to enhance the instream habitat by providing riparian planting and possibly incorporating other instream features such as boulders and rocks as discussed in Section 7.2.1. It is recommended that such enhancement be carried out. All these things are likely to improve the habitat by providing potential flow variation and habitat and will mitigate the loss of habitat arising from the proposal. Riparian planting of the realigned banks will provide shading (regulate water temperatures) and provide potential food inputs for aquatic ecosystems and also stabilise the banks and help reduce any bank erosion. Further, increasing vegetation diversity and density along the realigned race banks will also provide a sink for trapping sediment, toxins or nutrients entering the water, further protecting water quality.

The proposed future lowering of groundwater under the ponds and resultant discharge into Upper Knights Stream is not expected to have an adverse effect given the infrequent nature and nature of the discharge (clean water). Measures are proposed to ensure that sediment and erosion into the waterway is minimised by ensuring the outfall structure has protection such as rip rap to prevent scouring of the bed. Further, it is proposed (refer Technical Report No. 3) that the flow out of the pipe will be controlled to an extent where there is no significant variation in flow in the stream following rain then the net effect increase in flow is insignificant.

As such the Project, over time, is likely to provide an overall beneficial effect on the downstream receiving environment.

7.4 Overall Summary

It is considered that over time, areas of both new and existing water race habitat can be enhanced and water quality improved and a more natural character achieved. Some areas of aquatic ecosystem habitat will be lost but alternative routes along the race network will ensure that fish passage is maintained. Proposed plantings will improve the existing environment in the areas that remain, such that the effects of the proposal will be minor on aquatic ecology values.

Overall, with appropriate culvert and pipe design, ensuring alternative routes along the race network are provided, implementation of sediment and erosion control measures and riparian planting, it is considered that the effects on this already modified environment will be minor.

8. Mitigation measures and recommendations

Given the limited water ways within the alignment and mitigation measures recommended below, it is anticipated that effects of the proposed activity on the ecological environment will be acceptable with the implementation of appropriate mitigation measures.

The following mitigation measures are recommended to minimise effects on aquatic habitat values pre and during construction and operation. Many of these will be implemented through the CEMP and the remaining are recommended to be included as conditions of consent.

It is understood that the NZTA is comfortable with the recommended mitigation.

8.1 Prior to Construction

- Development and implementation of a CEMP including Specialised Environmental Management Plans (SEMP's) such as the Erosion and Sediment Control Plan (SEMP002) (contained within Volume 3 of the application);

- Development of a re-vegetation plan that is underpinned by ecological principles - to enhance the natural character, rehabilitate aquatic ecosystem community diversity and heterogeneity and mitigate habitat loss and disturbance. Such a plan should be consistent with areas identified in Technical Report No. 7 and associated plans (Drawing No.s 62236-A-L011 to L018 and 62236-A-L011 to L024, Volume 5) and SDC Planting Guide for Water Race Margins and include the terrestrial components as recommended in Technical Report No. 18;

- The alignment of the piped sections will be consistent with the water race environment and should not include any steep drops or perched sections;

- No planned refuelling or maintenance of construction equipment, nor equipment to be parked adjacent to freshwater environments for a significant time. Readily available spill kits for land and water to be kept on site with trained personnel;

- Educate employees of environmental responsibilities during inductions, in accordance with the CEMP;

- During the detailed design phase, investigate the option of alternative alignments for the water race sections that require piping/siphons as a result of the Project. Focus should be given to an alternative option for the piping of the SH1 water race such as a new alignment away from the motorway, diverting the race into lateral races or retaining the open race and installing a wire rope road side barrier on the motorway side of the race. This should be carried out in conjunction with SDC as the race network operators; and

- During detailed design, provide for the inclusion of light wells, resting areas and baffles along the piped sections to assist with fish passage.

8.2 During Construction

The following mitigation measures should be implemented at a minimum to minimise potential environmental impacts resulting from construction related activities:

- Until impacted riparian margins have been stabilised and works completed on the piped sections, outfall, culverts and any realigned sections, erosion control mechanisms, such as silt fencing and straw mulching, should be maintained to limit sedimentation of waterways arising from the works. This should be addressed in the CEMP and associated Erosion and Sediment Control Plan. Such measures should be in place even if the works occur in the dry bed;
- Care should still be taken to ensure that works do not affect the passage of fish or cause stranding of fish in pools or channels. For example, if a section of water race requires dewatering to enable the pipe to be installed, then the section of race should first be closed off at one end and time allowed for fish to move down the system before works commence. Observation should be made, especially of pooled water to ensure fish are not trapped and have moved out of the area. If there are trapped fish then these should be removed prior to works commencing and the site being dewatered;
- Carry out all instream works in the dry bed with water to the race network being shut off or bunds being put in place around the works area and water diverted around it to enable the works to occur in the dry bed. As detailed above, observations should be made of the area to ensure that fish are not trapped and if any are observed, they should be captured and moved to another section of the race network;
- Culverts are designed and constructed to provide for fish passage by making culvert inverts at or below bed level so as not to form a barrier during low flows;
- The outfall structure at Upper Knights Stream shall be designed to ensure erosion to the banks and souring and erosion of the bed of the stream does not occur;
- Any riparian vegetation required to be removed to construct the outfall shall be replaced with like vegetation immediately following the completion of work on the structure;
- Implement waste management devices at outflows to reduce waste loads entering freshwater environments, in accordance with the CEMP;
- Construction activities related to the water races to be limited to designated areas within the culvert/pipeline construction sites. Where possible, heavy machinery should be kept away from the banks to minimise potential for bank collapse;
- Appropriate design and construction of culverts and pipelines, including lining with appropriate material where possible to reduce potential for fines to be moved into the freshwater environment;
- Programme construction activities to avoid where practicable excavation of soils adjacent to freshwater environments during heavy rainfall and flood events, in accordance with the CEMP;
- Establish appropriate access corridors and ensure employees and vehicles do not leave the designated corridors, in accordance with the CEMP;
- All construction activities to occur within safe weather conditions to minimise impacts to the surrounding environment, in accordance with the CEMP;
- Works to install culverts and pipes avoid unnecessary modification of the water race bed and channel. Avoid large areas of concrete channelling as this reduces the connectivity of the

water race and eliminates instream habitat and potential food sources for instream organisms; and

- Re-vegetation plans to be underpinned by ecological principles and scientific advise ensuring stream quality and habitat integrity is maintained and habitat loss and disturbance is mitigated;
- Where appropriate, riparian planting should promote ecological linkages and provide potential fish spawning habitat;
- Monitoring and clearing of waste in freshwater environments is to be carried out in accordance with the CEMP;
- Consultation shall be carried out with SDC during the implementation of the planting plan and the plan should take into account the SDC Planting Guide for Water Race Margins;
- Careful riparian planting is recommended to ensure that sediment inputs from runoff from the road do not reach the water races and provides enhancement opportunities for the physical habitat whilst mitigating any potential effects of the runoff. Vegetation (such as native sedges to trap sediment) should be planted for a width greater than just the edge of the bank. This type of mitigation, whilst it takes up more land, can add ecological and amenity values to the area and encourages both in-stream ecosystems and provides habitat for terrestrial species. Proposed planting areas are identified in Technical Report No. 7 and associated plans (Drawing No.s 62236-A-L011 to L018 and 62236-A-L011 to L024, Volume 5) ; and
- All disturbed areas adjacent to the water races should be re-grassed as soon as possible. If it is outside of the growing season, the disturbed areas should be covered with mulch.

9. Conclusion

The Christchurch Southern Motorway Stage 2 (CSM2) Project seeks to construct a four-lane median separated motorway. The Project also includes widening and upgrading of Main South Road to provide for a four-lane median separated expressway along the existing arterial route (MSRFL).

This aquatic ecology investigation assesses the waterways within the Project footprint (water races between Rolleston up to and including Marshs Road) administered by Selwyn District Council (SDC) and from north of Marshs Road to Halswell Junction Road (including Montgomery's Drain) which are administered by the Christchurch City Council (CCC). It addresses a range of potential impacts resulting from construction and operation of the Project.

The aquatic risk assessment address the assessment of baseline (existing) conditions, consideration of potential impacts on environmental matters and determination of possible mitigation measures to minimise the potential impacts. Whilst specific mitigation measures are detailed in the Risk Assessment (Section 7.1), consideration is also given to the NZTA Environmental Plan. Opportunities for enhancement such as riparian planting and including in-stream features within stretches of water race will assist with promoting biodiversity on the transport network and therefore contribute to improving eco-system corridors consistent with ecological objectives of this Plan.

Development of land adjacent to a waterway can result in channelisation, modified riparian vegetation, development within the flood plain and restricted stream connectivity to the floodplain. The effects of development activities may lead to poor habitat quality, resulting in silt-laden macrophyte dominated beds and community composition dominated by pollutant tolerant species.

The key impacts of the Project on the modified aquatic ecosystems relate predominantly to construction and operational effects. The risk assessment detailed in section 7.1 considers potential impacts on environmental matters and recommends a range of mitigation measures to reduce the initial risk rating. It is though intended that these risk assessments would be revisited as part of the management review to ensure significant risks are properly addressed.

The implementation of mitigation measures will predominantly be under the management and responsibility of the NZTA. The CEMP and the supplementary Specialised Environmental Management Plans (SEMPs) detail the principles, practices and procedures to be implemented to manage, remedy and mitigate potential adverse environmental effects. The identified risks and recommended mitigation measures in this aquatic assessment are included in the CEMP and the relevant SEMP. These documents should be consulted by all Project team members when undertaking Project construction activities near, adjacent or within aquatic environments.

Investigations of the water races within the Project identified an already modified and channelised environment. All five races sampled (Weedons Road, Robinsons Road, Hamptons Road, Trents Road and Marshs Road) were impacted by marginal habitat with poor cover and silt laden substrate, a good macro-invertebrate diversity but dominated by pollutant tolerant species, and a reasonably poor fish diversity and abundance. These results are consistent with other Christchurch soft bottom streams (both urban and semi-urban). The additional fours sites (SH1, Blakes Road, Springs Road open channel and Montgomery's Drain) were observed to also have marginal physical habitats.

The water races and drains do not currently exhibit any true natural character as they are highly modified and controlled environments. It possible to protect the downstream receiving environment by ensuring that any stormwater discharge is of an acceptable level of water quality and meets the requirements set out in the NRRP. The current system discharges untreated stormwater directly to the water race network (via direct run-off), impacting flora and fauna within the Project are and receiving environment. The current Project proposes to monitor the quality of the stormwater discharge by ensuring the requirements set out in the NRRP are met. Rather than discharging to the water race network, the Project proposes an improvement to this system by discharging stormwater to land, with treatment systems in place. Rather than acute exposure to an untreated discharge, some contaminants may bind to the sediment matrix removing them from the system. This may reduce the overall impact to flora and fauna species exposed to contaminated sediments and water. The effectiveness of contaminant removal depends on a wide range of environmental factors including, vegetation cover, width of the riparian vegetation buffer, soil permeability and soil saturation. The long-term benefits of discharging stormwater to land may result in an improvement to water quality within the water races and downstream receiving environment with a subsequent improvement in in-stream community health (ie, diversity and abundance).

With the recommended mitigation and improved stormwater system reducing runoff into the water races as part of the Project, over time the quality of the environment is expected to improve. The systems recommended for this entire Project have taken into consideration the NRRP requirements and principles outlined in the SWAP which aims to replicate the natural environment, protect and improve water quality and quantity, manage flood risk, and maintain and improve natural habitats.

While the proposed piping and realigning of sections of races may disturb (short term during works) and reduce the available habitat for aquatic ecosystems (including fish and macroinvertebrates) in the immediate future, it is anticipated that in the long term the habitat will improve. This is a result of the proposed improved stormwater treatment resulting in less runoff (contaminants and sediment) to the races and via the implementation of a number of mitigation measures that have been recommended to minimise aquatic impacts.

These include ensuring only essential construction activities occur within the boundaries of water races to maintain bank stability, and bunding construction sites to reduce fines entering the freshwater environment. Construction and operational remediation includes restoration of riparian vegetation buffers along sensitive sections of the water races. The function of these areas will aim to reduce sediment fines entering the adjacent water races, restore and enhance the native terrestrial flora habitat, and restore water race bank habitat for instream fauna (ie, bank shading and vegetative inputs for food and fish habitat.

It is not expected that the discharge of contaminants or water to land where contaminants could enter is likely to give rise to any significant adverse effects on aquatic life.

The potential effects of the Project on the aquatic ecosystem relate to construction and operational effects. Given the already highly modified and controlled environment with a limited aquatic ecosystem, it is considered that, with the recommended mitigation measures in place, the Project will have a minor effect.

APPENDIX A

Example habitat assessment sheet

Habitat Assessment

Stream Name:_____________________ **Photo No.** ________ **Number of pottles:** _____

Site No. _____________ **Sample No.** ___________ **Date:** _____________ **Weather:** _________________

Water Clarity: (1) clear (2) opaque (3) turbid **Water colour:** (0) clear (1) brown/yellow (2) green (3) milky/grey
Easting_________________ **Northing**__________________ **Temp**________ **Cond**________

Catchment Scale Features

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Broad scale catchment landuse upstream – affecting stream inputs	Undisturbed native vegetation – forest, scrub or tussock	Disturbed native vegetation and/or exotic forest and/or low intensity grazing	moderate intensity pastoral landuse or low impact horticulture	Intensive pastoral landuse (dairy/deer) to intensive horticulture, urban/industrial
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Immediate landuse beyond the riparian zone at site	Undisturbed native vegetation – forest, scrub or tussock	Disturbed native vegetation and/or exotic forest and/or low intensity grazing	moderate intensity pastoral landuse or low impact horticulture	Intensive pastoral landuse (dairy/deer) to intensive horticulture, urban/industrial
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Riparian and Bank Features

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Width of natural Riparian Vegetative Zone to nearest human influenced landuse (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
Riparian vegetation type (score each bank riparian zone)	Dominant vegetation type is undisturbed native shrub or forest with understory, wetland vegetation, tall tussock grasses	Dominant vegetation type is introduced trees (willow, poplar, conifers), and/or mixed scrub with some loss of under story	Relatively ungrazed or unmanaged exotic grasses, scrub, rocks, gravel etc.	Highly grazed or mown surfaces, pasture grasses and weeds, through to bare ground, roads, buildings
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Habitat Parameter	**Category**			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
	Riparian vegetation	Occasional breaks or scars in	Breaks in vegetation cover	Vegetation sporadic through

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Completeness of Riparian vegetation cover between stream and adjacent landuse	provides complete ground cover with no appreciable breaks or tracks	vegetation cover (1-5 in reach)	common (6-10+), some active erosion evident.	to bare land/active erosion
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1

Reach Scale Parameters

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Frequency of Riffles (or bends) / Velocity-Depth Combinations	Great diversity of channel widths and depths forming a series of riffles, runs and pools; large variation in velocity throughout the stream (all 4 velocity/depth patterns present)	Little diversity in channel width, good diversity in stream depth, velocity still variable throughout stream. (3 velocity/depth patters present).	Little diversity in channel width and depth, velocity within channel only slightly variable. (2 velocity/depth patterns present)	No change in both channel width and depth, constant velocity throughout channel (or no velocity).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Channel Sinuosity (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
easily rated in these areas.)				
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills 75-50% of the available channel; or <50% of channel substrate is exposed.	Water fills 25-50% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

In-stream habitat quality parameters

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Instream habitat/ Roughness - Cover for instream fauna.	Greater than 70% of substrate favourable for faunal cover/ utilisation and fish cover – mixture of cobble, boulder, snags, undercut banks etc.	40-70% cover of suitable habitat including cobbles, boulders logs and snags	Only 20-40% cover is suitable habitat – habitat dominated by fine or unstable sediments, lack of instream cover features	Little stable cover or habitat, substrate open, fine, unstable.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Substrate heterogeneity and quality	Wide range of substrate sizes (<4), of angular nature and well packed, no size class > 50%. Bedrock, Boulder (>25), Large cobbles (12-25), Small cobbles (6-12), Gravel (0.5-6), Sand (<0.5), mud/silt.	3-4 size classes, some interstitial spaces filled with silt, no size class > 50%.	2-3 size classes, interstitial spaces rare, usually dominated by > 50% one class	One or two cobble sizes dominate substrate, cobbles more rounded and loser packing, interstitial spaces rare
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 30-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 55-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	5 10 15 20 25%	30 35 40 45 50 %	55 60 65 70 75 %	80 85 90 95 100 %
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends;	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
			moderate deposition of pools prevalent.	deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Emerged Macrophyte presence	Rooted macrophytes largely absent (less 20 %) – stony substrate with periphyton or moss/bryophytes, not obstructing flow patterns	Small areas of rooted emerged macrophytes (20 to <50%) in flowing channel, not obstructing flow patterns	Significant (≥50 – 80 %) of bed or channel affected by emergent macrophytes on edges, reducing water velocities in places	Emerged macrophytes dominate channel and clogging waterway, 80 – 100%
SCORE ___	10 9	8 7 6	5 4 3	2 1

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
Submerged Macrophyte presence	Rooted macrophytes largely absent (less 20%) – stony substrate with periphyton or moss/bryophytes, not obstructing flow patterns	Small areas of rooted submerged macrophytes (20 to <50%) in flowing channel, not obstructing flow patterns	Significant (≥50 – 80%) of bed or channel affected by submerged macrophytes in channel reducing water velocities in places	Submerged macrophytes dominate channel and clogging waterway, 80 – 100%
SCORE ___	10 9	8 7 6	5 4 3	2 1

APPENDIX B

Specific Site Survey Results

Site survey summaries

Site 1 - Weedons Road

The Weedons Road water race had a marginal overall habitat, with a poor catchment area dominated by rural/rural residential and intensive horticulture/ pastoral landuse and poor riparian vegetation of approximately 6 m width (although relatively complete cover of what was there). In addition, being a modified environment, the race has poor reach scale features typical of a race such as constant width (approximately 1.3 m), depth (average 0.3 m deep) and flow (0.2 to 0.4 m/s, bank edge to mid race) and a straight channel. In-stream habitat parameters were marginal with a substrate dominated by silt and fine sediment but some cover available for fish in undercut banks and limited overhanging vegetation. Two fish species were observed from the water race, brown trout and common bully, although in very low numbers (4 and 1, respectively). The common bully is a migratory species so requires access to the sea, although brown trout can also spend their entire lives in freshwater. Both species are common in other water races and streams around Christchurch. Macro-invertebrate presence was dominated by snails and a taxonomic richness dominated by pollutant tolerant species. A moderate percentage of EPT taxa were recorded, although these taxa were only recorded in low numbers. Water quality parameters measured were within the relevant guideline limits. Weedons Road water race has a habitat and aquatic ecosystem typical of other race systems within Christchurch, with both a depauperate fish community, and a macro-invertebrate community dominated by pollutant tolerant species.

Site 2 - Robinsons Road

The Robinsons Road water race had a marginal overall habitat, with a poor catchment area dominated by rural/rural residential and intensive horticulture/ pastoral landuse and poor riparian vegetation of approximately 6 - 12 m width (although relatively complete cover of what was there). Some shading to the race was provided by the riparian vegetation on the right bank (evergreen conifers). Like Weedons Road, being a modified environment, the race has poor reach scale features typical of a race such as constant width (approximately 0.9 to 1 m), depth (average 0.3 m deep) and flow (0.1 to 0.2 m/s, bank edge to mid race) and a straight channel. In-stream habitat parameters were poor with a substrate dominated by silt and fine sediment and minimal cover available for fish. However, three fish species were observed from the water race (in low number), being brown trout, common bully and upland bully. All three species are common in other water races and streams around Christchurch. Upland bullies are non-migratory and therefore do not require access to the sea, although it is important to maintain access for other fish species. Macro-invertebrate presence was dominated by snails and other pollutant tolerant species. The percentage of EPT taxa was moderate however the actual abundance of EPT taxa was low with these species only recorded in low numbers. Water quality parameters measured were within the relevant guideline limits. Robinsons Road water race has a habitat and aquatic ecosystem typical of other race systems within Christchurch, with both a depauperate fish community and a macro-invertebrate community dominated by pollutant tolerant species.

Site 3 - Hamptons Road

The Hamptons Road/Waterholes Road water race had a marginal overall habitat, with a poor catchment area dominated by rural/rural residential and intensive horticulture/ pastoral landuse and poor riparian vegetation of less than 6 m width (although relatively complete cover of what was there). Some shading to the race was provided by the evergreen conifers on the left bank. In addition, being a modified environment, the race has poor reach scale features typical of a race such as constant width (approximately 1.1 m), depth (average 0.2 m deep) and flow (0.1 to 0.4 m/s, bank edge to mid race) and a straight channel. In-stream habitat parameters were marginal with a substrate dominated by silt and fine sediment but some cover available for fish in macrophytes and limited overhanging vegetation. Two fish species were observed from the water race; common bully and upland bully, both in relatively high numbers. As common bully is a migratory species, it requires access to the sea, so it is important for fish passage to be maintained. Both species are common in other water races and streams around Christchurch. Macro-invertebrate presence was dominated by the caddisfly, *hudsonema*, and the site had a relatively high taxonomic richness, with 22 species identified. A moderate percentage of EPT taxa were recorded, although these taxa were only recorded in low numbers. Water quality parameters measured were within the relevant guideline limits. Hamptons Road water race has a habitat and aquatic ecosystem typical of other race systems within Christchurch, with a depauperate fish community (although good numbers of the two species present) and a macro-invertebrate community largely dominated by pollutant tolerant species.

Site 4 - Trents Road

The Trents Road water race had a marginal overall habitat, with a poor catchment area dominated by rural/rural residential and intensive horticulture/ pastoral land-use and poor riparian vegetation of less than 6 m wide (although relatively complete cover of what was there). This vegetation however provided little in the way of in-stream cover and shading. In addition, being a modified environment, the race has poor reach scale features typical of a race such as constant width (approximately 0.9 m), depth (average 0.22 m deep) and flow (0.1 to 0.4 m/s, bank edge to mid race) and a straight channel. In-stream habitat parameters were marginal with a substrate dominated by silt and fine sediment but some cover available for fish in areas of macrophytes. Two fish species were observed from the water race; common bully and upland bully, both in relatively high numbers. As common bully is a migratory species, it requires access to the sea, so it is important for fish passage to be maintained. Both species are common in other water races and streams around Christchurch. Macro-invertebrate presence was dominated by snails and a relatively diverse taxonomic richness although one dominated by pollutant tolerant species. A moderate percentage of EPT taxa were recorded, although these taxa were only recorded in low numbers. Water quality parameters measured were within the relevant guideline limits. Trents Road water race has a habitat and aquatic ecosystem typical of other race systems within Christchurch, with a depauperate fish community and a macro-invertebrate community dominated by pollutant tolerant species.

Site 5 - Marshs Road

The Marshs Road water race had a marginal overall habitat, with a poor catchment area dominated by urban/industrial and intensive horticulture/ pastoral landuse and poor riparian vegetation of less than 6 m wide with some breaks in the vegetation cover evident. In addition, being a modified environment, the race has poor reach scale features typical of a race such as constant width (approximately 1.0 m), depth (average 0.18 m deep) and flow (0.1 m/s) and a straight channel. In-stream habitat parameters were marginal with a substrate dominated by silt and fine sediment and limited cover available for fish with the site lacking riparian cover, overhanging vegetation or undercut banks. Water quality parameters measured were within the relevant guideline limits except for two exceedances, turbidity and total phosphorus.

No fish species were observed from the water race and this is likely a reflection of the poor habitat environment and poor water quality. Riparian vegetation is reduced by mown grass and banks sprayed for weeds, leaving the race exposed to the sun, with riparian vegetation providing no in-stream cover. Macro-invertebrate presence was dominated by snails and a taxonomic richness dominated by pollutant tolerant species. A moderate percentage of EPT taxa were recorded, although these taxa were only recorded in low numbers. Marshs Road water race has a habitat and macro-invertebrate ecosystem typical of other race systems within Christchurch, with a depauperate macro-invertebrate community dominated by pollutant tolerant species and no fish species observed.

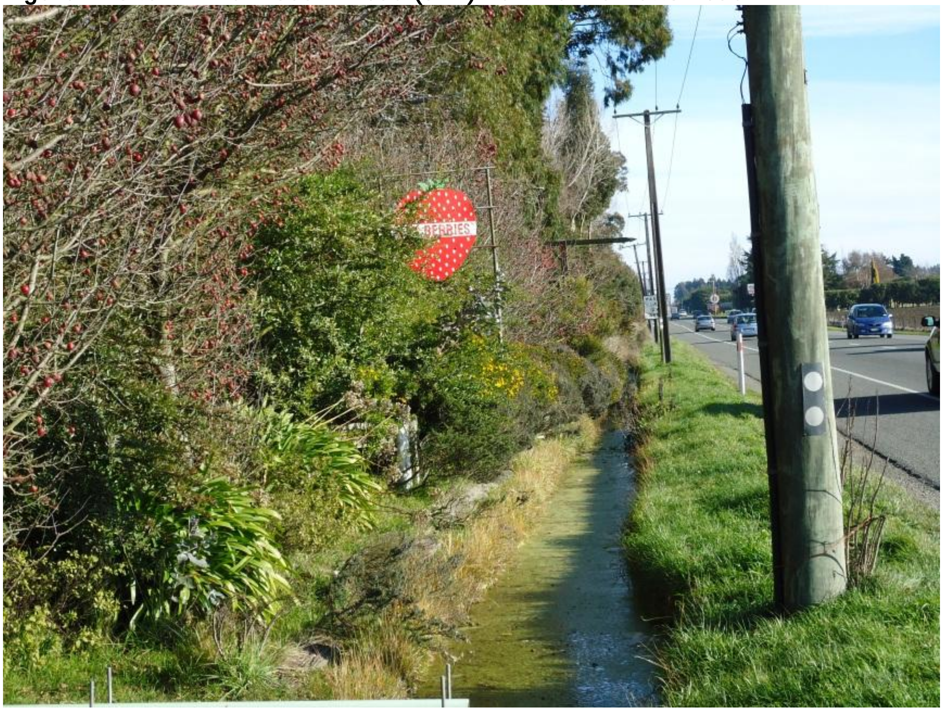
Additional observation sites

A brief description and photos of the additional sites observed during the site visits is provided below. As already outlined, these sites were not sampled as part of the field work due to them being dry on all occasions they were visited (sites C and D). In addition, sites A and B were lateral races of the main water races surveyed and were located adjacent to these races. As such, they were not sampled.

Site A – Main South Road (SH1)

Figure 1 Site A – Main South Road (SH1) near Berketts Road

Figure 2 Site A – Main South Road (SH1) north of Berketts Road



Site B – Blakes Road

Observations show that Site B is a similar width as the water races surveyed (about 1 m wide). Riparian cover consisted predominantly of a narrow strip (about 2 m wide) of mown grasses on the road side of the race (refer to Figure 3 and Figure 4). This race was located near to site 4 (Trents Road) and had similar riparian cover features to that site over some of the reach (refer to Figure 3) and mown grass consistent with residential gardens in other areas (refer to Figure 4).

Figure 3 Site B – Blakes Road

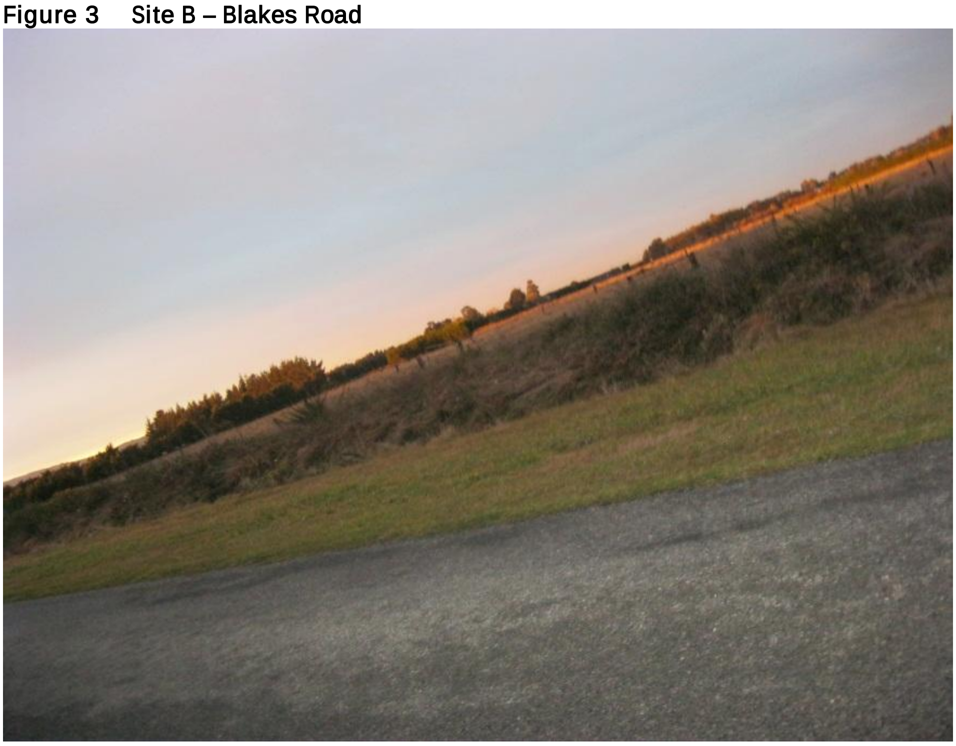


Figure 4 Site B – Blakes Road

Site C - Montgomery's Drain

This drain was not sampled as part of the field work due to it being dry and all occasions it was visited. It is not known to contain flow.

Montgomery's Drain) is piped along Halswell Junction Road between SH1 and Springs Road for a distance of approximately 2 km. From Springs Road it runs along an open channel (Figure 5) for a distance of approximately 500 m before going through an elevated inlet structure (Figure 6) into another piped section (about 100 m) until it discharges into Upper Knights Stream (also dry in this stretch).

Little information is available about the ecosystems of this drain as it is piped over such large distances and very rarely flows. The inlet structure and long lengths of piped sections of the drain would form a barrier to fish passage if the drain did sustain a consistent flow. The field investigation showed no significant riparian bank vegetation, with mown grass and hardstand of Halswell Junction Road on the left hand bank and a mix of hardstand, mown grass and grazed pasture grasses on the right bank. In addition, the drain currently receives stormwater runoff from Halswell Junction Road and will receive overflow from the Owaka Basin as part of CSM1.

Figure 5 Montgomery's Drain

Figure 6 Intake structure on Halswell Junction Road

Site D – Springs Road open channel

No information is available on this channel and it was unable to be sampled during the site investigation as there was no flow in it during any of the site visits.

Figure 7 Springs Road channel

Observations show that it is a similar width as the water races surveyed (about 1 m wide). Riparian cover consisted predominantly of mown grasses and was only a narrow strip (about 2 m) on the road side of the channel (refer to Figure 7). Figure 7 is taken along Springs Road, adjacent to John Paterson Drive, looking towards Halswell Junction Road.

Figure 8, taken along Springs Road, adjacent to Busch Lane, looking towards Marshs Road, showed evidence of areas where spraying has occurred on the banks and no cover was present.

Figure 8 Springs Road channel

APPENDIX C

Risk assessment methodology

Environmental Risk Assessment Methodology

Risk analysis may be undertaken to various degrees of refinement depending upon the risk information and data available. Analysis techniques include qualitative assessment, semi-quantitative assessment, and quantitative assessment.

In practice, a qualitative analysis is often used to first obtain a general indication of the level of risk and then a more quantitative analysis is applied to refine the risk.

A quantitative risk assessment can be undertaken based on statistical analysis for various consequences and probabilities. In the absence of statistical data, an estimate may be made of the degree of the consequence and frequency (refer to Section 4.3 of the Standard).

The risk assessment methodology for this AEE uses a semi-quantitative process for determining risk. The semi-quantitative process estimates the degree of the consequence and probability and assigns a score to each. The risk and impact assessment process used here to assess and weight potential Project risks was undertaken using an Environmental Risk and Likely Impact ('ERLI') approach. For each possible impact aspect, two key areas were addressed:

- Environmental risk; and
- Likely impact.

Limitations

As with any model, the relevance and applicability of the risk model revolves around a number of basic assumptions and limitations. The application of the risk model has been based on subjective ranges of consequences and probabilities.

The limitations of the application of the risk methodology for this assessment include:

- The assessment has been limited to a selected number of primary risks and the assessment of cumulative risk to the environment from multiple pollution sources or sources of environmental degradation has not been addressed. Cumulative risks are approached for this study in a qualitative manner only.

Although a semi-quantitative methodology was used to conduct the risk assessment, the resultant risk estimation is purely relative. The risk estimations do not imply an absolute scale of risk that can be applied to any other situation or assessment.

Environmental Risk

This essentially considers the risk of irreversible change to natural ecological processes and community interaction. Assessment addresses:

- Conservation significance of environmental, social and cultural values and regional context of these values;
- Current level of integrity of natural ecosystem processes;

- Known sensitivity of ecosystem processes/natural values to human induced change;
- Natural change and resilience of relevant ecosystem processes/natural values;
- Potential for cumulative social and environmental impacts; and
- Level of scientific certainty of the above factors.

Likely Impact

The considered likely impact of the Project, as modified and undertaken in accordance with mitigation strategies (including any environmental management plans or conditions from approval agencies) and includes:

- Geographic extent of the activities;
- Duration of the activities;
- Magnitude of potential environmental change;
- Confidence in prediction of impact;
- Confidence in mitigation strategies to minimise ecological risks; and
- Ability to monitor the impacts and detect change before irreversible change to system processes occurs.

The approach considered direct and indirect impacts, short and long term, cumulative, temporary and irreversible, and adverse and beneficial impacts.

The relative importance of each impact was examined to provide context and an ability to determine the impact's significance. In particular, the duration of the impact (temporary vs. permanent) and reversibility were considered. The ability of natural systems (including population, communities and ecosystems) to accept or assimilate impacts was also considered.

The above approach is used to provide the essential information that is used in the formal Risk Assessment as based on the Australian/New Zealand Standard 4360:2004. This methodology is outlined below.

<u>Stage 1: Identification of Risk</u>

This included identification of all relevant risks, addresses all known activities and related environmental aspects of the Project.

<u>Stage 2: Risk Analysis</u>

An important feature is recognition of the fact that an event's consequence extends beyond the immediate risk. This methodology ensures that the full consequences of events are visible to owners and managers and that the effects on the Project are all understood and treated. Each class of consequence is rated a score of 1 – 5, where '1' is minor consequence to '5' is critical.

An analysis of each risk is undertaken to determine an environmental event's likelihood of occurrence and its consequences. A five-level qualitative description of the likelihood and consequences for each risk enables a semi-quantitative method to be used to calculate a 'score' for each risk.

Definitions and scales for Consequences that are in accordance with Table 1 and definitions and scales for Likelihood are shown in Table 2.

Stage 3: Calculation of Risk Level

Two levels of risk are used:

The Primary Risk Level (PRL) is a conservative measure of risk, based on the most severe consequences across all the relevant criteria. The Secondary Risk Level (SRL) is a less conservative measure of risk, which incorporates all relevant criteria, not just the most severe ones.

In most circumstances PRL should be the preferred measure, as it is more conservative. Risk scores are banded into risk levels, which provides a 'plain English' view of the risk. Scores will always be visible to enable prioritisation within bands.

Table 3 and Table 4 show the bands, their threshold values and indicative management action.

Stage 4: Determination of Options for Treatment or Risks

Following the analysis of a risk it is necessary to investigate the options available for risk treatment and then determine the option or options that provide the greatest cost benefit.

Risks may be treated in one or a combination of ways.

- Avoiding a risk by preventing the activity that leads to the risk eventuating;
- Reducing the likelihood of the risk eventuating;
- Reducing the consequences if the risk does eventuate;
- Transfer the risk; and
- Retaining the risk.

Table 1 Consequence Scale (example)

Consequence	Description
Critical	Project objectives cannot be achieved
Major	Severe irreversible impacts to objectives

Significant	Some important objectives cannot be achieved
Moderate	Significant delay in achieving objectives
Minor	Negligible impacts to Project objectives

Table 2 Likelihood Rating (example)

Likelihood	Rating	Likelihood Calculator
Rare	1	The risk may occur only in exceptional circumstances
Unlikely	2	The risk could occur at some time
Possible	3	The risk might occur at some time
Likely	4	The risk will probably occur in most circumstances
Almost Certain	5	The risk is expected to occur in most circumstances

Table 3 Risk Assessment Matrix

Likelihood	Consequence				
	Critical (5)	Major (4)	Significant (3)	Moderate (2)	Minor (1)
Almost Certain (5)	High	High	High	Medium	Medium
Likely (4)	High	High	Medium	Medium	Low
Possible (3)	High	Medium	Medium	Low	Low
Unlikely (2)	Medium	Medium	Low	Low	Very Low
Rare (1)	Medium	Low	Low	Very Low	Very Low

Table 4 Risk Levels and Management Actions (example)

Risk Level (PRL or SRL)	Descriptor	Indicative Management Actions
1 – 4	Low	Manage by routine procedures, unlikely to need specific application of resources
5 – 10	Medium	Manage by specific monitoring or response procedures, develop more detailed actions as resources allow

11 – 16	High	Senior management attention needed and management responsibilities specified for further actions
17 - 25	Extreme	Immediate action required, senior management will be involved

APPENDIX D

Aquatic invertebrate taxa list

Table 5 Aquatic invertebrate taxa recorded from each site. Highlighted cells represent rare taxa

Site Number	Weedons – Ross Road	Robinsons Road	Hamptons	Trents Road	Marshes Road
	1	2	3	4	5
Sampling Date	5 July 2011	5 July 2011	5 July 2011	6 July 2011	6 July 2011
Mayflies					
Deleatidium	0	0	5	0	0
Stoneflies					
Zelandobius	1	1	9	1	1
Beetles					
Elmidae	0	0	61	6	5
Water Bugs					
Microvelia	0	0	0	1	1
Siagara	0	0	3	0	1
Odonta					
Xanthocnemis	0	4	0	0	0
True Flies					
Anthomyiidae	0	0	0	0	1
Austrosimulium	0	2	0	2	20
Ceratopogonidae	0	1	0	0	0
Chironomus	0	1	0	0	0
Corynoneura	0	0	0	1	1
Empididae	0	0	0	1	0
Orthocladiinae	0	7	1	1	11
Paradixa	2	0	1	0	1
Stratiomyidae	0	0	1	1	0

Site Number	Weedons – Ross Road	Robinsons Road	Hamptons	Trents Road	Marshes Road
	1	2	3	4	5
Sampling Date	5 July 2011	5 July 2011	5 July 2011	6 July 2011	6 July 2011
Tanypodinae	0	4	1	1	0
Zelandotipula	0	0	0	0	1
Caddisflies					
Aoteapsyche	2	0	0	0	0
Hudsonema	1	4	134	1	2
Hydrobiosis	0	0	1	0	0
Oxyethira	0	7	3	5	8
Paroxyethira	0	3	0	0	1
Polyplectropus	1	0	1	0	0
Psilochorema	1	0	2	1	1
Pycnocentria	2	1	0	0	0
Pycnocentrodes	0	0	2	9	0
Triplectides	1	0	1	1	0
Crustacea					
Copepoda	0	0	0	1	1
Ostracoda	11	11	1	3	1
Mites	1	0	1	1	2
Worms	2	3	2	2	1
Flatworms	0	1	0	3	0
Hirudinea	0	0	0	1	1
Snails					
Gyraulus	8	11	0	0	6

Site Number	Weedons – Ross Road	Robinsons Road	Hamptons	Trents Road	Marshes Road
	1	2	3	4	5
Sampling Date	5 July 2011	5 July 2011	5 July 2011	6 July 2011	6 July 2011
Physa	63	37	2	1	62
Potamopyrgus	102	112	2	250	155
Sphaeriidae	9	7	1	1	3
Proboscis Worms	0	2	0	0	2
Round Worms	0	0	1	0	0
Collembola	0	0	0	2	0