Oceana Gold Macraes Gold Project

Macraes Phase III

Aquatic Ecology Assessment

prepared by

Ryder Consulting

April 2011

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prepared by

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Cover: *Looking towards existing mining operations from the area proposed for the Frasers North Rock Stack, October 2010.*

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1. Executive Summary

Oceana Gold (NZ) Limited (OceanaGold) is proposing an expansion of the consented mine at the Macraes Gold Project (the Macraes Phase III Project) including new pits, waste rock stacks, tailings dam and a freshwater dam. This report presents ecological assessments for each of the proposed developments in relation to aquatic ecology, including possible mitigation options for any potential adverse effects identified.

The Macraes Phase III Project is located within the Macraes Ecological District, which contains significant natural values including the absence of aquatic pest plants and significant habitat for non-migratory galaxiids. However, the review of existing information and the October 2010 survey of waterways in the Macraes area indicate that there are very few sites with significant aquatic values likely to be affected by proposed mine developments.

Some flathead galaxias populations, which are found throughout the Macraes area, particularly in the Camp Creek catchment, could be impacted. This species does not have an official conservation threatened status and its wide distribution indicates that the potential loss of individuals from these relatively small localised areas will not greatly impact on the status of the wider population. Consideration should be given to fencing other galaxiid habitat in the general Macraes area that is under the control of OceanaGold. Many of these waterways are open to cattle and sheep, and there is evidence of habitat degradation from bank erosion and trampling of channel beds. The possibility of off-site mitigation for loss of non-migratory galaxiid habitat is an approach that warrants further discussion with the Department of Conservation.

Many areas in the vicinity of the proposed development have been extensively modified by past and existing farming and mining activities. These activities, together with small catchments providing minimal surface water features and low rainfall resulting in frequent low flow events, contribute to the limited aquatic values present in most of the areas likely to be affected by mine development. However, the middle and lower reaches of the affected catchments have higher quality natural values, with healthy invertebrate and fish communities. The use of silt ponds and other sediment and erosion control measures to prevent the movement of contaminants into the lower reaches of streams, and restricting unnecessary activities in the stream channels, will minimise any effects of the developments on these lower catchment environments.

2. Introduction

Background

Oceana Gold (NZ) Limited (OceanaGold) own and operate an open pit and underground gold mine in the Macraes Flat area of East Otago. The company is proposing an expansion of the consented mine at the Macraes Gold Project, the Macraes Phase III Project (the Project). Ryder Consulting Limited was engaged by OceanaGold to provide an ecological assessment of the different components of the Project. The brief of work required assessments of:

- existing significant aquatic ecological values in the vicinity of the proposed developments;
- potential effects of the proposed developments on aquatic ecosystems;
- possible mitigation options for potential adverse effects identified.

The proposed developments included in this report are:

- Macraes-Dunback Road realignment
- Golden Bar Road realignment
- Camp Creek Freshwater Dam
- Back Road Waste Rock Stack
- Top Tipperary Tailings Storage Facility
- Frasers South Waste Rock Stack
- Frasers North Waste Rock Stack

This report presents ecological assessments for each of these proposed developments set out under individual sections. These site-specific sections are followed by a generic section that addresses potential adverse effects and recommended mitigation relating to all developments.

In addition to the above work, a survey of the Highlay Creek catchment (a sub-catchment of Deepdeall Creek) was undertaken in February 2011 to assess its ecological character. This work is presented in a separate report (Ludgate *et al*. 2011).

3. Sources of information

Existing information

A review of published and unpublished literature and relevant databases was undertaken to obtain existing information on aquatic communities within the Macraes area. Biological surveys at several sites in Deepdell Creek and tributaries were undertaken throughout 1987 (Dungey 1988). Following on from these initial surveys, aquatic monitoring has been undertaken on a quarterly basis in Deepdell Creek and tributaries (Battery Creek and Northern Gully) and in the North Branch of the Waikouaiti River and its tributary Murphys Creek since 1990 as part of resource consent monitoring for the Macraes Mine (e.g., OFGC 1990, Bioresearches 1991, Ryder 1995, Ludgate and Goldsmith 2004, 2006, 2007, Ludgate 2008, Ryder Consulting 2009, Ryder Consulting 2010). This monitoring has included surveys of fish (since 1990) and benthic macroinvertebrate (since 1991) communities. Resource consent monitoring of benthic macroinvertebrates and fish was also undertaken in Tipperary and McCormick Creeks (tributaries of the Shag River) in 1997 (Ryder 1997).

Further surveys of benthic macroinvertebrate and fish communities have been undertaken in Tipperary and McCormick Creeks as part of mine expansion investigations in 1996 and 1997 (Glova 1996a, b, 1997).

Fisheries records from the New Zealand Freshwater Fish Database (NZFFD) are also available for other surveys undertaken in the general Macraes area by the Department of Conservation (DOC), Fish and Game Otago, and the University of Otago.

Aquatic survey, October 2010

In support of this (Phase III) Project, aquatic communities within the Macraes area were surveyed in October 2010. The survey included sites in the Deepdell Creek catchment (specifically Camp Creek and smaller tributaries of Deepdell Creek), the Tipperary and McCormick Creek catchment, the Cranky Jims Creek catchment and in the North Branch of the Waikouaiti River catchment, including tributaries of Murphys Creek. The approach taken was to sample representative habitats throughout the Macraes area, ensuring that several sites were sampled within each catchment and in areas of interest. Locations visited and assessed are marked on Figure 1. Refer to Appendix One for descriptions of sampling techniques and their significance.

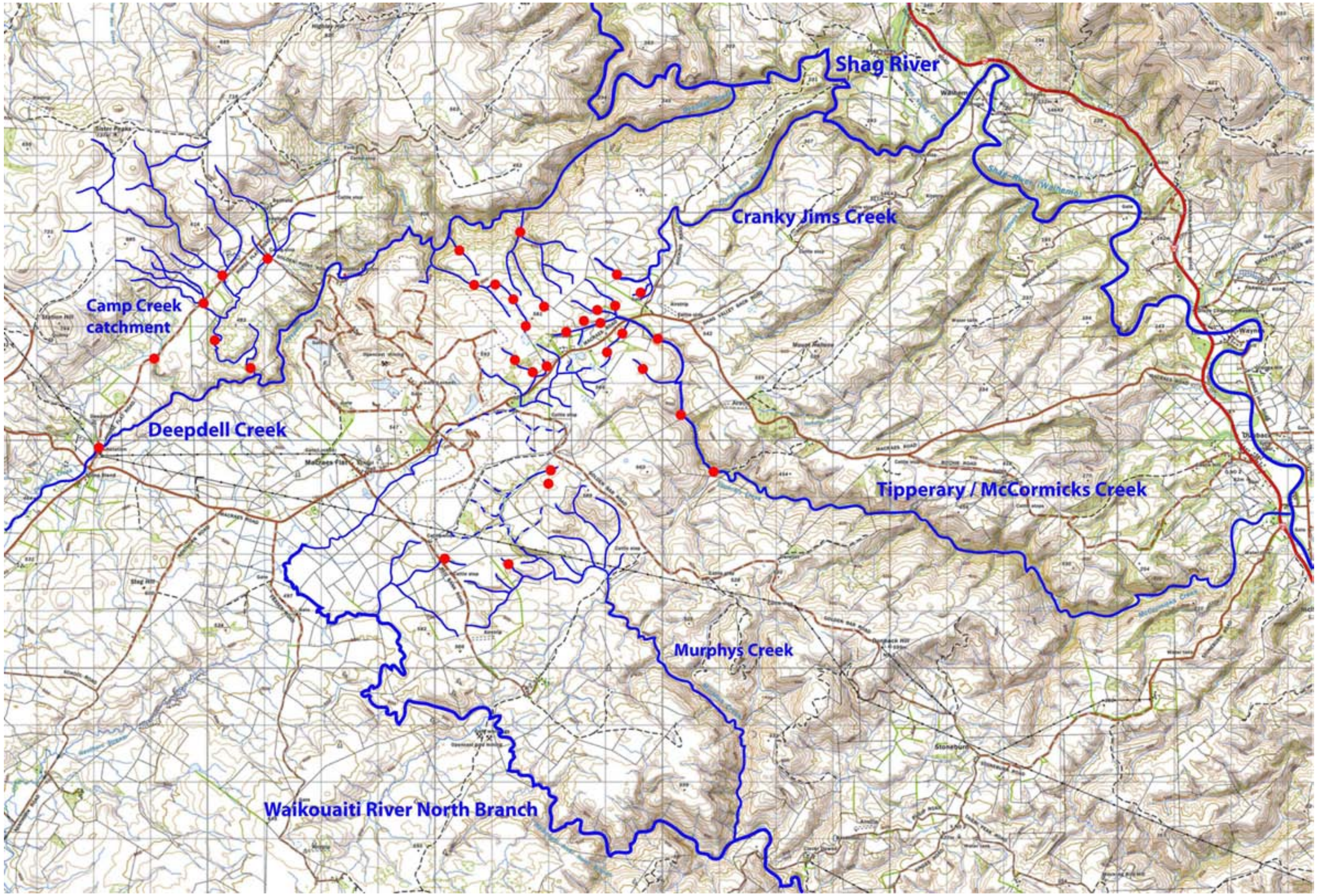

Figure 1 *Map showing locations of sites assessed in the October 2010 survey. Note only selected tributaries are marked. Dashed lines indicate previous watercourses now modified by existing mining activities.*

4. Non-migratory galaxiids

Distribution

Non-migratory galaxiids have been found throughout the Macraes area, including in tributaries of the Shag River and the North Branch of the Waikouaiti River. Tributaries of the Shag River include Deepdell Creek and its tributaries (Highlay Creek, 'Camp Creek' and several unnamed tributaries), and Tipperary and McCormick Creeks. The North Branch of the Waikouaiti River catchment includes the river mainstem itself and its tributaries, including Murphys Creek.

Several studies have investigated the identification of the galaxiid populations in the Macraes area using morphological and genetic methods.

Previous identification

Glova (1996a) carried out biophysical surveys in the Waikouaiti and Shag river catchments, which included electric fishing surveys. Laboratory examination of specimens concluded that galaxiids in Deepdell Creek closely resemble, but were most probably distinct genetically and morphologically from, *Galaxias depressiceps* (flathead galaxias). Galaxiids caught in the North Branch of the Waikouaiti River and its tributary, Murphys Creek, were identified to be the same type as in Deepdell Creek. However, laboratory examination of specimens from Tipperary Creek concluded that galaxiids from this catchment were morphologically different from those in Deepdell Creek and the Waikouaiti River, and that they aligned more with *G. vulgaris* (common river galaxias) than with *G. depressiceps*. Glova (1996a) concluded that the upper Shag River is likely a zone of hybridisation, however it was concluded that further samples and laboratory studies were required to resolve the taxonomic status of the galaxiids in the area.

Further surveys in the upper Shag River catchment were carried out by Glova (1996b), with galaxiids collected from Deepdell Creek, Hellene Creek, McCormicks Creek and its tributary Tipperary Creek. Galaxiids were collected for electrophoretic and morphometric analysis. The study found that, morphologically, galaxiids from Hellene Creek conformed to the characteristics of *G. depressiceps*, as was found in Glova (1996a) for galaxiids from Deepdell Creek, Murphys Creek and the North Branch of the Waikouaiti River. Based on results of electrophoretic analysis, it was determined that galaxiids from Tipperary and McCormicks Creeks were the same type, but their morphology caused confusion and most closely resembled *G. vulgaris*. Genetic analysis revealed that the galaxiid populations could all represent a hybrid population between *G. depressiceps* and *G. anomalus* (roundhead galaxias), but some *G. vulgaris* influence could not be ruled out. Galaxiids in Deepdell and Hellene Creeks were genetically different from each other, and both of these were different from those in Tipperary and McCormicks Creeks. However, galaxiids in Tipperary and McCormicks Creeks represented a single hybrid population and were not genetically distinct from one another.

Glova (1997) carried out surveys in the headwaters of McCormicks Creek, and collected galaxiids for detailed morphometric and genetic examinations. Morphologically it was confirmed that the galaxiids were not *G. anomalus*, *G. pullus* (dusky galaxias), *G. eldoni* (Eldons galaxias) or *G. depressiceps*, but likely represented a hybrid population. Genetic studies revealed similar conclusions to that of Glova (1996b), which was that the galaxiids represented a hybrid population between *G. depressiceps* and *G. anomalus*, but some *G. vulgaris* influence could not be ruled out.

Morphological data from galaxiid populations throughout the eastern South Island was subsequently analysed by McDowall and Hewitt (2004). The study included galaxiids from the Shag River and McCormicks Creek. However, McDowall and Hewitt (2004) stated that previous taxonomic and genetic work (likely referring to the work of Glova in 1996 and 1997) had produced equivocal identities and relationships of populations in the Shag River and McCormicks Creek to others of the group, and that the McCormicks Creek population could be a hybrid stock. Following their analysis, McDowall and Hewitt (2004) concluded that present morphological information does not permit identification of individual non-migratory galaxiids in the *G. vulgaris* species complex, with dependence on molecular data necessary for identification.

Current identification and status

A threat ranking process has recently (June 2009) been applied to New Zealand freshwater fish (Allibone *et al.* 2010). These rankings supersede the rankings conducted under the system of Molloy *et al.* (2002), as listed in Hitchmough (2002) and Hitchmough *et al.* (2007). The rankings include all described species, and genetically distinct but undescribed taxa. The Lower Shag galaxias (*Galaxias* sp. E), which was included in the 2005 ranking process as 'data deficient' (Hitchmough *et al.* 2007) (information is so lacking that a threat assessment is not possible; Molloy *et al.* 2002), has been regarded in the June 2009 ranking as belonging to a more widespread described taxa (Allibone *et al.* 2010). Recent genetic analysis suggests that the Lower Shag galaxias, as such, no longer exists, with all of the '*G. vulgaris* type' non-migratory galaxiids in the Shag River catchment being *G depressiceps* (P. Ravenscroft, DOC, pers. comm.). The *G. depressiceps* gene is stronger in the headwaters of the Shag River catchment, with the genetic make up further downstream in the catchment influenced more by *G. vulgaris*.

DOC are currently managing all non-migratory galaxiids in the Shag River catchment as *G. depressiceps* (P. Ravenscroft, DOC, pers. comm.). Similarly, all of the '*G. vulgaris* type' non-migratory galaxiids in the Waikouaiti River catchment are also being managed as *G. depressiceps* (P. Ravenscroft, DOC, pers. comm.). The flathead galaxias, *Galaxias depressiceps*, is listed by Allibone *et al.* (2010) as being 'Not Threatened', with a 'conservation dependent' qualifier. Consequently, galaxiids found in the immediate vicinity of the Macraes Gold mine can be regarded as being not threatened, notwithstanding DOC's concern about the potential loss of any population of this species.

5. Macraes-Dunback Road realignment

General

Macraes-Dunback Road will be realigned in three stages. The first realignment has been dealt with in a separate application and will not be discussed here. The second and third realignments are predominantly over land previously mined. OceanaGold is proposing to realign 5.12km of the existing road. The proposed new road will be 5.8km long.

Second realignment of Macraes-Dunback Road

The second realignment is to be undertaken where the Macraes-Dunback Road currently traverses the backfilled Innes Mills Pit. Prior to removal of this section of the road, a new section of temporary road will be constructed to the south of the existing road. This temporary road is to allow mining of the northern portion of the proposed Innes Mills Pit. The realignment will be formed using mine waste rock as the base. This second realignment is shown in Figure 2. The second realignment will affect about 0.5km of road and will reduce the road length by a minimal amount (25m). It will be undertaken prior to the removal of the existing road and is provisionally planned for 2016.

Third realignment of Macraes-Dunback Road

The third and final realignment is to be undertaken where the Macraes-Dunback Road currently traverses the backfilled Innes Mills Pit. Once mining has been completed to the north of the road the pit will be backfilled and the final road realignment will be constructed to allow Innes Mills to be mined to completion. Prior to removal of this section of the road a new section of road will be constructed to the north of the existing road. The realignment will be formed using mine waste rock as the base. This third and final realignment is shown in Figure 2. The final realignment will add an additional 0.3km to the road length making the entire road 0.8km longer than the currently existing road. It is provisionally planned for late 2016.

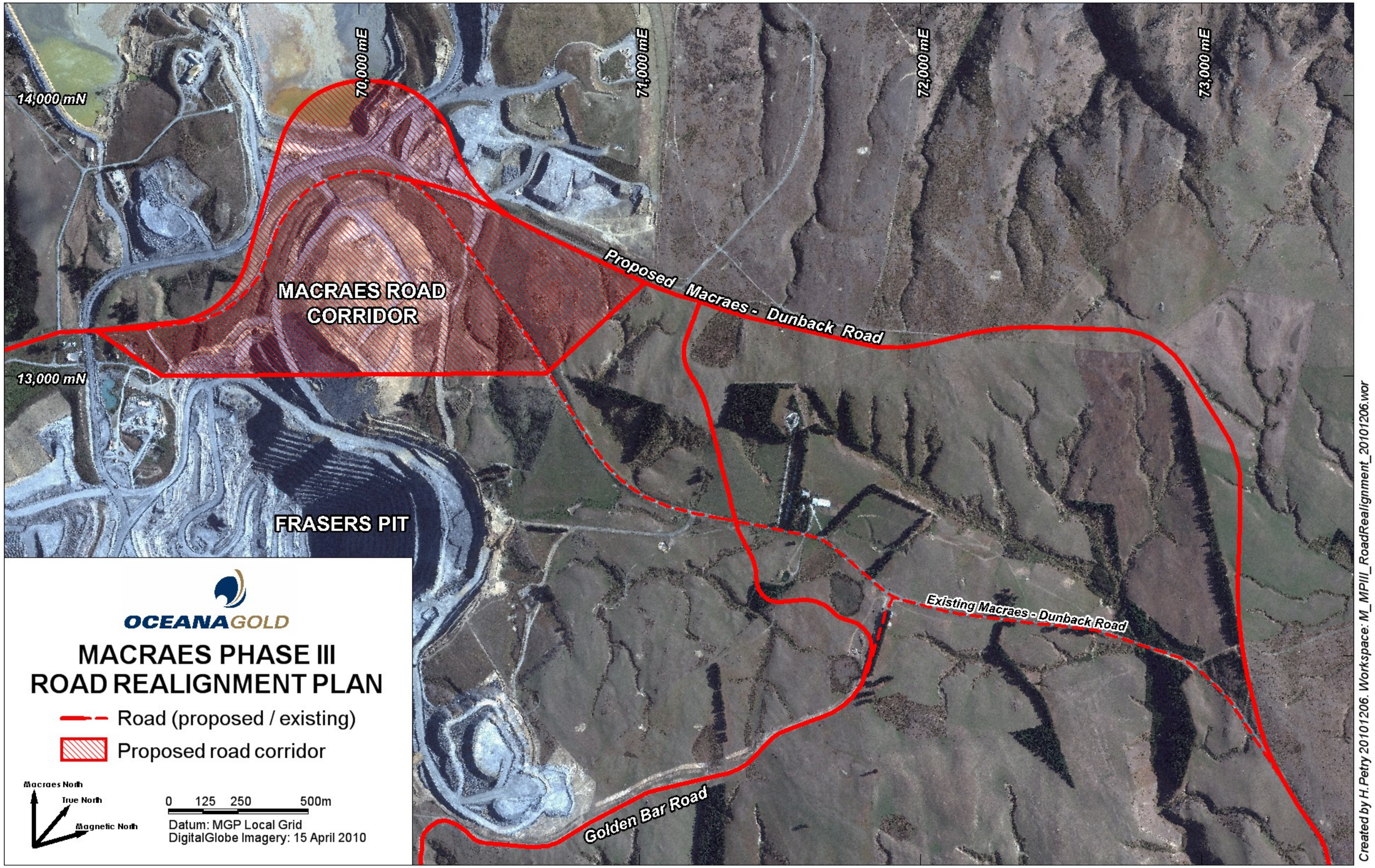

Figure 2 *Map showing location of proposed second and third road realignment stages of the Macraes-Dunback Road and proposed first and second road realignment stages of Golden Bar Road.*

Aquatic values

The areas traversed by the proposed second and third road realignment stages are dominated by existing mining activities and do not contain any waterways with significant aquatic values.

Potential adverse effects and recommended mitigation

The proposed second and third road realignment stages of the Macraes-Dunback Road cross land already extensively modified by mining activities with no aquatic values. As such, there are no adverse effects expected on aquatic communities and no mitigation is necessary.

6. Golden Bar Road realignment

General

Golden Bar Road will be realigned and extended (by approximately 1.65km) in two stages. Both stages of the realignment are situated predominantly over previously farmed land.

First Realignment of Golden Bar Road

The northern section of the existing Golden Bar Road is planned to be realigned in a north western direction to join with the existing Macraes-Dunback Road. A connection between the existing and realigned Macraes-Dunback Road will be constructed as shown in Figure 2. This realignment and connection is provisionally planned for 2014. The realigned section of Golden Bar Road will run along the northern face of Frasers East Waste Rock Stack within the current consented footprint before connecting with the existing Macraes-Dunback Road. The connection between the existing and realigned section of Macraes-Dunback Road is over land previously used for farming.

Second Realignment of Golden Bar Road

The second realignment is required for the Frasers North Waste Rock Stack to be constructed to the proposed extent. The realigned section of road would run from the face of the Frasers East Waste Rock Stack up the ridge west of the Top Tipperary Tailings Storage Facility abutment and rejoin the realigned Macraes-Dunback road. This second realignment is provisionally planned for 2017.

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council Regional Plan: Water for Otago (2004), the Waikouaiti River (excluding the South Branch) contains several significant values (Table 1), however many of these (e.g., inanga spawning areas, banded kokopu habitat) are limited to the lower catchment, near the sea at least 40 river kilometres from the proposed expansion. The upper reaches of the Waikouaiti River contain significant habitat for indigenous invertebrates and galaxiids in the main river and tributaries from the headwaters adjacent to the Macraes mine downstream to the confluence with Murphys Creek.

The listed value 'Presence of indigenous invertebrates threatened with extinction' refers to the predatory caddisfly *Neurochorema pilosum* (M. Hickey, ORC, pers. comm.), which inhabits stony streams, is endemic to southeast South Island, and is known from only three contiguous ecological regions (Collier 1993). However, this caddisfly species is not listed in the threatened species rankings listed in Hitchmough *et al.* (2007). The known distribution of this species in the Macraes area is well away from any proposed Macraes mine developments.

The listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

Table 1 *Natural values for the Waikouaiti River. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Waikouaiti River (excluding South Branch)	Large water body supporting high numbers of particular species, or habitat variety, which can provide for diverse life cycle requirements of a particular species, or a range of species Access within the main stem of a catchment through to the sea or a lake unimpeded by artificial means, such as weirs, and culverts Sand and gravel bed composition of importance for resident biota No aquatic pest plants Presence of significant areas for: • trout spawning • inanga spawning between I43:240084 and I43:266087 • development of juvenile fish Significant presence of: • eels • trout Presence of indigenous fish species threatened with extinction Presence of indigenous invertebrates threatened with extinction between I43:183242 and I43:093297, and including tributaries between I43:148264 and I43:093297	Significant habitat for flathead galaxiid, hybrid galaxiid, banded kokopu and koaro

Kai Tahu values (ORC Regional Plan: Water)

A variety of mana and access/customary use interests have been identified for the Waikouaiti River (excluding South Branch) (Table 2). Mana interests involve the notions of guardianship, life force, sacred places and treasured interests, which together define the relationship that Kai Tahu have with the Waikouaiti River (excluding South Branch). Access and customary use interests include the provision of food resources, the presence of significant spawning and nursery areas for native birds and/or fish, the location of traditional routes, and sources of weaving materials and medicines (Table 2).

Table 2 *Kai Tahu values for the Waikouaiti River (excluding South Branch). Schedule 1D, Otago Regional Council Regional Plan: Water for Otago (2004).*

Waikouaiti River (excluding South Branch)	Beliefs, values and uses	Explanation
Mana interests	MA1: Kaitiakitanga	The exercise of guardianship by Kai Tahu in accordance with tikanga Maori in relation to Otago's natural and physical resources; and includes the ethic of stewardship
	MA2: Mauri	Life force; for example the mauri of a river is most recognisable when there is abundance of water flow and the associated ecosystems are healthy and plentiful; a most important element in the relationship that Kai Tahu have with the water bodies of Otago
	MA3: Waahi tapu and/or Waiwhakaheke	Sacred places; sites, areas and values associated with water bodies that hold spiritual values of importance to Kai Tahu. (Note: Kai Tahu should be consulted regarding the location of these places, sites areas and values for a river identified as MA3)
	MA4: Waahi taoka	Treasured resource; values, sites and resources that are valued and reinforce the special relationship Kai Tahu have with Otago's water resources
Access/customary use interests	MB1: Mahika kai	Places where food is procured or produced
	MB2: Kohanga	Important nursery/spawning areas for native fisheries and/or breeding grounds for birds
	MB3: Trails	Sites and water bodies which formed part of traditional routes
	MB4: Cultural materials	Water bodies that are sources of traditional weaving materials and medicines

Aquatic habitat features

The proposed realignment of Golden Bar Road is located in the headwaters of the North Branch of the Waikouaiti River catchment. From the east, the proposed final realignment winds around the face of the Frasers East Waste Rock Stack before heading uphill to meet the proposed realignment of the Macraes-Dunback Road. The proposed route is currently dominated by pasture, with some areas of tussock grasslands and exotic plantations.

The proposed Golden Bar Road realignment traverses slopes above tributaries of the Waikouaiti River North Branch. These watercourses have been bisected already by the Frasers East Waste Rock Stack and the proposed Top Tipperary Tailings Storage Facility. Existing mining activities are located directly downstream of the area, with no continuous surface water flow between the upper and lower catchment due to the mine. Water from the upper catchment is collected in a pond, pumped around Frasers Pit and discharged into the lower catchment. Therefore, the existing mining activities have effectively isolated waterways in the headwaters from the lower catchment.

Three sites in the vicinity of the Golden Bar Road realignment were assessed in the North Branch of the Waikouaiti River catchment in October 2010 (Figure 3). Habitat descriptions for the area are below.

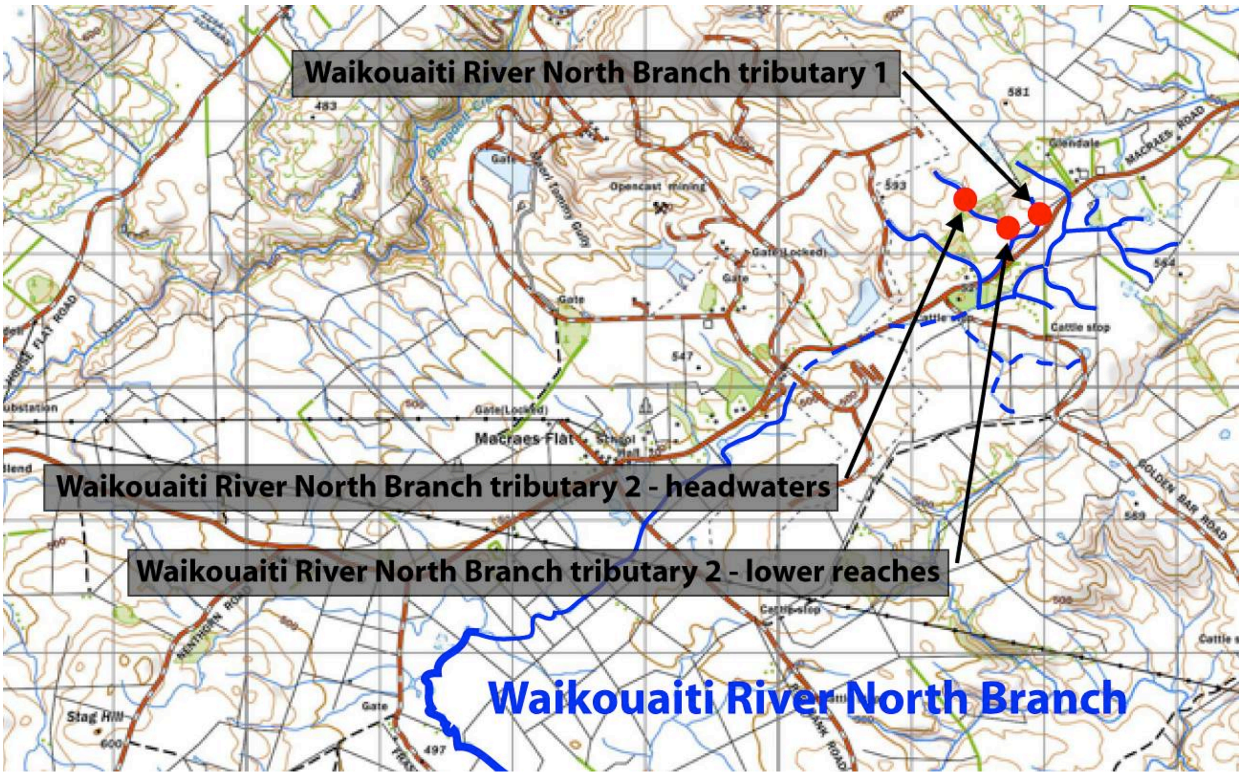

Figure 3 *Map showing location of sites assessed in the Golden Bar Road realignment area, October 2010. Note only selected tributaries marked. Dashed lines indicate previous watercourses now affected by existing mining activities.*

Tributaries of the Waikouaiti River North Branch have channels with open stock access and are generally dominated by occasional boggy sections, with no visible flowing water (Figure 4). Stock water ponds have also been created in the small streams in this area. The presence of these ponds has modified flows in the channels by reducing the amount of water that flows downstream, particularly during dry weather periods, and creating areas of slow flowing or standing water in the ponds and upstream for some distance. There are two large ponds that consist of flooded steep gullies, with one pond extending almost to the head of the catchment (Figure 5). This pond has no culvert so the only flow to the channel downstream is via seepage and when the pond water level overtops the dam. Aquatic habitat downstream of the two ponds consist of areas of wet, soft sediment with pasture grasses and tussock throughout, and negligible flow (Figure 6).

Figure 4 *Looking downstream in Waikouaiti River North Branch tributary 1 to the face of Frasers East Waste Rock Stack, with dry channel at base of gully.*

Figure 5 *Left: Stock water pond in headwaters of Waikouaiti River North Branch tributary 2. Right: Looking upstream to face of stock water pond dam.*

Figure 6 *Looking downstream in Waikouaiti River North Branch tributary 2.*

Water quality

The water quality in watercourses in the headwaters of the North Branch of the Waikouaiti River catchments have not been analytically assessed, however they are expected to be moderately degraded (elevated nutrients, average water clarity) due to the effects of unrestricted stock access, the presence of stock water ponds preventing continuous flow, and the large amount of exposed soft sediment in the channel.

Periphyton (benthic algae)

Watercourses in the headwaters of the North Branch of the Waikouaiti River catchments are dominated by soft substrates overgrown with vegetation providing little suitable habitat for significant periphyton growth, particularly the communities typically associated with stony bed stream environments.

Benthic macroinvertebrate communities

Kick net samples were collected from the channels downstream of the two stock water ponds in Waikouaiti River North Branch tributary 2. A total of 10 invertebrate taxa were identified in the sample from the headwater site, which was numerically dominated by ostracods, a small amphipod crustacean (*Paracalliope fluviatilis*), the dipteran Tanypodinae and aquatic snails (*Potamopyrgus antipodarum*) (Table 3). 'High quality'[1] stream invertebrate taxa for this type of habitat were also found at the site, such as *Nannochorista* scorpionflies and *Psilochorema* caddisflies. The invertebrate community in the lower reaches was generally of poorer quality relative to upstream, with low

[1] 'High quality' refers to an invertebrate taxa's preference for good water quality (or a lack of tolerance to poor water quality) and/or good quality physical habitat such as a stony bed largely free of surface fine sediments. Conversely, 'low quality' implies an invertebrate taxa is capable, or even prefers, lower water quality conditions and is tolerant of fine sediment deposition and slow flowing water. Occasionally, we refer to an invertebrate community being of high or low quality. In this context, the community will be dominated by either high quality or low quality taxa.

taxonomic diversity and dominated by ostracods and oligochaete worms, although high quality scirtid beetle larvae were also dominant in the sample (Table 3). The taxa found in at these sites are all typical of slow flowing, soft bottomed, wetland-type habitats.

Invertebrate community health index scores were calculated using tolerances developed for soft-bottomed habitats (Table 3). At the headwater site, the soft-bottomed MCI score was indicative of 'good' water quality and the soft-bottomed SQMCI score was indicative of 'fair' water quality. For the lower reach, scores were indicative of 'poor' to 'fair' water quality, using Stark's narrative categories (Table A1.2).

Table 3 *Macroinvertebrate taxa in samples collected from Waikouaiti River North Branch tributary 2, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.*

TAXON	MCI-sb score	North Branch of Waikouaiti River tributary	
		Headwaters	Lower reaches
ACARI	5.2	C	
COLEOPTERA			
Dytiscidae	0.4		C
Elmidae	7.2		C
Scirtidae	6.4	A	VVA
CRUSTACEA			
Ostracoda	1.9	VA	VVA
Paracalliope fluviatilis	5.5	VA	
DIPTERA			
Stratiomyidae	4.2	C	
Tanypodinae	6.5	VA	
MECOPTERA			
Nannochorista philpotti	7	C	
MOLLUSCA			
Potamopyrgus antipodarum	2.1	VA	
OLIGOCHAETA	3.8		VA
TRICHOPTERA			
Hudsonema alienum	6.5	C	
Psilochorema species	7.8	C	
Number of taxa		10	5
MCI-sb score		106	79
SQMCI-sb score		4.2	4.1

Fish communities

Surveys for fish were not undertaken in the headwaters of the North Branch of the Waikouaiti River catchment due to an absence of habitat suitable for supporting fish communities. Very little surface water was present with negligible flow, and in general only areas of soft, wet sediment infested with vegetation were present. These environments are generally not suitable for sustaining fish communities of the type likely to be found in this area of North Otago.

An interrogation of the New Zealand Freshwater Fish Database (NZFFD) indicated that flathead galaxias, longfin (*Anguilla dieffenbachii*) and shortfin (*A. australis*) eels, upland (*Gobiomorphus breviceps*) and common (*G. cotidianus*) bullies, and brown trout (*Salmo trutta*) have been found in the North Branch of the Waikouaiti River, however these records have generally been located in the lower reaches of the river, well downstream of the proposed earthworks. A survey by Glova (1996a) in the headwaters of the North Branch near the Macraes-Dunback Road found no fish species. There are no other records of surveys in the headwaters of the catchment.

In general, fish surveys have been undertaken in areas generally well downstream of the proposed earthworks area, where healthy and diverse fish communities have been found. The few surveys undertaken in headwater areas of the affected catchment have found no fish species. The absence of fish from these areas is likely due to the poor quality habitat for fish, as observed during the October 2010 survey, and described above.

Potential adverse effects and recommended mitigation

The proposed road realignments cross the headwaters of the Waikouaiti River North Branch catchment. This area has been extensively modified by farming activities. Instream habitat in these headwater areas is generally poor, with stock water ponds and negligible flow through wet, gully-like habitat. This soft-bottomed, wet gully habitat supports a relatively healthy macroinvertebrate community (due to the presence of some 'high quality' invertebrate taxa), but is generally not suitable for supporting fish communities, due largely to a lack of water.

As the proposed road realignments only traverse slopes above waterways, there will be no loss of stream habitat. The waterways are isolated from the lower catchment by existing mining activities, so any effects would be highly localised. The existing environment has no sensitive aquatic environments and, overall, can be regarded as providing poor quality habitat. Because they are located at the very head of the catchment close to the ridge line with neighbouring catchments, the quantity of perennial flowing stream habitat is very small and this further contributes to the impoverished nature of the stream fauna and flora. Section 12 of this report discusses potential effects and mitigation relating to general mine activities near waterways.

7. Camp Creek Freshwater Dam

General

Camp Creek is a major tributary of Deepdell Creek, situated upstream of the Macraes mining operation. The headwaters of Camp Creek are in the vicinity of the Sister Peaks, at an elevation of 737m a.s.l. The catchment drains steep slopes and the creek flows in a southeasterly direction to a plateau at approximately 500m elevation near Horse Flat Road. Below Horse Flat Road the creek enters a 3km long gorge before entering Deepdell Creek on its true left.

There is a proposal by OceanaGold to establish a reservoir in this catchment by constructing a dam. The purpose of the reservoir is to augment flows in lower Deepdell Creek to mitigate the potential effect of leachate from the waste rock stacks and tailings impoundment. Details surrounding this proposal are discussed more fully in the report of Golder Associates (Golder Associates 2011a).

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council (ORC) Regional Plan: Water for Otago (2004), Deepdell Creek contains significant natural values including the absence of aquatic pest plants and significant habitat for galaxiids (Table 4). However, the listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

There are no values listed by the ORC (2004) for Camp Creek, however it is expected that the values present in Deepdell Creek are also relevant for Camp Creek.

Table 4 *Natural values for Deepdell Creek. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Deepdell Creek	No aquatic pest plants Presence of indigenous fish species threatened with extinction	Significant habitat for flathead galaxiid

General habitat features

Several sites were assessed in the Camp Creek catchment in October 2010, including three sites in Camp Creek itself and two tributaries (Figure 7). Habitat descriptions for these sites are presented below.

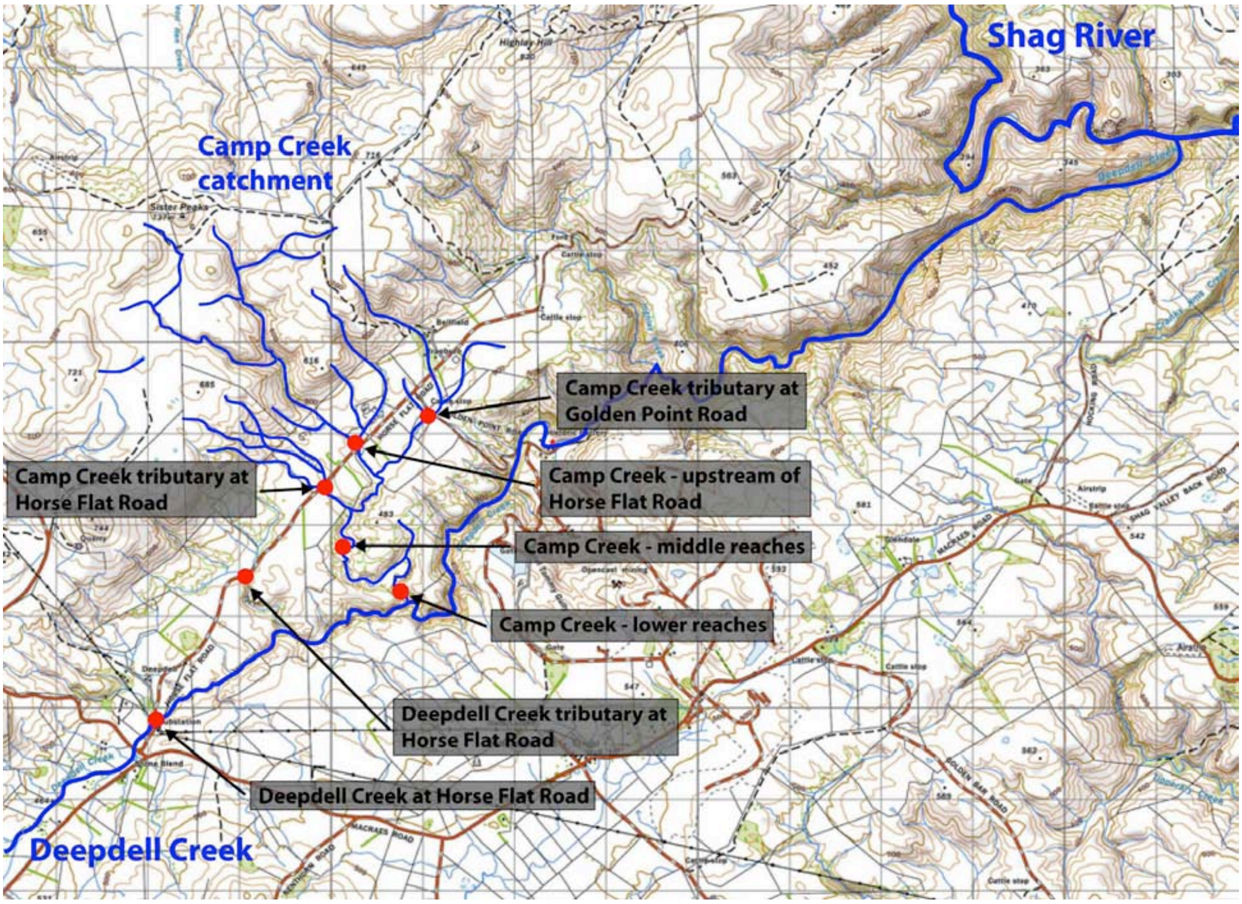

Figure 7 *Map showing location of sites assessed in the Camp Creek area, October 2010.*

The upper reaches of Camp Creek, upstream of Horse Flat Road, are constrained within a straight channel bordered by open pasture, with unrestricted stock access to the creek (Figure 8). Large areas of the banks have eroded (scouring and slumping). Instream habitat is dominated by riffles and runs, with some small pool areas, and bed substrate is dominated by gravels and cobbles. Large beds of the aquatic plant *Glyceria fluitans* are present in the creek channel. *Glyceria fluitans* is on Biosecurity New Zealand's Schedule of Prohibited Plant Species.

Figure 8 *Camp Creek upstream of Horse Flat Road.*

The middle reaches of Camp Creek meander along the base of a steep gorge surrounded by gorse, matagouri and tussocks, with more open pasture grass away from the creek banks (Figure 9). The presence of stock is evident throughout the area, with stock tracks along both banks and crossing points throughout. Instream habitat is dominated by short runs and riffles, interrupted by large pool sections. Bed substrate is dominated by cobbles and gravels, with areas of fine gravels and sand. Bedrock slabs are present in some pools.

Figure 9 *The middle reaches of Camp Creek in the middle section of the proposed inundation area.*

The lower reaches of Camp Creek, close to the confluence with Deepdell Creek, have similar aquatic habitat to the middle reaches. The creek meanders through a steep gorge with valley sides covered with tussocks, matagouri, and grasses, but with gorse, tussocks and grasses along the creek banks (Figure 10). Stock are present throughout the area with several crossing points. Instream habitat is dominated by riffles and runs with some pool sections where the creek widens. Bed substrate is dominated by flat cobbles and gravels, with large areas of bedrock covered by fine sediments in pool sections. Small beds of the aquatic plant *Glyceria fluitans* are present along the creek edges.

Figure 10 *The lower reaches of Camp Creek, near the confluence with Deepdell Creek.*

Overall, instream habitat quality is higher in the lower and middle reaches of Camp Creek than upstream of Horse Flat Road. Habitat quality in the headwaters of Camp Creek (approximately 0.6-3km upstream of Horse Flat Road) is unknown as the area was unable to be accessed for assessment.

Tributaries of Camp Creek are bordered by pasture grasses, with unrestricted stock access. These streams have low gradients, with generally very little water present in the channels and only occasional sections of wetland-like habitat with visible surface water (Figure 11). Some areas are dominated by wet areas of soft sediment with pasture grasses and tussocks. Beds of *Glyceria fluitans* are present throughout the channels. Several of the tributaries have very obvious low aquatic values, with large areas likely to dry up during periods of dry weather.


Figure 11 *Tributaries of Camp Creek. Left: Looking downstream from Horse Flat Road. Right: Looking downstream from Golden Point Road.*

The upper reaches of Deepdell Creek at Horse Flat Road are contained within a deep channel in pond-like habitat, with very low water velocities (Figure 12). This habitat contrasts with the lower reaches of Deepdell Creek, which have clear flowing water over bedrock and cobble bed substrate.

Figure 12 *Deepdell Creek at Horse Flat Road.*

Water quality

Water temperatures throughout Camp Creek were relatively low in October 2010 (Table 5). Temperatures were higher in the upper reaches of Camp Creek relative to middle and lower reaches, probably due to the absence of bank-side shading in the upstream areas. A pH range of between 6.5 and 9.0 is typically cited as being appropriate for freshwater bodies of New Zealand (ANZECC 1992). The pH at all three sites in Camp Creek was well within this range (Table 5). Dissolved oxygen levels were high, with all readings above 9 mg/L, providing suitable conditions for sensitive fish. Conductivity was low to moderate, and was higher in the mid and lower reaches, suggesting moderate nutrient enrichment.

Table 5 *Water quality in Camp Creek, October 2010.*

Site	pH	Temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)	Conductivity (µS/cm)
Camp Creek upstream of Horse Flat Road	7.9	11.5	9.2	84.9	57.7
Camp Creek - middle reaches	8.3	9.3	10.1	88.2	114.7
Camp Creek - lower reaches	8.4	9.5	10.0	87.6	91.3

The water quality in the Deepdell Creek tributary at Horse Flat Road and the Camp Creek tributaries have not been analytically assessed, however they are expected to be moderately degraded (elevated nutrients, average water clarity) due to the effects of unrestricted stock access and the large amount of exposed soft sediment in the channel. Water quality in Deepdell Creek at Horse Flat Road is also expected to be moderately degraded due to slow water movement and effects of surrounding land use.

Periphyton

Periphyton communities in the upper reaches of Camp Creek comprised thick mats of diatoms and the cyanobacteria *Anabaena*, and long filamentous green algae (*Stigeoclonium*). Benthic mats and filaments covered up to 100% of the creek bed. *Stigeoclonium* is found in a range of conditions from clean to enriched waters (Biggs and Kilroy 2000).

The middle reaches of the creek had less algal cover, with occasional patches of brown *Gomphoneis* diatom mats and filamentous green algae (*Stigeoclonium*). Small algal patches were present in pools and slower flowing areas, while riffles were generally clean of algae. *Gomphoneis* diatoms often dominate periphyton communities in moderately enriched to enriched waters (Biggs and Kilroy 2000).

The downstream reaches of the creek, near the confluence with Deepdell Creek, contained small patches of long filamentous green algae (*Stigeoclonium*) and medium to thick brown mats of *Gomphoneis* diatoms covering up to 100% of larger substrates (e.g., large cobbles, boulders). Overall, algal abundance appeared to be higher in open areas where sunlight could reach the creek bed, providing more suitable conditions for algal growth.

Deepdell Creek at Horse Flat Road, Deepdell Creek tributary at Horse Flat Road and the two Camp Creek tributaries are dominated by either deep, pond-like water or soft substrates overgrown with vegetation. These conditions provide little suitable habitat for periphyton growth, particularly the communities typically associated with stony bed stream environments.

Benthic macroinvertebrate communities

There are no reported surveys of invertebrate communities in Camp Creek, with sampling in the Deepdell Creek catchment generally confined to Deepdell Creek (in association with resource consent monitoring), except for smaller tributary streams near the Macraes mine. Sampling for this Project was undertaken throughout the Camp Creek catchment in October 2010.

Invertebrate sampling was not undertaken at Deepdell Creek at Horse Flat Road, Deepdell Creek tributary at Horse Flat Road and the two Camp Creek tributaries (at Horse Flat Road and Golden Point Road). Deepdell Creek at Horse Flat Road is likely to support an invertebrate community more typically found in pond habitat, including ostracods (seed shrimp), small dipterans (e.g., chironomid midge larvae) and common snails (*Potamopyrgus antipodarum*). The tributary streams are likely to contain taxa that are typical of slow flowing, soft bottomed, wetland type habitats. Freshwater crayfish or koura (*Paranephrops zealandicus*) were found in the Deepdell Creek tributary during electric fishing survey. Koura are classified as 'Chronically Threatened - Gradual Decline' (Hitchmough *et al.* 2007).

Macroinvertebrate communities in Camp Creek itself were generally indicative of good water quality and habitat, with all three sites dominated by *Deleatidium* mayflies (Table 6). However, invertebrates indicative of poor water quality, such as oligochaete worms and *Austrosimulium* sandfly larvae, were also abundant upstream of Horse Flat Road. Taxonomic diversity was generally higher in the middle and lower reaches of the creek than in upstream areas.

Average MCI health index scores were 'fair' to 'good' for water quality upstream of Horse Flat Road and in the middle reaches, and 'fair' in the lower reaches (Table 6). The average SQMCI score upstream of Horse Flat Road was indicative of 'good' water and habitat quality, while average scores at sites downstream were considerably higher and indicative of 'excellent' water quality (Table 6).

Table 6 *Macroinvertebrate taxa in samples collected from Camp Creek, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.*

		Camp Creek					
		Upstream of Horse Flat Road		Middle reaches		Lower reaches	
TAXON	**MCI score**	1	2	1	2	1	2
COLEOPTERA							
Elmidae	6	C	R	A	A	A	C
Scirtidae	8			C		C	
CRUSTACEA							
Ostracoda	3		C				
DIPTERA							
Aphrophila species	5	C			A	C	R
Austrosimulium species	3	A	VA		C	A	R
Ceratopogonidae	3						R
Maoridiamesa species	3					A	R
Orthocladiinae	2		A	C	C	A	A
Tabanidae	3					R	
Tanypodinae	5				C		R
Zelandotipula species	6		R				
EPHEMEROPTERA							
Deleatidium species	8	VVA	VA	VVA	VVA	VVA	VA
HEMIPTERA							
Sigara species	5				R		
MEGALOPTERA							
Archichauliodes diversus	7				C	R	R
MOLLUSCA							
Potamopyrgus antipodarum	4	A	A	A	C	VA	C
Sphaerium novaezelandiae	3				R		
OLIGOCHAETA	1	VA	VA	A	A	A	C
PLECOPTERA							
Zelandobius species	5		A	C	A	C	C
Zelandoperla species	10		C			C	
TRICHOPTERA							
Aoteapsyche species	4		C	C	C	A	C
Hudsonema alienum	6		R				
Hudsonema amabile	6			R		C	
Hydrobiosis umbripennis group	5	C				A	
Oxyethira albiceps	2		C				R
Polyplectropus species	8		R				
Psilochorema species	8		R	R	C		
Pycnocentria species	7			C	C		
Pycnocentrodes species	5	A		A	C	R	C
Number of taxa		8	15	12	16	17	15
Number of EPT taxa		3	8	7	6	7	5
% EPT		60	49	86	84	50	84
MCI score		93	101	107	98	100	84
SQMCI score		6.5	4.0	7.4	7.3	6.6	6.3
Average MCI score		97		102		92	
Average SQMCI score		5.3		7.3		6.5	

Overall, benthic macroinvertebrate communities were relatively healthy throughout Camp Creek, however communities in the middle and lower reaches were generally of higher quality than those upstream of Horse Flat Road. Invertebrate communities in the tributaries are expected to be dominated by low quality taxa more typical of those found in soft bottomed habitat.

Fish communities

There is only one confirmed NZFFD record of a fish survey in Camp Creek. That survey was undertaken throughout the Macraes area by DOC in 2006 in an attempt to elucidate the identification of the non-migratory galaxiids in the area (see Section 3 above). The survey included a site in Camp Creek in January 2006 and was undertaken immediately upstream of Horse Flat Road. Eleven flathead galaxias, ranging in length from 40 to 64mm, and one 700mm long longfin eel (data from NZFFD) were found.

Two further records in the NZFFD may be from the Camp Creek catchment, however the map references place the survey sites in between a tributary of Camp Creek and a tributary of Deepdell Creek. Therefore, it is possible that one, both or neither of the survey sites were in the Camp Creek catchment. Both records are from Fish and Game Otago with the survey site near Golden Point Road. Records are dated May 1987 and February 1996. Brown trout were caught during both surveys, with unidentified galaxias (flathead galaxias, see Section 3) and crayfish also detected.

The October 2010 survey included a tributary of Camp Creek at Golden Point Road, and was at a similar location as the Fish and Game Otago NZFFD record described above. However, habitat in the creek was very poor, with low water clarity and no suitable habitat for fish. Therefore, the brown trout, flathead galaxias and crayfish found in the area by Fish and Game are probably no longer present due to local changes in habitat.

In October 2010 flathead galaxias were found throughout Camp Creek and the tributary at Horse Flat Road, with higher abundance in the lower and middle reaches (Table 7). Several galaxiids caught in the lower reaches were gravid (i.e., carrying eggs). Abundance of flathead galaxias was considerably lower upstream of Horse Flat Road where only one individual was caught. Longfin eels were also caught in the lower and middle reaches of Camp Creek, however eels were not caught in areas further upstream or in the tributary.

Table 7 *Number of fish (length range in mm in brackets) caught in Camp Creek and tributary, October 2010.*

Site	Flathead galaxias (*Galaxias depressiceps*)	Longfin eel (*Anguilla dieffenbachii*)
Camp Creek upstream of Horse Flat Road	1 (54mm)	–
Camp Creek tributary at Horse Flat Road	2 (61–81mm)	–
Camp Creek - middle reaches	33 (41–90mm)	2 (~800–1100mm)
Camp Creek - lower reaches	26 (48–86mm)	1 (800mm)

Overall, healthy galaxiid populations are present in the lower and middle reaches of Camp Creek, with occasional large longfin eels also present. However, densities of galaxiids in the upper reaches of Camp Creek and in tributaries appear to be low. The status of galaxiid populations in the headwaters of Camp Creek (approximately 0.6-3km upstream of Horse Flat Road) is unknown as the area was unable to be accessed for assessment. It is possible that, provided suitable habitat is present, populations of galaxiids could be present in the headwaters.

Potential adverse effects and recommended mitigation

The proposed reservoir on Camp Creek would be created by a dam with a maximum height of approximately 29 metres, inundating an area of 13.7 hectares and retaining 1,400,000 m^3 of water when full (Engineering Geology Ltd. 2011). Maximum water depth at the dam face is likely to be in the order of 26 metres. The proposed dam will result in the conversion of extensive areas of Camp Creek (approximately 1.8km long) and tributaries from riverine to lake habitat. This conversion will modify habitat currently utilised by benthic macroinvertebrates, crayfish and fish (predominantly flathead galaxias, but some longfin eel also).

In general, the new lake habitat will not provide suitable habitat for flathead galaxiids, although it is probable that the whitebait stage will inhabit the margins of the reservoir particularly around tributary inflows, and it is likely that the wider galaxiid population of Camp Creek will subsequently decrease. Flathead galaxias are found throughout the Macraes area, including large populations in Deepdell Creek and associated tributaries, and any loss of galaxiids due to a dam on Camp Creek is likely to have only a minor effect on the size of the wider galaxiid population. Further, there is potential offset this loss by providing more reliable summer flows in Deepdell Creek downstream of the Camp Creek confluence, as discussed below.

The purpose of the Camp Creek reservoir is to provide a means of increasing the long term dilution of contaminants entering Deepdell Creek from mine leachate, through releases of water into Deepdell Creek under low flow conditions. Such a management approach could be beneficial to downstream galaxiid and invertebrate populations by reducing the frequency and duration of low flow periods, which are a common feature of the existing environment. We have observed decreases in Deepdell Creek galaxiid populations following drought conditions. For example, a severe drought event occurred in the Macraes area in 1999, resulting in very low flows in Deepdell Creek, especially over the summer period. Several sites in Deepdell Creek had no flow and only isolated pools were present. These pools were surveyed (whereas riffle habitat is normally surveyed) for fish, with results showing considerably lower galaxiid abundance in 1999 than in previous or subsequent years (Figure 13). Flow releases from the Camp Creek reservoir would prevent such extreme low flow events from occurring and provide greater protection of the downstream galaxiid population.

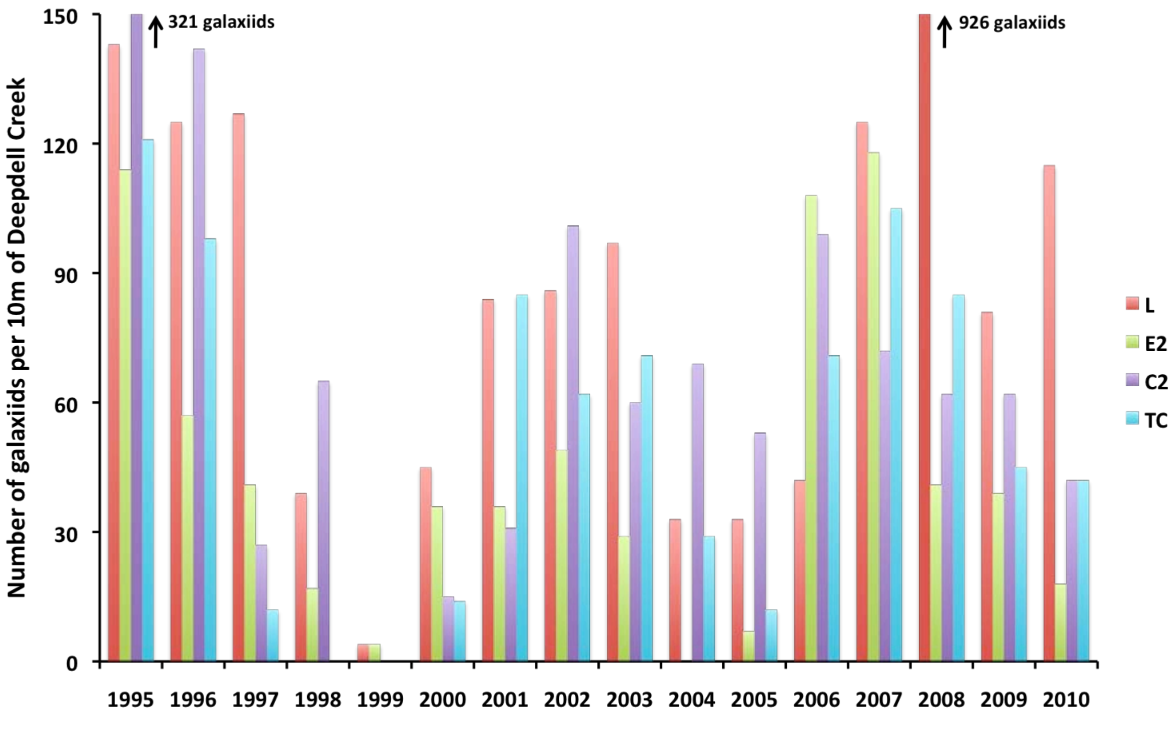

Figure 13 *Number of flathead galaxiids (per 10m length of creek) found in summer surveys of Deepdell Creek, 1995 to 2010. Data from annual resource consent monitoring of Deepdell Creek sites.*

Application of habitat suitability curves to in-stream habitat data from four small Otago streams indicated that flows of between 100-300 Litres/second provided near maximum stream habitat for three species of non-migratory galaxiid, including *Galaxias* *depressiceps*, or flathead galaxiids (Baker *et al*. 2003). The mean daily flow for Deepdell Creek at Golden point weir has been calculated at approximately 96 Litres/second (Golder Associates 2011b), which is at the lower end of the optimum flow range identified by Baker *et al*. (2003). Furthermore, flows in Deepdell can drop much lower than this and, as already described above, the creek has been know to run dry in recent years (Golder Associates 2011b, G. Ryder pers obs.). The estimated mean annual minimum flow of Deepdell Creek just downstream of the Macraes Gold Mine site is a very low 5.5 L/s (Golder Associates). This range could increase to 14.4 L/s assuming a 10 L/s flow release from a reservoir on Camp Creek. Consequently, future flow augmentation in Deepdell Creek during low flow events is likely to be beneficial to the resident galaxiid population in terms of maintaining physical habitat.

Summer low flows often coincide with increased water temperatures, which can affect abundance, growth, metabolism, reproduction, and activity levels of aquatic insects. New Zealand mayflies are generally absent or poorly represented when temperatures exceed 20-21ºC (Quinn *et al*. 1994). Monitoring of macroinvertebrate communities has been undertaken four times per year in Deepdell Creek since the early 1990s. Results reveal the health and abundance of the invertebrate population fluctuates, with periods of low river flow (e.g., the 1999 drought event) considerably reducing invertebrate abundance (Figure 14), particularly mayflies (Figures 15).

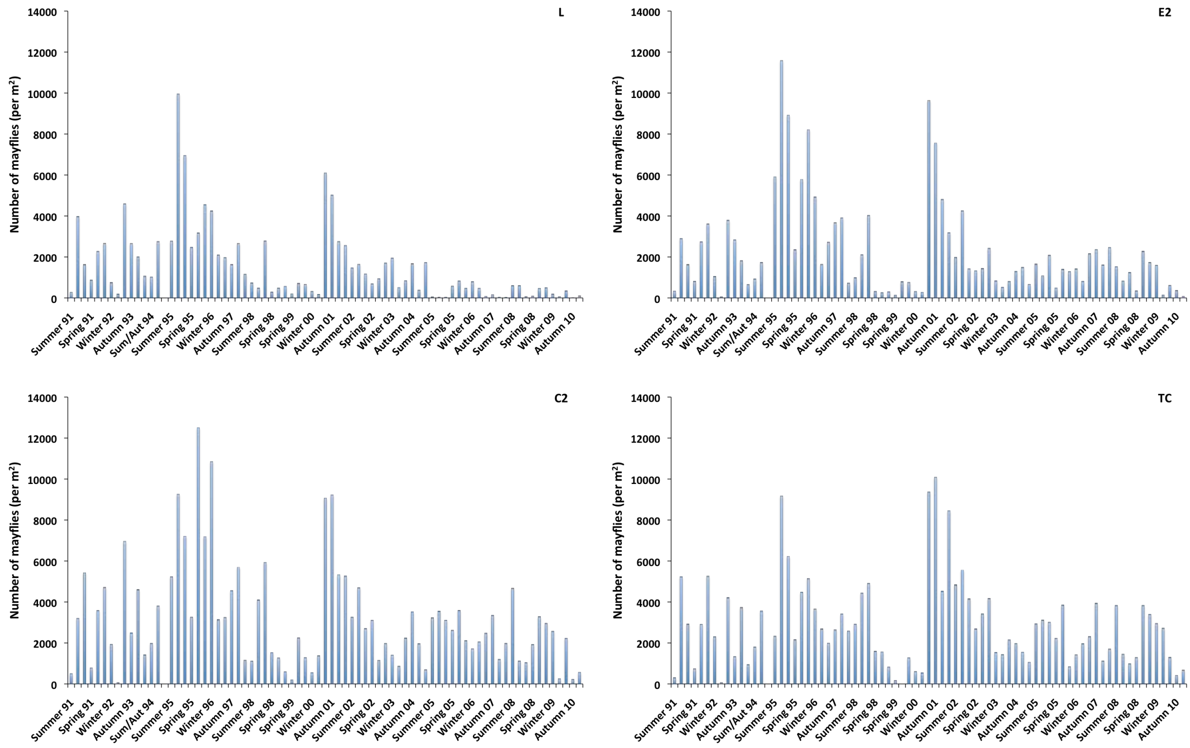

Figure 14 *Mean number of mayflies (per m^2) at the four regular monitoring sites in Deepdell Creek, 1991-2010.*

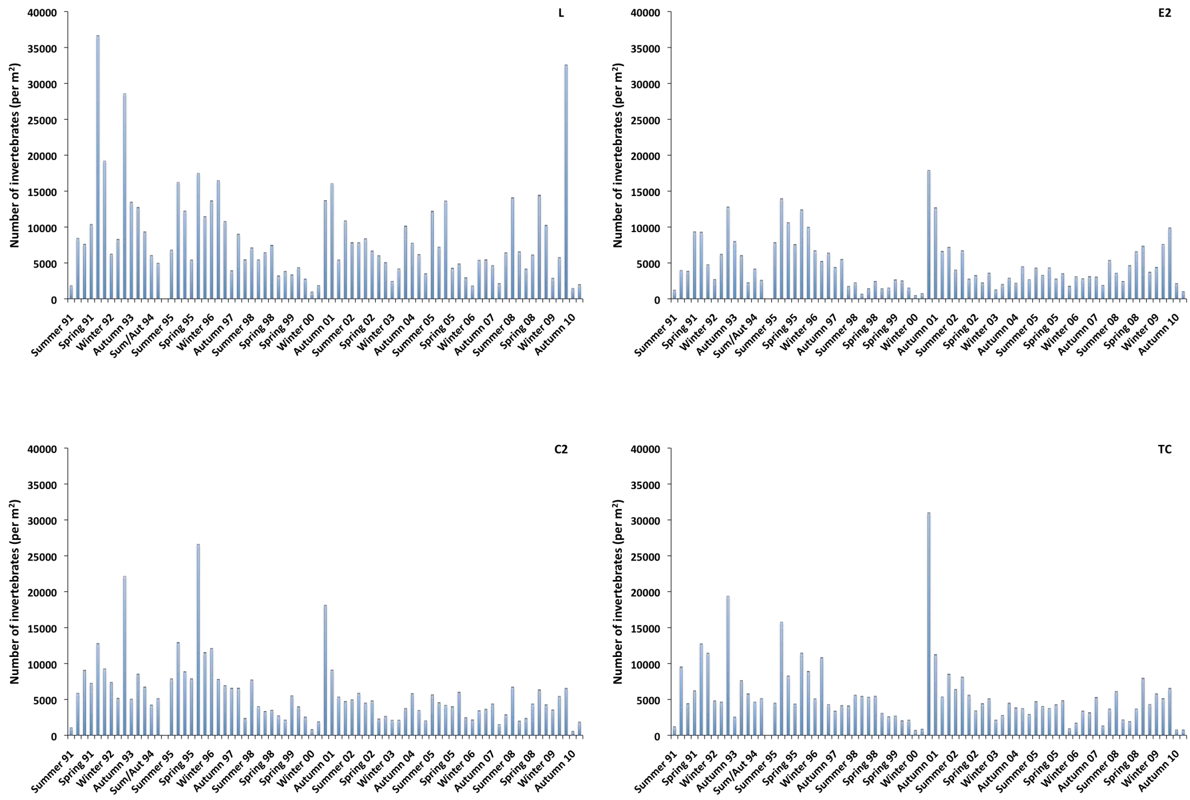

Figure 15 *Mean number of invertebrates (per m^2) at the four regular monitoring sites in Deepdell Creek, 1991-2010.*

Overall, while densities have fluctuated over time, macroinvertebrate communities have maintained similar composition. It is, however, possible that an increase in contaminant inputs due to leachate from mine tailings could adversely affect stream communities in future years. Consequently, enhancing river flows in Deepdell Creek at critical times of the year through flow releases from an upstream reservoir can reduce the potential for adverse water quality effects on fish and macroinvertebrate communities, while reducing the frequency and severity of drought-like conditions, which are known to adversely affect these communities.

The likely magnitude of these flow releases has been estimated. Summer flows in the order of 10 Litres/second, and possibly up to 16 Litres/second, may be released from the reservoir to augment the flows in Deepdell Creek for contaminant dilution, as described above and in the Golder Associates report (2011a). Such releases will assist in maintaining flow conditions in Deepdell Creek at levels more appropriate for flathead galaxiids (Baker *et al*. 2003) and ensure appropriate water quality criteria are met (Golder Associates 2011a).

Camp Creek below the proposed location of the dam face flows for approximately 1,000 metres before reaching Deepdell Creek. The reservoir could take considerable time to fill, possibly up to 8 years (Golder Associates 2011a), and flows below the dam over this time are likely to be reduced and generally become more stable than occurs now. During filling, it is recommended that a minimum flow of 2 Litres/second, or whatever flow is sufficient to provide a continuous surface flow to the Deepdell Creek confluence, be maintained below the dam to enable the non-migratory galaxiid population in the lower section of the creek opportunity to adjust to the changing flow regime.

Fencing off the reservoir and main tributaries from stock, and encouraging the development of a thick grass and tussock riparian margin, will assist in the stripping of sediment and nutrients prior to reaching the reservoir. This will represent an improvement in the current situation, where stock including cattle have unimpeded access to Camp Creek and its tributaries through the entire catchment.

Despite such measures, it is still likely that the reservoir will vertically stratify at times of the year and in doing so potentially create a layer of low oxygen water in the deeper part of the lake. This water may be discharged to the lower creek when water is released, however, the discharge system can be engineered to ensure the released water gets as much aeration as possible in the area close to the toe of the dam (Brett Sinclair, Golder Associates, pers comm.). As the water level in the dam is drawn down over summer, the turn-over of water within the reservoir could increase. Aeration of partially anoxic water over the highly uneven bed of Camp Creek will further aid the re-aeration of the water prior to discharging into Deepdell Creek.

The dam will effectively create an upstream fish barrier between Camp Creek and Deepdell Creek, isolating any flathead galaxiid populations from eel and trout present in Deepdell Creek. As flathead galaxiids are non-migratory, and are able to complete their entire life cycle in a short section of stream, a dam should not adversely affect populations in the upper catchment. The dam will effectively create a 'refuge' for galaxiids in the upper catchment. This potential situation provides possibilities for enhancement, including fencing off the creek to stock and planting of riparian vegetation, initiatives which could improve habitat and water quality in the upper reaches of Camp Creek, and in doing so increase the galaxiid population. Alternatively, mitigation could be provided in the form of off-site management of other, more endangered, non-migratory galaxiid species in Otago. It is recommended that such an approach be explored further with the Department of Conservation.

In contrast to non-migratory galaxiids, longfin eels migrate long distances and require access to the sea to spawn. It is likely that eels present in Camp Creek are occasionally restricted from access to the sea by natural barriers (e.g., dry river bed) in Deepdell Creek, which supports a very limited eel population. Longfin eels in New Zealand are 'Declining' (Allibone *et al.* 2010), but only a small number of eels are present in Camp Creek, and there is limited habitat, so any loss due to the dam would be less than minor from a species point of view. Further, the creation of the reservoir could result in a meaningful increase in habitat suitable for eels, provided a means of access to and from the reservoir was provided. However, artificially stocking the reservoir could have implications for any headwater galaxiid populations, which would be vulnerable to increased eel predation. Consequently, any potential initiatives along these lines should be preceded by consultation with the Department of Conservation.

8. Back Road Waste Rock Stack

General

The proposed Back Road Waste Rock Stack is located on slopes draining into Deepdell Creek, downstream of the current Macraes mining operation. Silt ponds are also proposed in association with the waste rock stack, although the number and exact location of these has not been determined at this stage. The catchment is dominated by tussocklands, with scrub and some pasture in the gorges.

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council (ORC) Regional Plan: Water for Otago (2004), Deepdell Creek contains significant natural values including the absence of aquatic pest plants and significant habitat for galaxiids (Table 8). However, the listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

Table 8 *Natural values for Deepdell Creek. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Deepdell Creek	No aquatic pest plants Presence of indigenous fish species threatened with extinction	Significant habitat for flathead galaxiid

Aquatic habitat features

Several sites were assessed in the Back Road Waste Rock Stack area in October 2010 (Figure 16). Habitat descriptions for these sites are presented below.

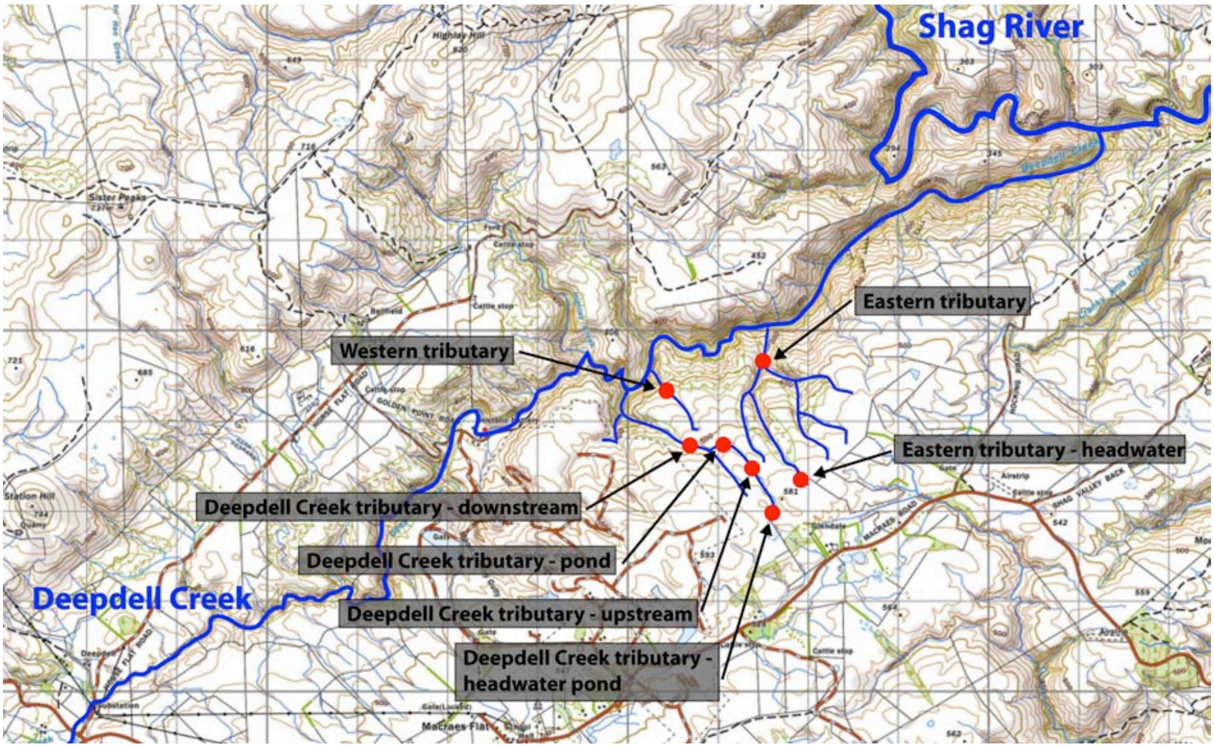

Figure 16 *Map showing location of sites surveyed in relation to the Back Road Waste Rock Stack area, October 2010.*

The headwaters of the Deepdell Creek 'Eastern tributary' (see Figure 17) contain a small pond that has no distinct outlet, so the only flow to the channel downstream is via seepage and when the pond water level overtops the dam. The pond drains into boggy wetland channels with tussock and grasses at the base of a shallow valley (Figure 18).

The Eastern tributary was also surveyed in its lower reaches. The channel is bordered by steep valley sides with an open valley floor in places. Large areas of the channel consist of boggy wetland habitat between tussocks and pasture grasses where the valley is wide, with areas of flowing water where the channel is more confined (Figure 17). Stock have unrestricted access to the stream bed, with several crossing points observed. The channel is deeply incised in places, with large areas of bank erosion. Instream habitat consists of shallow riffles with some small pools. Bed substrate comprises cobbles and small boulders, with patches of fine gravels. Areas of sediment deposition are present in slower flowing areas.

Figure 17 *Lower reaches of the Deepdell Creek 'Eastern' tributary.*

Figure 18 *Headwaters of Deepdell Creek 'Eastern' tributary. Left: Small pond in channel. Right: Boggy channel in shallow valley downstream of pond.*

The middle reaches of a very small tributary of Deepdell Creek, named 'Western' tributary (Figure 16) has a confined, high gradient channel within a steep gully, with matagouri and tussocks along the banks (Figure 19). Stock have direct access to the channel, with extensive tracks alongside and pugging visible in the channel. The channel carries a very small flow of water under normal conditions. The tributary has a bed substrate dominated by fine sediments with small patches of fine gravels and cobbles.

Figure 19 *Deepdell Creek 'Western' tributary.*

The headwaters of another Deepdell Creek tributary within the proposed site (Figure 16) contains a pond with large areas of open water with beds of *Glyceria fluitans* (Figure 20). A culvert drains the pond beneath an access track into a boggy downstream channel. The upper reaches of the creek (but downstream of the pond) are confined by a steep pasture covered gully. Steep cliffs with tussocks, matagouri and spaniards line the banks (Figure 21). Stock have unrestricted access to the creek, with several tracks observed and pugging visible in the channel.

The channel contains pasture grasses with some areas of *Glyceria fluitans*, with some shading from tussocks along the sides of the channel. Instream habitat is very limited with the majority of the channel containing very little visible water and large areas of soft sediments.


Figure 20 *Pond in headwaters of Deepdell Creek tributary. Left: Pond from access track. Right: Boggy channel downstream of pond.*

Figure 21 *Upstream section of Deepdell Creek tributary.*

The middle reaches of the Deepdell Creek tributary contain a pond with beds of *Glyceria fluitans*, areas of open water and boggy, and wetland habitat towards the upstream end (Figure 22). A large culvert under an access road has considerable erosion around the downstream end and has a perched opening, which would represent a barrier to fish passage. Stock have open access to the pond and surrounding channel, with pugging evident throughout the area.

Figure 22 *Left: Pond in the middle reaches of Deepdell Creek tributary. Right: Erosion around downstream end of culvert from pond.*

The lower reaches of the Deepdell Creek tributary consist of similar habitat to upstream areas, with pasture grasses and steep banks of native vegetation bordering the channel (Figure 23). Stock have unrestricted access to the creek, with pugging visible throughout the channel. The channel is covered with pasture grasses with some areas of *Glyceria fluitans* and tussocks. Visibly flowing water is sparse, with the majority of the channel dominated by soft sediments and aquatic vegetation.

Figure 23 *Lower reaches of Deepdell Creek tributary. Left: Tributary channel. Right: Bed of the tributary.*

Water quality

The water quality in the majority of the watercourses in the Back Road Waste Rock Stack is expected to be moderately degraded (elevated nutrients and suspended sediments, average water clarity) due to the effects of stock and the large areas of exposed soft sediment in the channel. The water temperature at the lower 'Eastern' tributary site was relatively low, while pH was well within the range of between 6.5 and 9.0, which is typically cited as being an appropriate range for New Zealand freshwater environments. Dissolved oxygen levels were high and above 9 mg/L, providing suitable conditions for fish. Conductivity was low, indicating low nutrient levels (Table 9). It is expected that this site has better water quality relative to other streams in the immediate area, due to a more consistent flow of water.

Table 9 *Water quality in the lower 'Eastern' tributary of Deepdell Creek draining the Back Road Waste Rock Stack area, October 2010.*

Site	pH	Temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)	Conductivity (µS/cm)
'Eastern' tributary	8.0	9.2	10.06	87.5	74.9

Periphyton

Watercourses in the Back Road Waste Rock Stack area are dominated by soft substrates overgrown with vegetation providing little suitable habitat for significant periphyton growth. The only visible algae consisted of small areas of thin diatom mats on larger substrates (e.g., cobbles, boulders) at the lower site on the 'Eastern' tributary, with small patches of filamentous green algae amongst aquatic plants in wetland-like habitat in other streams in the area.

Benthic macroinvertebrate communities

Two kick net samples were collected from the Deepdell Creek tributary at the lower site on the 'Eastern' tributary. A total of 16 invertebrate taxa were identified from the site, which was numerically dominated by oligochaete worms and orthoclad midge larvae (Table 10). Taxa indicative of high water quality were also found at the site, including *Nothodixa* fly larvae. Invertebrate community health index scores were calculated using tolerances developed for soft-bottomed habitats (Table 10). The average soft-bottomed MCI score was indicative of 'fair' water quality and the soft-bottomed SQMCI score was indicative of 'poor' water quality, using Stark's narrative categories (Table A1.2).

Single kick net samples were also collected from upstream and downstream areas of another Deepdell Creek tributary. The upstream site had low taxonomic diversity, and was numerically dominated by oligochaete worms and orthoclad midge larvae, as was seen in the Deepdell Creek 'Eastern' tributary (Table 10). The downstream site had higher diversity, but was similarly dominated by oligochaete worms and orthoclad midge larvae with *Potamopyrgus* snails also very abundant. Invertebrate community health index scores were low throughout the tributary, with soft-bottomed MCI scores indicative of 'poor' to 'fair' water quality and soft-bottomed SQMCI scores indicative of 'poor' water quality, using Stark's narrative categories (Table A1.2).

Overall, benthic macroinvertebrate communities in tributaries of Deepdell Creek in the proposed Back Road Waste Rock Stack area are of poor quality, characterised by taxa typically found in slow flowing, soft bottomed, wetland type habitats.

Table 10 *Macroinvertebrate taxa in samples collected from the proposed Back Road Waste Rock Stack area, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.*

		Eastern tributary		Deepdell Creek tributary	
TAXON	**MCI-sb score**	**1**	**2**	**Upstream**	**Downstream**
ACARI	5.2			R	C
COLEOPTERA					
Dytiscidae	0.4				C
Scirtidae	6.4			R	C
CRUSTACEA					
Ostracoda	1.9	R		A	C
Paracalliope fluviatilis	5.5	R	C		
DIPTERA					
Austrosimulium species	3.9	A	A	R	A
Empididae	5.4	R	C		
Hexatomini	6.7	R			
Muscidae	1.6				C
Nothodixa species	9.3		C		
Orthocladiinae	3.2	VA	VA	VA	VA
Paralimnophila skusei	7.4				R
Tanypodinae	6.5				C
EPHEMEROPTERA					
Deleatidium species	5.6	A	C		C
MEGALOPTERA					
Archichauliodes diversus	7.3	R			
MOLLUSCA					
Potamopyrgus antipodarum	2.1	R		A	VA
Sphaerium novaezelandiae	2.9			R	C
OLIGOCHAETA	3.8	VVA	VA	VA	VVA
PLATYHELMINTHES	0.9	C	C		
PLECOPTERA					
Zelandobius species	7.4	C	C		A
TRICHOPTERA					
Hudsonema alienum	6.5				C
Hydrobiosidae early instar	6.7	C			
Hydrobiosis umbripennis group	6.7	R			
Oxyethira albiceps	1.2	C	R	R	C
Number of taxa		15	10	9	16
MCI-sb score		91	92	68	83
SQMCI-sb score		3.8	3.8	3.3	3.6
Average MCI-sb score		92			
Average SQMCI-sb score		3.8			

Fish communities

Surveys for fish were not undertaken in the headwaters of the Deepdell Creek catchment as a part of this investigation, due to an absence of habitat suitable for supporting fish communities, and there are no records of fish surveys in tributaries of Deepdell Creek near the Back Road Waste Rock Stack area. Very little surface water was present, and generally only wet areas of soft sediment were present, infested with vegetation and having negligible flow. These conditions are not conducive to sustaining fish communities. The 'Eastern' tributary of Deepdell Creek had the greatest flow of any stream in the area, and good water quality, however physical habitat for fish was very limited.

Flathead galaxiids and longfin eels could potentially be present in the lower reaches of some of the streams in the Back Road Waste Rock Stack area under higher flow conditions. However, limited instream habitat and low river flows most likely restrict movement of fish into the upper reaches of these very small streams.

Potential adverse effects and recommended mitigation

The proposed Back Road Waste Rock Stack is located in the Deepdell Creek catchment, and covers an area containing several very small tributary streams of Deepdell Creek. These tributary streams enter Deepdell Creek downstream of existing mining activities. Waste rock will be stacked along the top of a ridgeline that contains several small ponds located in headwaters of these streams. The rock stack will also cover the upper reaches of the streams where they drain the ridgeline. These streams contain generally poor quality instream habitat, due to almost negligible flow down gully-like habitat. Macroinvertebrate communities are indicative of poor water quality, probably due to a lack of consistent flowing water, while fish communities are likely to be confined to the lower catchment, near the confluence with Deepdell Creek. While the stream habitat will be lost due to the rock stack, the ecological effects of this loss will be less than minor effects due to the existing poor quality habitat and associated impoverished communities.

Any silt ponds on Deepdell Creek tributaries in this area will reduce sediment runoff from the rock stack of Deepdell Creek and the lower reaches of the Deepdell Creek tributaries. However, the construction of silt ponds will modify the existing creek habitat, converting it to pond habitat. Given the existing creek habitat is of poor quality, with little surface water providing very limited habitat for benthic macroinvertebrates and fish, and stock have access throughout the streams, any loss of creek habitat will not be significant. Indeed, the presence of a pond may improve the aquatic environment, providing habitat for aquatic plants and invertebrates typically found in pond environments. There is no suitable habitat for fish in the upper reaches, and so there is no adverse effect on fish passage. It is likely that higher quality aquatic communities are present in the lower reaches of these tributaries, near Deepdell Creek, and thus it is important to provide flowing water from any silt ponds to downstream reaches. Fencing the streams from stock could also improve stream conditions.

9. Top Tipperary Tailings Storage Facility

General

The proposed Top Tipperary Tailings Storage Facility is located at the head of the Tipperary / McCormicks Creek catchment. The head of this catchment is dominated by pasture grass and farm land, with areas of tussock grasslands and scrub in some gullies. Cranky Jims Creek and Tipperary Creek may be potential sites for silt ponds. Both Cranky Jims Creek and Tipperary/McCormicks Creek flow into the Shag River.

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council Regional Plan: Water for Otago (2004), Tipperary Creek contains significant natural values including significant habitat for galaxiids (Table 11). The listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

ORC (2004) does not identify any natural values in the Cranky Jims Creek catchment.

Table 11 *Natural values for Tipperary Creek. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Tipperary Creek	No aquatic pest plants Presence of indigenous fish species threatened with extinction	Significant habitat for hybrid galaxiid species

Aquatic habitat features

Several sites were assessed in the vicinity of the proposed Top Tipperary Tailings Storage Facility area in October 2010 (Figure 24). Habitat descriptions for these sites are below.

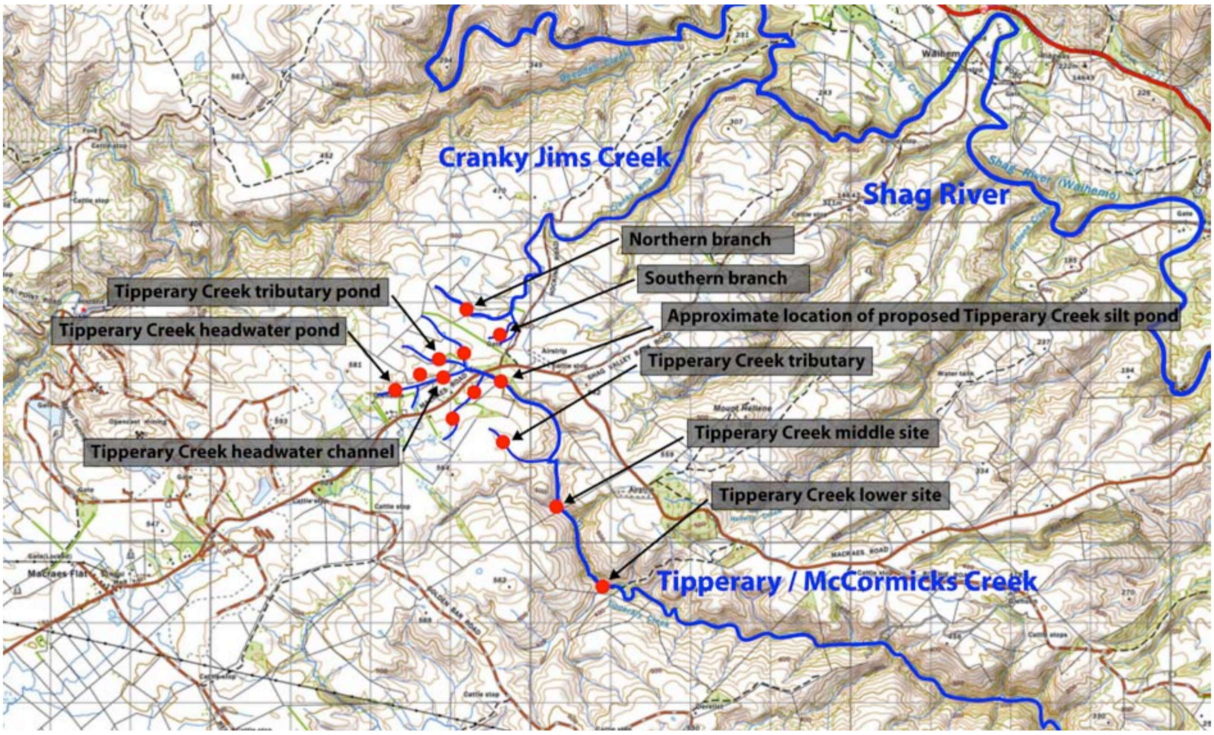

Figure 24 *Map showing location of sites assessed in the Top Tipperary Tailings Storage Facility area, October 2010.*

Sites within the upper sections of the Cranky Jims Creek catchment include channels that have already been artificially dammed to form existing stock water ponds (Figures 25 and 26). The presence of these ponds has modified flows in the channels by reducing the flow of water downstream, particularly during dry weather periods, and creating areas of slow flowing or standing water. Two of the stock water ponds have culverts that allow water to flow freely downstream, however the other ponds have no culverts (or the existing culverts are blocked) so the only flow to the channel downstream is via seepage and when the pond water level overtops the dams. Downstream aquatic habitat is dominated by wet areas of soft sediments with pasture grasses and tussock throughout, and negligible flow. Some small sections have a more confined channel with flowing water and patches of bedrock substrate. Stock access is unrestricted throughout, except in short sections where the channel is narrow and incised, restricting access.

Figure 25 *Left: Stock water pond in northern branch of Cranky Jims Creek. Right: Channel upstream of stock water pond.*

Figure 26 *Left: Stock water pond in southern branch of Cranky Jims Creek. Right: Channel downstream of stock water pond.*

Several tributaries draining farmland into Tipperary Creek also contain stock water ponds (Figure 27), with a pond also present in the headwaters of Tipperary Creek itself. These ponds have large beds of aquatic plants (e.g., *Glyceria fluitans*) around the edges. As in the Cranky Jims Creek catchment, the presence of these ponds has reduced water flows downstream, particularly where no culverts are present or the existing culverts are blocked, with water movement into downstream areas restricted to seepage and when the pond levels overtops the dam. Aquatic habitat is dominated by wet areas of soft sediments with pasture grasses and tussock throughout, and negligible flow (Figure 28). Stock access is unrestricted throughout, except in short sections where the channels are narrow and incised.

Figure 27 *Left: Stock water pond in tributary of Tipperary Creek. Right: Channel downstream of stock water pond.*

Figure 28 *Left: Stock water pond in tributary of Tipperary Creek. Right: Channel downstream of stock water pond.*

Headwater tributaries of Tipperary Creek, upstream of the Macraes-Dunback Road, are characterised by gullies with boggy, wetland-like habitat at their base draining open pasture areas and with open stock access (Figure 29). Tipperary Creek itself contains very few areas of visibly flowing water due to the absence of a defined channel. Water movement is diffuse through low gradient wetland areas containing tussock and pasture grasses and beds of *Glyceria fluitans* (Figure 29).


Figure 29 *Left: Headwaters of tributary of Tipperary Creek. Right: Wetland areas in the headwaters of Tipperary Creek, looking downstream towards the Macraes-Dunback Road.*

A tributary that enters Tipperary Creek immediately downstream of the Macraes-Dunback Road drains an area of tussock and open pasture into a channel that contains several farm ponds. These ponds reduce downstream water movement. The ponds and channels contain poor quality aquatic habitat as in the headwaters of Tipperary Creek described above. The lower reaches of the channel, downstream of the pond nearest Tipperary Creek, contain some flowing water, however the habitat is of poor quality as observed elsewhere in the catchment.

The Tipperary Creek tributary has an incised channel with boggy, wetland-like habitat and an existing stock water pond (Figure 30). The pond has a blocked culvert, and downstream water movement occurs via a small overflow channel. Aquatic values are low.


Figure 30 *Left: Stock water pond at Tipperary Creek tributary below the Macraes-Dunback road. Right: Incised channel upstream of stock water pond.*

The Tipperary Creek channel downstream of the Macraes-Dunback Road supports similar wetland habitat to that in the headwaters, however, approximately 300m downstream of the road, the channel becomes more defined and has areas of bedrock and gravel/cobble substrate. The channel is well defined further downstream with a bed dominated by cobbles and gravels, but also areas of finer gravels and sediments (Figure 31). Large areas of fine sediments are present beneath the gravel substrate and within the *Glyceria* beds. The banks of the creek are lined with pasture grass with open stock access.

Figure 31 *Tipperary Creek below the Macraes-Dunback Road. Left: Gravel and cobble bed substrate. Right: Beds of Glyceria fluitans.*

Further downstream, Tipperary Creek is confined within a steep gorge. The creek becomes increasingly bordered by gorse, broom and bracken with open pasture areas and open stock access (Figure 32). Instream habitat comprises riffles and runs with some deeper pool areas. Bed substrate is dominated by cobbles and small boulders, however considerable areas of bedrock are also present. At the most downstream site (Tipperary Creek lower site) Tipperary Creek flows underground, with a 70m long reach of dry creek bed (Figure 33).

Figure 32 *Tipperary Creek middle site. Left: Cobble and boulder bed substrate. Right: Deep pool habitat.*

Figure 33 *Tipperary Creek lower site. Left: Cobble and boulder bed substrate. Right: Section of dry creek bed.*

Overall, aquatic values are considerably higher at the sites lower downstream in the Tipperary Creek catchment. These higher values are due to increased flow providing habitat more suitable for stream invertebrate and fish communities relative to the sluggish flowing wetland-like habitat in the headwaters.

Water quality

Water quality was assessed at four sites on the Tipperary Creek mainstem and in two farm ponds; one in the headwaters of Tipperary Creek and the other in a tributary of Tipperary Creek. Water quality in the Tipperary Creek tributary farm pond was high, with relatively high dissolved oxygen levels and low conductivity levels. Water quality was poor in the headwater pond of Tipperary Creek, where dissolved oxygen levels were very low indicating anoxic (oxygen deficient) conditions (Table 12).

In Tipperary Creek itself, the most upstream site was located in a wetland-like area with little flowing water. Water quality was poor at this site relative to other sites downstream, with low dissolved oxygen levels and higher conductivity levels. In the sections of Tipperary Creek with a defined stream channel and continuous flowing water, water quality was high.

Water temperatures throughout the creek were relatively low (Table 12), and reflected the cool October weather at the time of sampling. Lower water temperatures at downstream sites were most likely due to the stream being confined to a steep gorge upstream of the site, providing shading. The pH at all flowing sites in Tipperary Creek was well within guideline levels and dissolved oxygen levels were high, with all readings well above 9 mg/L, providing suitable conditions for fish. Conductivity was relatively low throughout the creek, decreasing at downstream sites.

Table 12 *Water quality in streams and ponds in the Top Tipperary Tailings Storage Facility area, October 2010.*

Site	pH	Temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)	Conductivity (µS/cm)
Tipperary Creek tributary pond	7.82	10.5	9.64	85.9	105.6
Tipperary Creek headwater pond	6.86	7.9	2.05	18.0	79.7
Tipperary Creek headwater channel	7.72	6.8	8.94	73.5	113.6
Tipperary Creek below Macraes-Dunback Road	8.37	7.9	11.49	96.9	94.0
Tipperary Creek middle site	8.33	7.9	10.79	90.8	84.9
Tipperary Creek lower site	8.52	4.9	11.83	92.6	79.6

Water quality surveys of Tipperary Creek and several of its tributaries (Glova 1996b and 1997) found moderate to high dissolved oxygen levels relatively low dissolved nutrients and conductivity levels (Table 13).

Table 13 *Water quality in Tipperary Creek and tributaries, 1996-1997. Table 1 from Glova (1996b), Table 2 from Glova (1997).*

TABLE 1 Nutrient concentrations (mg m^{-3}) in duplicate in Tipperary Creek, 24 September 1996. Values for samples collected in the headwater tributary 28 August 1996 (Glova 1996) are included for comparative purposes. TDN = total dissolved oxygen; TDP = total dissolved phosphorus; DON = dissolved organic nitrogen; DOP = dissolved organic phosphorus; NO_3-N = nitrate-nitrogen; NH_4-N = ammonium-nitrogen; DRP = dissolved reactive phosphorus.

	°C	TDN	TDP	DON	DOP	*NO_3-N	NH_4-N	DRP
Tipperary Creek (above confluence with headwater tributary)	6.9	303.8	6.8	285	2.7	12.2	6.5	4.1
		303.0	6.8	284	2.9	12.5	6.6	3.9
Headwater tributary (sampled 28 August 1996)	3.8	350.0	10.2	284	3.7	60.7	5.8	6.5
		348.0	10.6	284	3.5	59.8	4.5	7.1

TABLE 2 Water temperature (°C), pH, dissolved oxygen (DO, mg l^{-1}), conductivity (C, μs cm^{-1}), and nutrient concentrations (mg m^{-3}) in duplicate at four headwater sites in McCormicks Creek, 18 February 1997. TDN = total dissolved nitrogen; TDP = total dissolved phosphorus; DON = dissolved organic nitrogen; NO_3-N = nitrate-nitrogen; NH_4-N = ammonium-nitrogen; DRP = dissolved reactive phosphorus.

Site	°C	pH	DO	C	TDN	TDP	DON	DOP	NO_3-N	NH_4-N	DRP
T1	15.5	7.3	9.3	84	366	9.4	327	6.2	31.1	7.8	3.3
					344	9.3	305	5.7	31.6	7.1	3.5
T1A	16.4	7.3	8.8	87	280	7.8	265	3.9	7.2	7.9	3.9
					312	7.1	293	3.6	6.5	12.6	3.5
T2	17.5	7.7	9.6	79	468	11.2	378	7.4	77.0	13.2	3.8
					464	10.9	371	6.6	79.2	13.7	4.3
T3	14.1	7.9	7.5	81	283	8.4	235	2.3	40.3	7.4	6.1
					289	8.2	241	1.8	40.7	7.3	6.4

Periphyton

Watercourses in the headwaters of the Tipperary Creek catchment are dominated by soft bottom substrates covered by overhanging vegetation. These conditions provide limited habitat for significant periphyton growth. Further downstream, periphyton is more common where the creek has a more defined channel and continuous flowing water over a stony bed. In Tipperary Creek below the Macraes-Dunback Road, the bed was covered in a thin to medium thick mat of the filamentous diatom *Melosira*, which is commonly found throughout New Zealand, and can dominate periphyton communities in moderately enriched waters (Biggs and Kilroy 2000). Periphyton communities further downstream were dominated by thick mats of the diatom *Cymbella* that covered up to 100% of the bed. *Cymbella* is widespread in clean or degraded stony streams, and can form thick blooms during periods of low flow (Moore 2000).

Benthic macroinvertebrate communities

Macroinvertebrate communities were assessed in October 2010 at several sites in Tipperary Creek and in a stock water pond located on a tributary.

The tributary stock water pond contained taxa typical of pond environments, including ostracods, waterboatmen (*Sigara* species), *Potamopyrgus* snails, and oligochaete worms (Table 14). Invertebrate community health index scores were calculated using tolerances developed for soft-bottomed habitats (Table 14). While these index scores were not developed for pond environments, the site score can provide an indication of relative health in pond environments. Both the soft-bottomed MCI and SQMCI scores were very low and indicative of 'poor' water quality, using Stark's narrative categories (Table A1.2).

A stock water pond in the headwaters of the Tipperary Creek main stem was also assessed. The community in this pond was similar to that found in the tributary pond, being dominated by ostracods, *Potamopyrgus* snails and *Xanthocnemis* damselfly larvae (Table 14). As in the tributary pond, the soft-bottomed MCI and SQMCI scores were very low and indicative of 'poor' water quality (Table A1.2).

The upper reaches of Tipperary Creek consisted of wetland-type areas with few sections of obvious flowing water. As such, the invertebrate community consisted of taxa typical of soft bottomed, wetland environments, including *Potamopyrgus* snails, orthoclad midge larvae and oligochaete worms (Table 14). Taxonomic diversity was relatively high, with 16 different taxa present, however soft bottomed health index scores were low and indicative of 'poor' water quality (Table A1.2).

Further downstream in Tipperary Creek, downstream of the Macraes-Dunback Road, the creek had a defined channel with flowing water and good habitat for stream invertebrates. The community in this area was dominated by scirtid beetles, orthoclad midge larvae, *Potamopyrgus* snails, and *Zelandobius* stoneflies (Table 14). While abundance of

Deleatidium mayflies was also high, invertebrate community index scores were low, with the MCI site score indicative of 'fair' water quality, and the average SQMCI score indicative of 'poor' water quality.

Table 14 *Macroinvertebrate taxa in samples collected from the proposed Top Tipperary Tailings Storage Facility area, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.*

			Tipperary Creek								
			Tributary pond	Headwater pond	Headwater channel	At Tipperary Creek Silt Pond		Middle site		Lower site	
TAXON	MCI score	MCI-sb score				1	2	1	2	1	2
ACARI	5	5.2	C								
COLEOPTERA											
Dytiscidae	5	0.4	R		C						
Elmidae	6	7.2							VA	A	C
Hydraenidae	8	6.7	R		C						
Rhantus pulverosus	5	1.0	A	R							
Scirtidae	8	6.4		R	R	VA	A	R	C		
CRUSTACEA											
Amphipoda	5	5.5						R			
Chiltonia species	5	5.5			C						
Ostracoda	3	1.9	VA	A				C			R
Paranephrops zealandicus	5	8.4							R		
DIPTERA											
Aphrophila species	5	5.6									R
Austrosimulium species	3	3.9	R		C	C	A	R			
Ceratopogonidae	3	6.2		R							R
Chironomus zealandicus	1	3.4	R	R							
Empididae	3	5.4					C				
Hexatomini	5	6.7					C				
Limonia species	6	6.3									R
Maoridiamesa species	3	4.9									R
Orthocladiinae	2	3.2	C	C	A	VA	VVA	A	A	A	C
Paradixa species	4	8.5			A						
Paralimnophila skusei	6	7.4				C		R			
Stratiomyidae	5	4.2		C	R					R	R
Tanypodinae	5	6.5			C					R	C
Zelandotipula species	6	3.6			R						
EPHEMEROPTERA											
Deleatidium species	8	5.6				A	A	A	VA	VVA	VA
HEMIPTERA											
Sigara species	5	2.4	VA								
MEGALOPTERA											
Archichauliodes diversus	7	7.3							C	C	
MOLLUSCA											
Gyraulus species	3	1.7	C	C							
Lymnaeidae	3	1.2			R						
Potamopyrgus antipodarum	4	2.1	A	A	VVA	VA	VVA	A	VVA	C	R
Sphaerium novaezelandiae	3	2.9		R	C		A				
NEMATODA	3	3.1								R	
ODONATA											
Xanthocnemis zealandica	5	1.2	R	A							
OLIGOCHAETA	1	3.8	A	C	A	VA	A	R	A		
PLATYHELMINTHES	3	0.9			A		A				
PLECOPTERA											
Zelandobius species	5	7.4				A	VVA	C	A	C	R
Zelandoperla species	10	8.9							C		
TRICHOPTERA											
Aoteapsyche species	4	6.0						R	C	A	R
Hudsonema alienum	6	6.5		R			R				
Oeconesidae	9	6.4				R					
Oxyethira albiceps	2	1.2			A		C	R			R
Polyplectropus species	8	8.1						R	C		R
Psilochorema species	8	7.8					C	R	A	A	R
Pycnocentria species	7	6.8								R	R
Pycnocentrodes species	5	3.8						R	C		
Triplectides species	5	5.7	R								
Number of taxa			14	13	16	9	14	15	14	12	17
Number of EPT taxa			-	-	-	3	5	7	7	5	7
% EPT			-	-	-	10	27	51	18	82	83
MCI (-sb) score			(61)	(68)	(76)	102	87	96	116	107	99
SQMCI (-sb) score			(2.3)	(2.3)	(2.4)	4.0	3.7	4.6	4.9	7.5	7.3
Average MCI score						95		106		103	
Average SQMCI score						3.9		4.7		7.4	

In the middle reaches of Tipperary Creek, well downstream of the proposed Top Tipperary Tailings Storage Facility, the quality of the invertebrate community was greater relative to headwaters sites. The communities at middle and lower sites were dominated by *Deleatidium* mayflies, although invertebrates indicative of poor water quality, such as orthoclad midges and *Potamopyrgus* snails, were also abundant (Table 14). Orthoclad midges are commonly found in benthic algal mats, and the thick diatom mats at the two downstream sites provided good habitat for midge larvae. MCI site scores were similar at both sites and indicative of 'good' water quality. The average SQMCI score at the middle site was indicative of 'fair' water quality, while at the lower site the average SQMCI score was considerably higher and indicative of 'excellent' water quality, again using Stark's narrative categories (Table A1.2).

Overall, the October 2010 survey found invertebrate communities in headwater areas of Tipperary Creek and its tributaries to be of poor quality, consisting of taxa typical of the soft-bottomed, wetland-like habitat present in the area. The quality of the communities improved significantly with distance downstream where more suitable habitat was present.

Glova (1996a) surveyed benthic macroinvertebrate communities in a small tributary of Tipperary Creek (near the October 2010 middle site, see Figure 24) and found a diverse community consisting of 16 distinct taxa (Appendix Two – Table A2.1). *Deleatidium* mayflies dominated the community, with oligochaete worms and chironomid midge larvae also abundant. Crayfish of all sizes were also common throughout the creek, indicating a successful breeding population. The average MCI score was 102, indicative of 'good' water quality (Table A1.2). Glova (1996a) described the invertebrate fauna as approaching that of pristine character, and this may be attributable largely to the perennial, albeit small, flow and the abundance of riparian cover surrounding the tributary.

Glova followed up the 1996 survey with further surveys in Tipperary Creek upstream and downstream of the tributary surveyed earlier. Glova (1996b) found Tipperary Creek invertebrate communities to have very high diversity, with 30 different taxa found at the downstream site (Appendix Two – Table A2.2). The community was dominated by chironomid midge larvae, *Potamopyrgus* snails, *Deleatidium* mayflies and *Aoteapsyche* caddisflies.

Glova (1997) then surveyed several sites in tributaries of Tipperary Creek. The invertebrate communities at these sites were of similar quality to those found in Tipperary Creek itself in Glova's earlier surveys, with *Potamopyrgus* snails, oligochaete worms and ostracods the most abundant taxa (Appendix Two – Table A2.3). *Deleatidium* mayflies were abundant at one of the sites, but overall the community was dominated by invertebrates indicative of poor water quality and habitat conditions. Invertebrate community health index scores (MCI) were indicative of 'fair' to 'good' water quality.

Ryder (1997) surveyed several sites in Tipperary Creek as a part of regular resource consent monitoring. Eight sites were surveyed in the creek, and these were located from approximately 200m upstream of the October 2010 middle site, to approximately 4.5km downstream of the October 2010 lower site. The communities were generally dominated by *Potamopyrgus* snails, *Deleatidium* mayflies, elmid beetle larvae and *Pycnocentrodes* caddisflies. Freshwater crayfish and *Archichauliodes* (dobsonflies or 'toe biters') were also abundant. Invertebrate community health index scores were generally high, with average scores at each site ranging between 4.5 and 6.8. These average scores are indicative of a range from 'fair' to 'excellent' water quality, using Stark's narrative categories (Table A1.2).

Overall, results from October 2010 surveys and previous sampling in the Tipperary Creek catchment indicate that invertebrate community health is impoverished in the headwater channel and tributaries, but improves downstream of the Macraes-Dunback Road, where flows increase and habitat suitable for benthic communities is more common.

Fish communities

No fish recent fish surveys have been undertaken in the headwaters of the Tipperary Creek catchment, upstream of the Macraes-Dunback Road, due to a lack of suitable habitat. Inspections of the area in October 2010 found the channels were dominated by areas of wet, soft sediment and vegetation. Flow was negligible.

Fish communities in the lower reaches of Tipperary Creek, downstream of the Macraes-Dunback Road, were surveyed in October 2010 (Table 15). No fish were found in Tipperary Creek below the Macraes-Dunback Road, while further downstream, healthy populations of flathead galaxias were present.

Table 15 *Number of fish (length range in mm in brackets) caught in Tipperary / McCormicks Creek, October 2010.*

Site	Flathead galaxias (*Galaxias depressiceps*)	Longfin eel (*Anguilla dieffenbachii*)
Tipperary Creek below Macraes-Dunback Road	–	–
Tipperary Creek middle site	4 (67–92mm)	1 (800mm)
Tipperary Creek lower site	20 (58–86mm)	–

The Tipperary / McCormicks Creek catchment is known to support a robust population of flathead galaxiids. Longfin eel are also present. Shortfin eel, upland and common bullies and brown trout have all been found in the lower reaches of the Tipperary / McCormicks Creek catchment, well downstream of the proposed Top Tipperary Tailings Storage Facility. A survey by DOC at the Macraes-Dunback Road bridge over Tipperary Creek in 2006 found no fish, corroborating the results of the October 2010 survey.

The only record of brown trout in the Tipperary / McCormicks Creek catchment is from the lower reaches of the river, directly upstream of the confluence with the Shag River. This record is from the NZFFD and was recorded by Fish and Game Otago in April 1998. None of the fish surveys in the upper reaches of Tipperary / McCormicks Creek, including the October 2010 survey, have detected trout.

Overall, fish surveys have generally been undertaken in areas well downstream of the proposed Top Tipperary Tailings Storage Facility, where robust flathead galaxiid populations have been found. Fish communities are more diverse further downstream, with galaxiids, eels, bullies and trout having been previously found. The absence of fish surveys in headwater areas highlights the unsuitable habitat for fish in these areas.

Potential adverse effects and recommended mitigation

The proposed Top Tipperary Tailings Storage Facility covers a large area of the Tipperary Creek headwaters. Aquatic values throughout this area are low, due to minimal flow and wetland-like habitat. While the Tipperary Creek catchment is currently modified by farming activity only, the additional effect of a mine storage facility on aquatic values is still no more than minor, given the lack of significant aquatic values in the upper catchment.

The positioning of a tailings facility in the upper reaches of the catchment increases the risk of contamination of the lower reaches of the catchment from mining activities, particularly the introduction of fine sediments to downstream reaches. However, silt ponds will reduce this risk. Proposed concepts for managing erosion and sediment control have been developed by OceanaGold and are based on Environment Canterbury's Erosion and Sediment Control Guidelines (Environment Canterbury 2007).

There will also be some form of treatment of seepage from the tailings dam designed to achieve compliance with water quality criteria (Golder Associates 2011a). Compliance points are proposed in Tipperary Creek downstream of the dam at the boundary between Oceana Gold's property and the neighbouring property (TC01). A second compliance point is proposed just downstream of the confluence between McCormicks Creek and the Shag River (Shag at McCormicks).

If silt ponds were to be positioned high in the Tipperary catchment (e.g., between the proposed location and the current Macraes-Dunback Road), all of the flowing sections of creek would be retained, thus maintaining suitable habitat for stream communities at the proposed site and in downstream areas. Any potential contaminants from the tailings facility would still be captured in a pond located in a higher position up the catchment.

Our experience from monitoring creeks downstream of existing mining activities at Macraes indicates only minor effects on fish and stream invertebrates. As such, we do not expect benthic invertebrate and fish communities present in the lower reaches of the Tipperary / McCormicks catchment to be adversely affected by the proposed tailings facility provided the management methods described above are implemented.

10. Frasers South Waste Rock Stack

General

The proposed Frasers South Waste Rock Stack is to be located adjacent to the existing Frasers West Waste Rock Stack, in the headwaters of Murphys Creek, a tributary of the North Branch of the Waikouaiti River. Note that the Frasers West Waste Rock Stack, located downstream of the proposed south rock stack, isolates the upper Murphys Creek catchment from downstream areas.

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council Regional Plan: Water for Otago (2004), the Waikouaiti River (excluding the South Branch) contains several significant values (Table 16), however many of these (e.g., inanga spawning areas, banded kokopu habitat) are limited to the lower catchment, near the sea. The upper reaches of the Waikouaiti River contain significant habitat for indigenous invertebrates and galaxiids in the main river and tributaries from the headwaters adjacent to the Macraes mine downstream to the confluence with Murphys Creek.

The listed value 'Presence of indigenous invertebrates threatened with extinction' refers to the predatory caddisfly *Neurochorema pilosum* (M. Hickey, ORC, pers. comm.), which inhabits stony streams, is endemic to southeast South Island, and is known from only three contiguous ecological regions (Collier 1993). However, this caddisfly species is not listed in the threatened species rankings listed in Hitchmough *et al.* (2007). The known distribution of this species in the Macraes area is well away from any proposed Macraes mine developments.

The listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

Table 16 *Natural values for the Waikouaiti River. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Waikouaiti River (excluding South Branch)	Large water body supporting high numbers of particular species, or habitat variety, which can provide for diverse life cycle requirements of a particular species, or a range of species Access within the main stem of a catchment through to the sea or a lake unimpeded by artificial means, such as weirs, and culverts Sand and gravel bed composition of importance for resident biota No aquatic pest plants Presence of significant areas for: • trout spawning • inanga spawning between I43:240084 and I43:266087 • development of juvenile fish Significant presence of: • eels • trout Presence of indigenous fish species threatened with extinction Presence of indigenous invertebrates threatened with extinction between I43:183242 and I43:093297, and including tributaries between I43:148264 and I43:093297	Significant habitat for flathead galaxiid, hybrid galaxiid, banded kokopu and koaro

Kai Tahu values (ORC Regional Plan: Water)

A variety of mana and access/customary use interests have been identified for the Waikouaiti River (excluding South Branch) (Table 17). Mana interests involve the notions of guardianship, life force, sacred places and treasured interests, which together define the relationship that Kai Tahu have with the Waikouaiti River (excluding South Branch). Access and customary use interests include the provision of food resources, the presence of significant spawning and nursery areas for native birds and/or fish, the location of traditional routes, and sources of weaving materials and medicines (Table 17).

Table 17 *Kai Tahu values for the Waikouaiti River (excluding South Branch). Schedule 1D, Otago Regional Council Regional Plan: Water for Otago (2004).*

Waikouaiti River (excluding South Branch)	Beliefs, values and uses	Explanation
Mana interests	MA1: Kaitiakitanga	The exercise of guardianship by Kai Tahu in accordance with tikanga Maori in relation to Otago's natural and physical resources; and includes the ethic of stewardship
	MA2: Mauri	Life force; for example the mauri of a river is most recognisable when there is abundance of water flow and the associated ecosystems are healthy and plentiful; a most important element in the relationship that Kai Tahu have with the water bodies of Otago
	MA3: Waahi tapu and/or Waiwhakaheke	Sacred places; sites, areas and values associated with water bodies that hold spiritual values of importance to Kai Tahu. (Note: Kai Tahu should be consulted regarding the location of these places, sites areas and values for a river identified as MA3)
	MA4: Waahi taoka	Treasured resource; values, sites and resources that are valued and reinforce the special relationship Kai Tahu have with Otago's water resources
Access/customary use interests	MB1: Mahika kai	Places where food is procured or produced
	MB2: Kohanga	Important nursery/spawning areas for native fisheries and/or breeding grounds for birds
	MB3: Trails	Sites and water bodies which formed part of traditional routes
	MB4: Cultural materials	Water bodies that are sources of traditional weaving materials and medicines

Aquatic habitat features

Two sites were assessed in the Frasers South Waste Rock Stack area in October 2010 (Figure 34). Habitat descriptions for these sites are presented below.

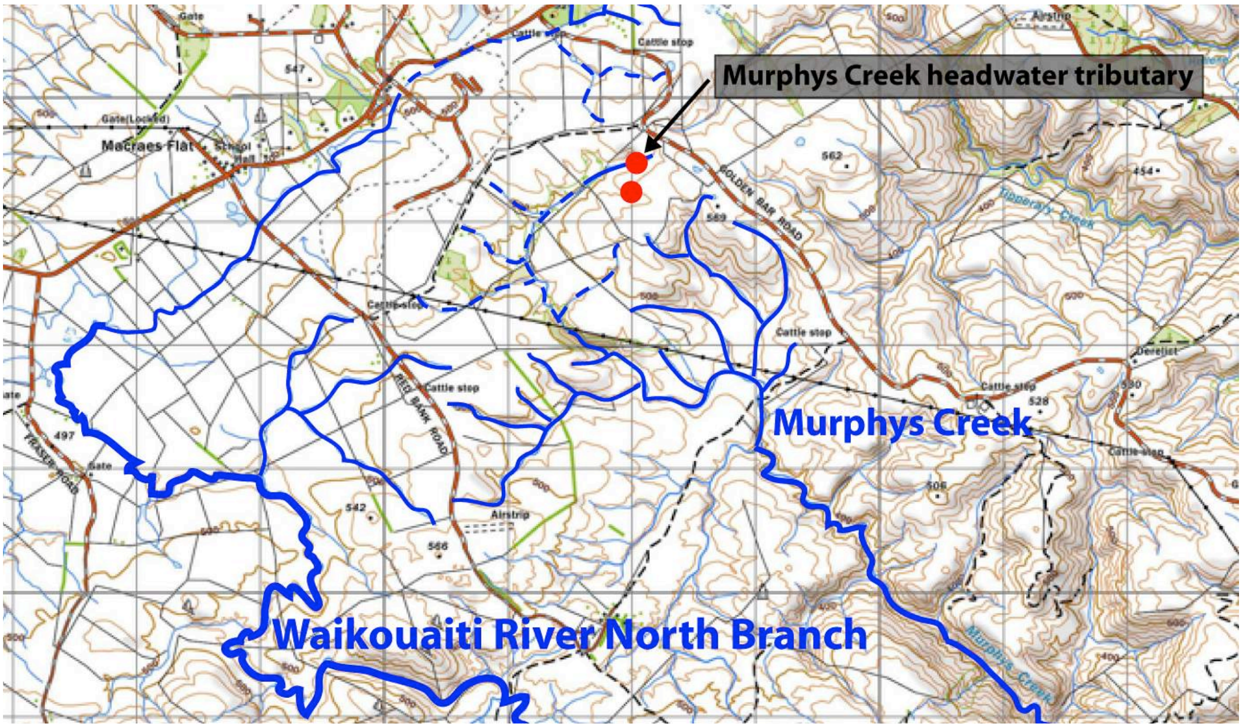

Figure 34 *Map showing location of sites assessed in the Frasers South Waste Rock Stack area, October 2010.*

The headwater tributaries of Murphys Creek, upstream of existing mining activities, are situated in valleys of open pasture, with wetland-like habitat along the valley floor (Figure 35). Further downstream, trickles of flowing water are visible where channels become more confined, and the bed changes from soft sediments and grasses to fine gravels with patches of cobbles and bedrock (Figure 35). Fine sediments are evident throughout the channels, with large areas of bank erosion. Aquatic values are low.

Figure 35 *Left: Headwaters of Murphys Creek tributary, with boggy valley floor between grasses. Right: A more defined channel in the lower reaches of the creek.*

Ponds are present at the base of the two valleys assessed. One pond retains the appearance of a natural wetland while the other appears to have been formed by an existing waste rock stack blocking water movement further downstream (Figure 36). Stock have open access throughout both wetland areas. An existing waste rock stack is located along the edge of both ponds.

Figure 36 *Left: Wetland pond adjacent to waste rock stack in the Murphys Creek tributary. Right: Pond formed by waste rock stack blocking water movement.*

Water quality

The water quality in the headwaters of Murphys Creek was not directly assessed, however it is expected to be moderately degraded (moderate nutrient levels and average water clarity) due to the effects of unrestricted stock access, causing extensive pugging, and the large amount of exposed soft sediment in the channel. Glova (1996a), in a survey as part of mine expansion investigations in 1996, did not undertake water quality sampling in a headwater site in Murphys Creek as he considered the site to have little biological significance.

Periphyton

Watercourses in the headwaters of Murphys Creek are dominated by soft substrates overgrown with vegetation, providing little suitable habitat for significant periphyton growth.

Benthic macroinvertebrate communities

A kick net sample collected from a headwater tributary of Murphys Creek, downstream of Golden Bar Road, indicated relatively low taxonomic diversity (Table 17). The community was dominated by orthoclad midge larvae, with other taxa found in low abundance. All taxa found were typical of slow flowing, soft bottomed, wetland type habitats. Invertebrate community health index scores were calculated using tolerances developed for soft-bottomed habitats (Table 17). The soft-bottomed MCI and SQMCI scores were indicative of ‘poor’ to ‘fair’ water quality (Table A1.2).

Table 18 *Macroinvertebrate taxa in sample collected from the proposed Frasers South Waste Rock Stack area, October 2010. ‘VVA’ = very, very abundant, ‘VA’ = very abundant, ‘A’ = abundant, ‘C’ = common, and ‘R’ = rare.*

TAXON	MCI-sb score	Murphys Creek headwater tributary
ACARI	5.2	R
COLEOPTERA		
Scirtidae	6.4	C
CRUSTACEA		
Chiltonia species	5.5	C
Ostracoda	1.9	R
DIPTERA		
Austrosimulium species	3.9	R
Orthocladiinae	3.2	A
OLIGOCHAETA	3.8	R
TRICHOPTERA		
Oxyethira albiceps	1.2	R
Number of taxa		8
MCI-sb score		78
SQMCI-sb score		4.0

In addition to the October 2010 survey, Glova (1996a) surveyed headwater sites in Murphys Creek, but did not undertake any invertebrate sampling as the site appeared to have little biological significance.

Fish communities

We did not survey fish in the headwaters of the Murphys Creek catchment due to the absence of suitable habitat. Very little surface water was present in the area, which was characterised by wet depressions of soft sediment and vegetation, and negligible surface flow. These conditions are not suitable to sustain a stream fish community.

An interrogation of the New Zealand Freshwater Fish Database (NZFFD) found records associated with two surveys in the Murphys Creek catchment. One of the surveys found shortfin eels and the other detected no fish species. Other surveys of Murphys Creek, by Ryder Consulting and NIWA, have found occasional longfin eel and common and upland bullies. An extensive search in various habitats in the headwaters of Murphys Creek by Glova (1996a) found flathead galaxiids.

While fish surveys have generally been undertaken in areas well downstream of the proposed rock stack area, where relatively healthy and diverse fish communities have been found, the only survey of headwater areas higher in the catchment found only low numbers of galaxiids. The isolation of Murphys Creek headwaters from downstream reaches by existing rock stacks, and the generally poor quality habitat for fish in headwater areas, suggests that the local galaxiid population will be either non-existent or very small.

Potential adverse effects and recommended mitigation

The proposed waste rock stack is to be located in an area that has already been extensively modified by mining activities. Aquatic habitat is generally poor, with negligible surface flow through wet, gully-like habitat. This soft-bottomed, wet gully habitat supports a relatively poor quality macroinvertebrate community and generally unsuitable fish habitat.

The large pond in the area may once have contained significant natural values as the area includes natural wetland vegetation and considerable areas of open water. However, the existing waste rock stack adjacent to the pond limits water movement into downstream areas and has encroached on the wetland habitat. Stock access to the wetland also contributes to reducing natural values.

Waterways in the immediate area are isolated from the lower catchment by existing mining activities, so any potential effects on aquatic communities would be highly localised. The existing environment has no sensitive aquatic habitat and overall can be regarded as providing poor quality habitat. As the area is located at the very head of the catchment, close to the ridge line with neighbouring catchments, the quantity of perennial flowing stream habitat is very small and this further contributes to the impoverished nature of the stream fauna and flora.

11. Frasers North Waste Rock Stack

General

The proposed Frasers North Waste Rock Stack is located in the headwaters of the North Branch of Waikouaiti River catchment. However, existing mining activities are located directly downstream of the area, with no continuous surface water flow between the upper and lower catchment. Consequently, the existing mining activities have effectively isolated waterways in the headwaters from the lower catchment.

Natural values (ORC Regional Plan: Water)

According to the Otago Regional Council Regional Plan: Water for Otago (2004), the Waikouaiti River (excluding the South Branch) contains several significant values (Table 18), however many of these (e.g., inanga spawning areas, banded kokopu habitat) are limited to the lower catchment, near the sea. The upper reaches of the Waikouaiti River contain significant habitat for indigenous invertebrates and galaxiids in the main river and tributaries from the headwaters adjacent to the Macraes mine downstream to the confluence with Murphys Creek.

The listed value 'Presence of indigenous invertebrates threatened with extinction' refers to the predatory caddisfly *Neurochorema pilosum* (M. Hickey, ORC, pers. comm.), which inhabits stony streams, is endemic to southeast South Island, and is known from only three contiguous ecological regions (Collier 1993). However, this caddisfly species is not listed in the threatened species rankings listed in Hitchmough *et al.* (2007). The known distribution of this species in the Macraes area is well away from any proposed Macraes mine developments.

The listed value 'Presence of indigenous fish species threatened with extinction' is no longer correct, as the flathead galaxias recorded in the catchment has recently been re-classified as 'Not Threatened' (Allibone *et al.* 2010).

Table 19 *Natural values for the Waikouaiti River. Schedule 1A, Otago Regional Council Regional Plan: Water for Otago (2004).*

Water body	Ecosystem values	Significant indigenous vegetation and significant habitat of indigenous fauna
Waikouaiti River (excluding South Branch)	Large water body supporting high numbers of particular species, or habitat variety, which can provide for diverse life cycle requirements of a particular species, or a range of species Access within the main stem of a catchment through to the sea or a lake unimpeded by artificial means, such as weirs, and culverts Sand and gravel bed composition of importance for resident biota No aquatic pest plants Presence of significant areas for: • trout spawning • inanga spawning between I43:240084 and I43:266087 • development of juvenile fish Significant presence of: • eels • trout Presence of indigenous fish species threatened with extinction Presence of indigenous invertebrates threatened with extinction between I43:183242 and I43:093297, and including tributaries between I43:148264 and I43:093297	Significant habitat for flathead galaxiid, hybrid galaxiid, banded kokopu and koaro

Kai Tahu values (ORC Regional Plan: Water)

A variety of mana and access/customary use interests have been identified for the Waikouaiti River (excluding South Branch) (Table 20). Mana interests involve the notions of guardianship, life force, sacred places and treasured interests, which together define the relationship that Kai Tahu have with the Waikouaiti River (excluding South Branch). Access and customary use interests include the provision of food resources, the presence of significant spawning and nursery areas for native birds and/or fish, the location of traditional routes, and sources of weaving materials and medicines (Table 20).

Table 20 *Kai Tahu values for the Waikouaiti River (excluding South Branch). Schedule 1D, Otago Regional Council Regional Plan: Water for Otago (2004).*

Waikouaiti River (excluding South Branch)	Beliefs, values and uses	Explanation
Mana interests	MA1: Kaitiakitanga	The exercise of guardianship by Kai Tahu in accordance with tikanga Maori in relation to Otago's natural and physical resources; and includes the ethic of stewardship
	MA2: Mauri	Life force; for example the mauri of a river is most recognisable when there is abundance of water flow and the associated ecosystems are healthy and plentiful; a most important element in the relationship that Kai Tahu have with the water bodies of Otago
	MA3: Waahi tapu and/or Waiwhakaheke	Sacred places; sites, areas and values associated with water bodies that hold spiritual values of importance to Kai Tahu. (Note: Kai Tahu should be consulted regarding the location of these places, sites areas and values for a river identified as MA3)
	MA4: Waahi taoka	Treasured resource; values, sites and resources that are valued and reinforce the special relationship Kai Tahu have with Otago's water resources
Access/customary use interests	MB1: Mahika kai	Places where food is procured or produced
	MB2: Kohanga	Important nursery/spawning areas for native fisheries and/or breeding grounds for birds
	MB3: Trails	Sites and water bodies which formed part of traditional routes
	MB4: Cultural materials	Water bodies that are sources of traditional weaving materials and medicines

Aquatic habitat features

The proposed Frasers North Waste Rock Stack is located in the headwaters of the North Branch of Waikouaiti River catchment where land is dominated by pasture, with some areas of tussock grasslands and exotic pine plantations.

Watercourses in the immediate area have been already bisected by the Frasers East Waste Rock Stack. Existing mining activities are located directly downstream of the area, with no continuous surface water flow between the upper and lower catchment. Water from the upper catchment is collected in a pond, pumped around Frasers Pit and discharged into the lower catchment. Upon closure it is intended to divert this water into Frasers pit.

Three sites in the vicinity of the proposed Frasers North Waste Rock Stack were assessed in October 2010 (Figure 37). Habitat descriptions for the area are presented below.

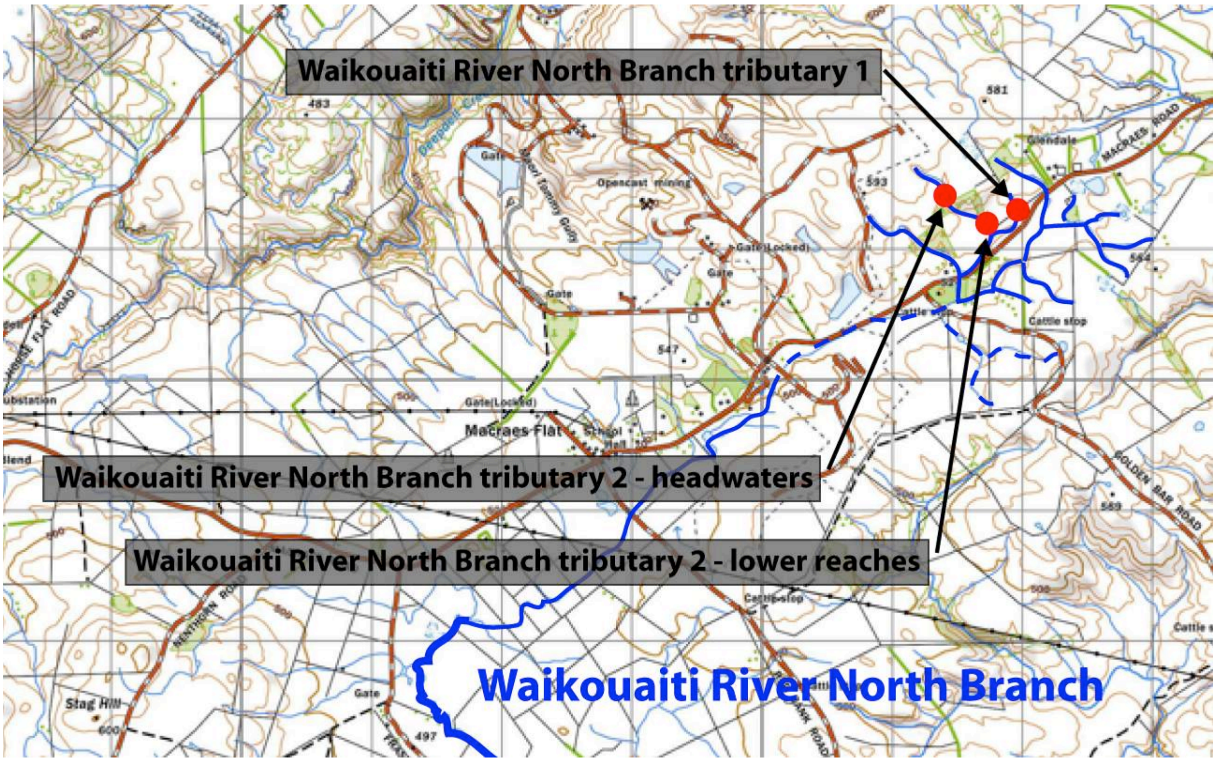

Figure 37 *Map showing location of sites assessed in the proposed Frasers North Waste Rock Stack area, October 2010. Note only selected tributaries marked. Dashed lines indicate previous watercourses now affected by existing mining activities.*

Tributaries of the Waikouaiti River North Branch have channels that consist of occasional boggy sections and no visible flowing water (Figure 38). Stock have open access. Stock water ponds have been created in the small streams in this area. The presence of these ponds has modified flows by creating areas of slow flowing or standing water and reducing the flow of downstream water during dry weather periods. There are two large ponds that have flooded steep gullies with one pond extending almost to the head of the catchment (Figure 39). This pond has no culvert so the only flow to the channel downstream is via seepage and when the pond water level overtops the dam. Aquatic habitat downstream of the two ponds consists of wet areas of soft sediment with pasture grasses and tussock throughout, with negligible surface flow (Figure 40).

Figure 38 *Looking downstream in Waikouaiti River North Branch tributary 1 to the face of Frasers East Waste Rock Stack, with dry channel at base of gully.*

Figure 39 *Left: Stock water pond in headwaters of Waikouaiti River North Branch tributary 2. Right: Looking upstream to face of stock water pond dam.*

Figure 40 *Looking downstream in the lower reaches of Waikouaiti River North Branch tributary 2.*

Water quality

The water quality was not directly assessed, however the surface waters in this area are expected to be moderately degraded (elevated nutrients, average water clarity) due to the effects of unrestricted stock access, the presence of stock water ponds reducing downstream flows under low flow conditions, and the large areas of exposed soft sediment in the channel.

Periphyton

There is little habitat suitable for the accrual of periphyton. The local watercourses are dominated by soft substrates overgrown with vegetation providing significant cover.

Benthic macroinvertebrate communities

Kick net samples were collected from the channel downstream of the two stock water ponds in Waikouaiti River North Branch tributary 2. Ten invertebrate taxa were identified in the sample collected from the headwater site, numerically dominated by ostracods, a small amphipod crustacean (*Paracalliope fluviatilis*), the dipteran Tanypodinae and aquatic snails (*Potamopyrgus antipodarum*) (Table 21). 'High quality' stream invertebrate taxa for this type of habitat were also found at the site such as *Nannochorista* scorpionflies and *Psilochorema* caddisflies.

The invertebrate community in lower reaches was of poorer quality than that found upstream, with low taxonomic diversity and dominated by ostracods and oligochaete worms (Table 21). While some high quality scirtid beetle larvae were also dominant, the taxa found are mostly typical of slow flowing, soft bottomed, wetland type habitats.

Invertebrate community health index scores were calculated using tolerances developed for soft-bottomed habitats (Table 21). The soft-bottomed MCI score was indicative of 'good' water quality and the soft-bottomed SQMCI score was indicative of 'fair' water quality at the headwater site, while the lower reaches had scores indicative of 'poor' to 'fair' water quality (Table A1.2).

Table 21 *Macroinvertebrate taxa in samples collected from Waikouaiti River North Branch tributary 2, October 2010. 'VVA' = very, very abundant, 'VA' = very abundant, 'A' = abundant, 'C' = common, and 'R' = rare.*

		North Branch of Waikouaiti River tributary	
TAXON	**MCI-sb score**	**Headwaters**	**Lower reaches**
ACARI	5.2	C	
COLEOPTERA			
Dytiscidae	0.4		C
Elmidae	7.2		C
Scirtidae	6.4	A	VVA
CRUSTACEA			
Ostracoda	1.9	VA	VVA
Paracalliope fluviatilis	5.5	VA	
DIPTERA			
Stratiomyidae	4.2	C	
Tanypodinae	6.5	VA	
MECOPTERA			
Nannochorista philpotti	7	C	
MOLLUSCA			
Potamopyrgus antipodarum	2.1	VA	
OLIGOCHAETA	3.8		VA
TRICHOPTERA			
Hudsonema alienum	6.5	C	
Psilochorema species	7.8	C	
Number of taxa		10	5
MCI-sb score		106	79
SQMCI-sb score		4.2	4.1

Fish communities

No fish surveys were undertaken in the headwaters of the North Branch of the Waikouaiti River catchment due to a lack of habitat suitable for supporting fish communities. As already noted above, very little surface water was present, and what was present was dominated by areas of wet soft sediment infested with vegetation, and negligible surface flow.

An interrogation of the New Zealand Freshwater Fish Database (NZFFD) indicated that flathead galaxias, longfin and shortfin eels, upland and common bullies and brown trout have been previously found in the North Branch of the Waikouaiti River. However, these records generally relate to the lower reaches of the river, well downstream of the proposed mine works. A survey by Glova (1996a) in the headwaters of the North Branch near the Macraes-Dunback Road found no fish species. There are no other records of surveys in the headwaters of the catchment.

Overall, fish surveys have been undertaken in areas generally well downstream of the proposed rock stack area, where healthy and diverse fish communities have been found. The few surveys undertaken in headwater areas of the affected catchments have found no fish species. This is not unexpected given the lack of suitable habitat as observed during the October 2010 survey.

Potential adverse effects and recommended mitigation

The Fraser North Waste Rock Stack is located in the headwaters of the Waikouaiti River North Branch catchment. This area has been extensively modified by farming activities, and existing mining activities prevent continuous surface water flow between the upper and lower catchment. Water from the upper catchment is collected in a pond, pumped around Frasers Pit and discharged into the lower catchment. Therefore, existing mining activities have effectively isolated the waterways in the headwaters from the lower catchment. Instream habitat in these headwater areas is generally poor, with stock water ponds and negligible flow through wet, gully-like habitat. This soft-bottomed, wet gully habitat supports a relatively healthy macroinvertebrate community (due to the presence of some 'high quality' invertebrate taxa), but is not suitable for supporting fish communities.

The existing environment has no sensitive aquatic environments and overall can be regarded as providing poor quality habitat. Because they are located at the very head of the catchment close to the ridge line with neighbouring catchments, the quantity of perennial flowing stream habitat is very small and this further contributes to the impoverished nature of the stream fauna and flora. The loss of these headwater streams due to the proposed rock stack is therefore considered not significant, due to the poor quality of the aquatic environment and the modified nature of the waterways.

12. An overview of potential adverse effects of activities near waterways and recommended mitigation and monitoring

There are a number of potential aquatic ecological effects common to all of the proposed mine expansion areas. In general, significant effects can be avoided by implementing robust management plans and construction guidelines.

Fish passage

The placement of new culverts can create barriers to fish movement into upstream reaches if installed without considering fish passage requirements. Information on such requirements is readily available (e.g., ARC 2000; Boubée *et al.* 1999) and should be consulted to ensure any new or modified culverts provide for passage where suitable fish habitat exists. For example, culverts should be buried so the bottom is filled with streambed material, with pipes under 3m in diameter buried to a depth of 0.3-0.6m (Boubée *et al.* 1999).

Sediment mobilisation and run-off

Most watercourses within the proposed project areas are bordered by tussock or pasture grasslands, with areas of exposed soil. Because of this existing modified situation, the likelihood of increased sediment run-off during construction activities is relatively high. However, the risk of sediment losses to streams can be reduced by employing best-practice design and mitigation measures through the development of the construction management plan incorporating sediment and erosion control measures. OceanaGold has proposed concepts for managing erosion and sediment control based on Environment Canterbury's Erosion and Sediment Control Guidelines (Environment Canterbury 2007). For example, specific erosion and sediment control measures are to include:

- cleanwater diversion drains with small dams located in gullies where necessary to divert runoff into the diversion drains. Where necessary (e.g., steeper ground, erosive soils) the drains will be lined (e.g., rockfill, geotextile) and energy dissipation will also be provided at high energy locations;
- silt ponds downstream of disturbed areas. Permanent silt ponds will be designed according to existing criteria. Sizing will depend on the catchment area and runoff coefficient. Decants similar to those currently on site will be

adopted, but will be designed to allow for attachment of floating decants. Service and emergency spillways will be provided and designed to pass the flows from 10 year and 100 year return period rainfall events;

- shoulders of waste rock stacks and tailings storage facility embankments will have benches every 20m vertical height to control runoff;
- perimeter surface water drains located around the perimeter of waste rock stacks and tailings storage facility embankments where appropriate, to ensure runoff is conveyed to the base of gullies without erosion. Such drains will be lined where necessary and energy dissipation will be provided at high energy locations.

In our experience of monitoring surface waters associated with the Macraes mine, the ecological effects of sediment runoff are minor.

Accidental contaminant spills

The presence of construction machinery in and around waterways always presents a risk of contaminants (e.g., diesel, lubricants) entering watercourses with the potential to harm aquatic life. This issue can be appropriately addressed by way of an appropriate on-site contaminant management plan, which could form a component of the construction management plan. As a general rule, any possible contaminants stored on site should be kept away from watercourses and bunded. Refuelling of machinery should also take place away from watercourses.

Nuisance aquatic weed/algae introduction

Machinery and personnel involved in construction could potentially transfer nuisance weeds/algae (e.g., *Didymosphenia geminata* - didymo) to local watercourses. While didymo has not been recorded in the Shag or Waikouaiti River catchments, and many watercourses within the mining area may not be suitable for didymo establishment, if didymo was to enter these streams it may be able to travel downstream to establish at more suitable locations in the lower Shag or Waikouaiti Rivers.

To ensure didymo and nuisance weeds are not introduced or spread it is recommended that, wherever possible, equipment and other items to be used in or near waterways are first inspected and if necessary cleaned prior to use. Consultation with Otago Regional Council (biosecurity staff) is recommended prior to commencement of works.

Monitoring

There is an established surface water monitoring programme for the Macraes mine that includes a number of sites where regular aquatic ecological surveys are undertaken (see Figure 41). Monitoring includes quarterly assessments of benthic macroinvertebrates and periphyton, and annual surveys of fish populations.

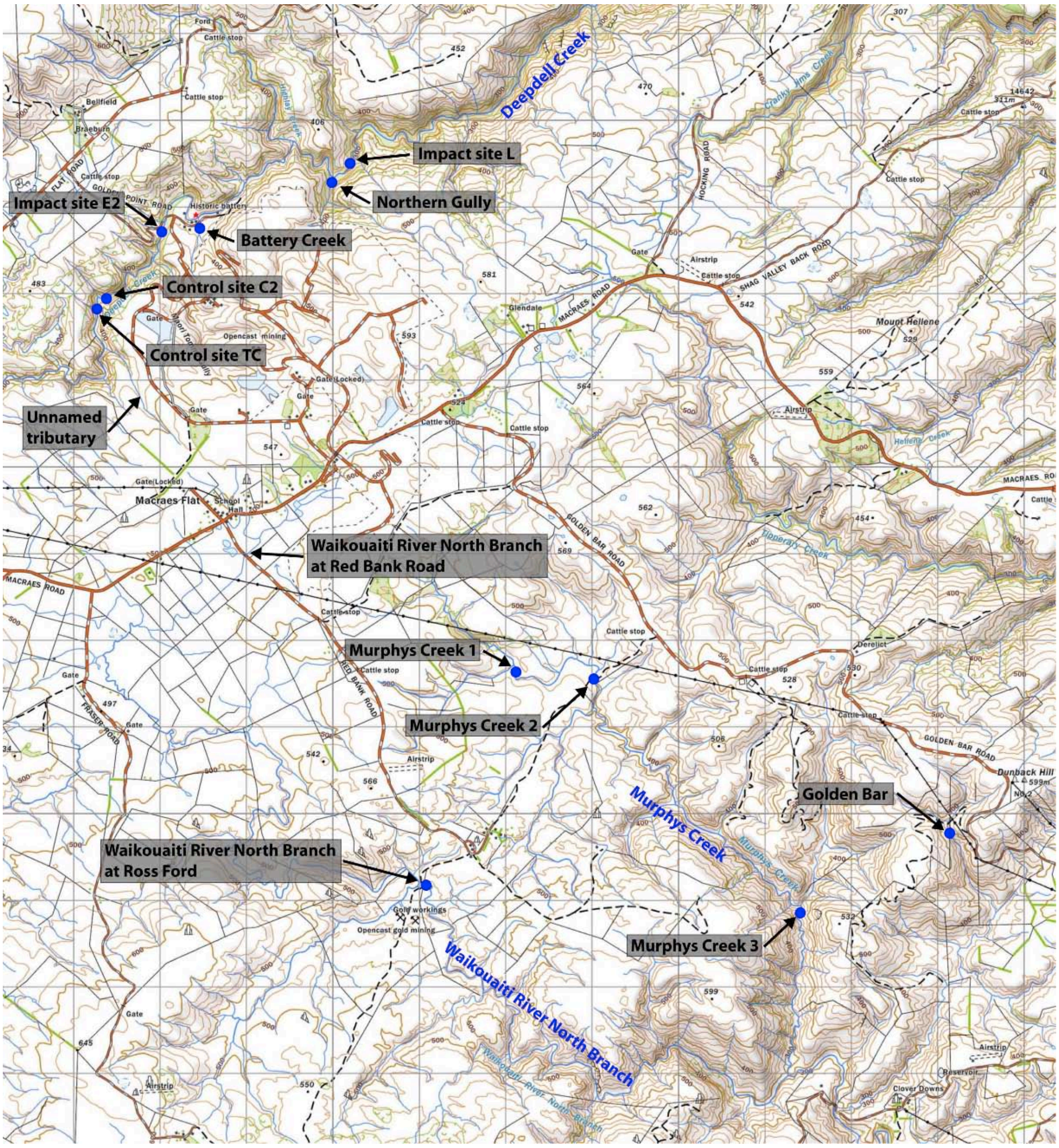

Figure 41 *Map showing <u>current</u> aquatic ecological monitoring sites associated with the Macraes Mine (blue dots).*

We consider that this monitoring programme is sufficient to asses the potential effects of existing and proposed expansion of mine activities, with the following amendments:

Existing Sites

- Deepdell Creek at DC01 (TC), upstream of the mine area,
- Deepdell Creek at DC03 (Site E), downstream of the confluence with Maori Tommy Gully,
- Deepdell Creek at DC 07 (Site L), downstream of the confluence with Northern Gully,
- Northern Gully at NG01, close to confluence with Deepdell Creek,
- Tipperary Creek at TC01, downstream of the Top Tipperary Tailings Storage Facility (I42:147332),
- Murphys Creek at MC100 (MC1), approximately 100 metres downstream of mining activities,
- Murphys Creek at MC01 (MC2), at Murphys tailings ford (I42:129312),
- North Branch of the Waikouaiti River at NBWRRF, at Ross Ford (I42:109289),
- North Branch of the Waikouaiti River at NB03 downstream of the confluence with Golden Bar Creek.

Additional Sites

- Deepdell Creek at DC00, upstream of the confluence with Camp Creek,
- Deepdell Creek at DC 08 (Site M), downstream of DC 07,
- Tipperary Creek at TC01, downstream of the Top Tipperary Tailings Storage Facility (I42:147332),
- McCormicks Creek at TC02, downstream of TC01 (I42:182324),
- Cranky Jims at CJ01, at Hocking Road stone culvert (NZTM E1404263 N4976044),

We recommend that the following sites be removed from the monitoring programme, mainly due to unsuitability of the site (e.g., frequent lack of flowing water) or due to a new site being proposed that better reflects the water body and potential impacts:

- North Branch of the Waikouaiti River at NBWRRB, at Red Bank Road
- Unnamed Creek, whose confluence with Deepdell Creek is located at Map Reference NZMS 260 I42:073 350
- Deepdell Creek, upstream of the mine area at C2 (just downstream of DC01 (TC)
- Battery Creek, close to confluence with Deepdell Creek

No monitoring of the Shag River or is proposed as monitoring the ecology of Deepdell Creek and McCormacks Creek further upstream would detect any potential effects long before they would be able to be detected in the Shag River.

The proposed monitoring sites are shown on Figure 42.

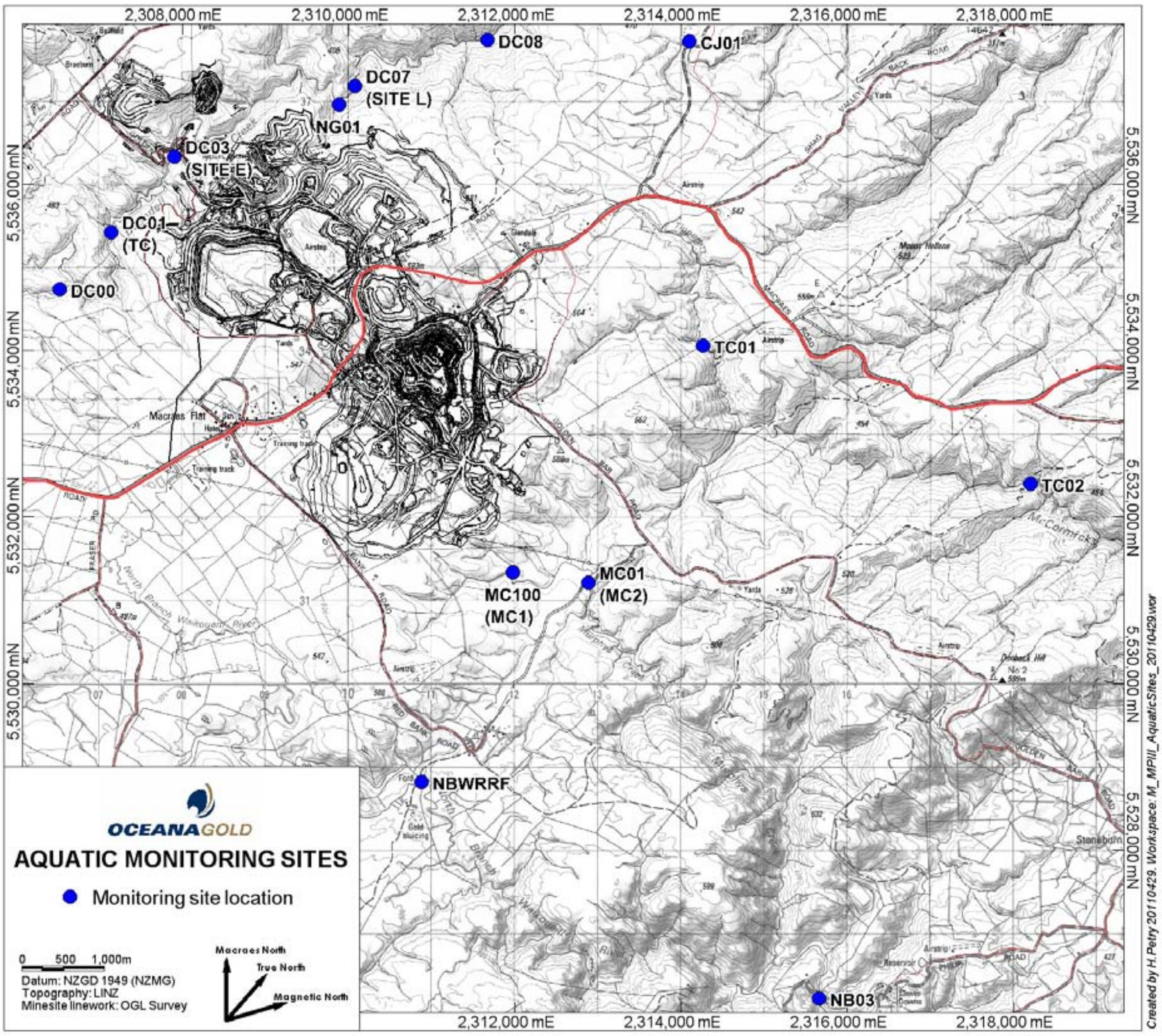

Figure 42 *Map showing* <u>*proposed*</u> *aquatic ecological monitoring sites associated with the Macraes Mine (blue dots).*

As per the existing monitoring programme, it is recommended that monitoring of macro-invertebrates and periphyton is carried out at each of the monitoring sites (unless there are insufficient flows to support any significant aquatic community) on one occasion during each of the following periods each year:

- December to February inclusive;
- March to May inclusive;
- June to August inclusive;
- September to November inclusive.

Further, an annual electric fishing survey should be carried out at each of the monitoring sites (unless there are insufficient flows) during the period December to February inclusive.

Where possible, all aquatic biology monitoring should be undertaken during low or stable flows.

Components to be monitored:

1. Benthic macroinvertebrates - the taxonomic composition and abundances shall be monitored at all sites.
2. Fish - the taxonomic composition and abundances of fish shall be monitored by an electric-fishing survey at all of the biological monitoring sites.
3. Benthic algae - a qualitative assessment of the height and percentage cover of dominant species of benthic algae shall be made at all of the biological monitoring sites.

13. Summary and Conclusion

Overall, the review of existing information and the October 2010 survey of waterways in the Macraes area indicate that there are very few sites with significant aquatic values likely to be affected by the proposed mine developments.

Some flathead galaxias populations, particularly in the Camp Creek catchment, would be impacted by the proposed developments. However, this species is not threatened and its wide distribution in the Macraes area indicates that the loss of individuals from these relatively small localised areas will not greatly impact on the status of the wider population. Augmentation of Deepdell Creek summer low flows via flow releases from the Camp Creek reservoir may act to maintain the Deepdell Creek galaxiid population through the maintenance of physical habitat and invertebrate food supply during critical drought periods. Consideration should be given to fencing other galaxiid habitat in the general Macraes area that is under the control of OceanaGold. Many of these waterways are open to cattle and sheep, and there is evidence of habitat degradation from bank erosion and trampling of channel beds. Alternatively, off-site mitigation to assist in the management of a more at risk non-migratory galaxiid population should be explored with the Department of Conservation.

Many areas in the vicinity of the proposed development have been extensively modified by past and existing farming and mining activities. These activities, together with small catchments providing minimal surface water features, contribute to the limited aquatic values present in most of the areas likely to be affected by mine development. However, the middle and lower reaches of the affected catchments have higher quality natural values, with healthy invertebrate and fish communities. The use of silt ponds and other proposed sediment control measures to prevent the movement of contaminants into the lower reaches of streams, and restricting unnecessary activities in the stream channels, will minimise any effects of the developments on these lower catchment environments.

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Appendix One

Sampling techniques for water quality, periphyton, benthic macroinvertebrates and fish

Water quality

Water quality parameters were recorded using a calibrated handheld YSI Professional Plus multi-probe field meter and included temperature (°C), conductivity (µS/cm) (an indicator of nutrient enrichment), dissolved oxygen concentration (mg/L), dissolved oxygen saturation (%) and pH. The significance of these water quality variables is briefly discussed below.

Dissolved oxygen

Adequate supplies of dissolved oxygen are essential for sustaining healthy aquatic communities, particularly fish and macroinvertebrates. Dissolved oxygen guidelines involve those that relate to minimum oxygen concentration levels (or saturation) and minimum concentrations of oxygen demanding substances (i.e., BOD or biochemical oxygen demand) in water. A minimum dissolved oxygen saturation of 80% is an acceptable minimum standard for hill country aquatic environments and would protect trout, which is the fish species most sensitive to low dissolved oxygen in New Zealand waters (Dean and Richardson 1999). This level is also specified in the Third Schedule of the Resource Management Act 1991 (Classes AE - water managed for aquatic ecosystem purposes, F – water managed for fishery purposes, FS - water managed for fish spawning purposes, SG - water managed for the gathering or cultivating of shellfish for human consumption).

pH

The development of nuisance algae growths due to nutrient enrichment can influence water quality by influencing dissolved oxygen and pH levels in the water column. During the day, algae photosynthesise (and respire) and, in doing so, produce oxygen. Conversely, at night, algae only respire and so consume oxygen. Thus, high abundance of algae can result in daily swings in dissolved oxygen and pH, potentially compromising sensitive fish and fish food (macroinvertebrates). A pH range of between 6.5 and 9.0 is typically cited as being appropriate for freshwater bodies of New Zealand (ANZECC 1992).

Temperature

Fish are often strongly affected by temperature, with effects of temperature on mortality, growth and reproductive behaviour all described from New Zealand or elsewhere. Trout and salmon are generally regarded as being less tolerant of higher water temperatures than New Zealand native fish (e.g., bullies, eels and koaro) and therefore if trout are the species protected against elevated temperature, this will result in protection of other freshwater fish species. Adult trout cease feeding around 19°C and lethal effects occur at between 24-30°C. A daily maximum temperature of 11°C is recommended for salmonid spawning areas during winter (May-September).

The Third Schedule of the Resource Management Act 1991, Class F Water (water managed for fishery purposes) and Class FS Water (water managed for fish spawning purposes), states that the natural temperature of the water shall not be changed by more than 3°C.

Periphyton

Periphyton or benthic algae is the material that forms slippery surfaces that are often seen, or at least felt, on upper stone surfaces of rivers and streams. Under favourable conditions (high nutrients, warm temperatures and stable flows), these growths flourish and develop into thick layers of varying colour and texture.

Samples of representative algal cover were collected from each site. These samples were taken back to the laboratory and inspected under 200-400x magnification to identify algal species present using the keys of Biggs and Kilroy (2000), Entwisle *et al.* (1988) and Moore (2000).

Macroinvertebrates

Freshwater benthic macroinvertebrates are small organisms that live on the beds of rivers, lakes and wetlands, have no backbone and are larger than 250 microns (0.25mm) in size. This broad grouping includes insect larvae (e.g., caddisflies, mayflies, stoneflies), aquatic worms (oligochaetes), snails and crustaceans (e.g., amphipods, isopods and freshwater crayfish). Macroinvertebrates utilise a variety of food sources depending on the species, with benthic algae or 'periphyton' a key food item for many species.

Macroinvertebrates are important in streams and lakes because they are a primary food item for many New Zealand freshwater fish species and a number of wetland and riverine bird species. Their ability to transfer primary production (i.e., algae or 'periphyton' growth) into a food source for fish and birds is a fundamental aspect of healthy stream and river ecosystems.

Aquatic macroinvertebrates are also good indicators of ecological change in freshwater environments. Changes in abundance (density or 'numbers') can be influenced by changes in water quality, periphyton biomass and flow history. Because different macroinvertebrate species have different tolerances to instream environmental factors such as dissolved oxygen, temperature, contaminant concentrations, fine sediment deposition and periphyton cover, the presence or absence of particular species, and their relative abundance to one another, can provide an indication of water quality conditions.

Stream invertebrate communities can also be influenced in varying degrees by flow, through direct effects on water depth and velocity (affecting their physical habitat), and indirectly by affecting temperature, dissolved oxygen, contaminant dilution and the development of nuisance periphyton growths.

Field collection

Benthic macroinvertebrates were sampled using a kicknet with a 500µm diameter mesh. Samples were collected by disturbing the substrate in a representative area immediately upstream of the net or by sweeping the net through aquatic vegetation. Samples were preserved with ethanol and returned to the laboratory.

Laboratory analysis

Samples were processed according to Protocol P2: 200 fixed count and scan for rare taxa (Stark *et al.* 2001), which is summarised briefly below.

In the laboratory the samples were passed through a 500µm sieve to remove fine material. Contents of the sieves were then placed in a white tray of known size. A 6cm x 6cm quadrat was randomly placed in the tray and the contents of the quadrat removed to a second tray. All of the macroinvertebrates visible to the naked eye in the second tray were removed and the residue transferred to a labelled vial. The macroinvertebrates were then identified under a dissecting microscope (10-40X) using criteria from Winterbourn *et al.* (2000) and transferred to a labelled vial. If 200 individuals were not present in the first quadrat a further quadrat was taken, and this process continued until 200 macroinvertebrates had been identified. At the end of the process the first tray was scanned to find any rare taxa not found in the quadrats. These individuals were identified under a dissecting microscope (10-40X) using criteria from Winterbourn *et al.* (2000) and transferred to a labelled vial.

Data summaries and metric calculations

Abundances of macroinvertebrates in the quadrats were scaled up to the total number in each sample using a weighting factor based on tray size. This abundance data was then converted into coded abundance scores using the codes established by Stark (1998) (Table A1.1).

Table A1.1 *Coded abundance scores used to summarise macroinvertebrate data (after Stark 1998).*

Abundance	Coded Abundance	Weighting factor
1 - 4	Rare (R)	1
5 - 19	Common (C)	5
20 - 99	Abundant (A)	20
100 - 499	Very abundant (VA)	100
> 500	Very very abundant (VVA)	500

For each site, benthic macroinvertebrate community health was assessed by determining the following characteristics:

Taxonomic richness: Reflects health of the community through a measurement of the variety of the taxa present. Taxonomic richness generally increases with increasing water quality, habitat diversity, and habitat stability.

Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, and percentage of the total abundance comprising EPT taxa (% EPT): These insect groups are generally dominated by pollution sensitive taxa. In stony bed rivers, these indexes usually increase with better water quality and increased habitat diversity.

Macroinvertebrate Community Index (MCI) (Stark 1993): The MCI uses the occurrence of specific macroinvertebrate taxa to determine the level of organic enrichment in a stream. Taxon scores are between 1 and 10, 1 representing species highly tolerant to organic pollution (e.g., worms and some dipteran species) and 10 representing species highly sensitive to organic pollution (e.g., most mayflies and stoneflies). A site score is obtained by summing the scores of individual taxa and dividing this total by the number of taxa present at the site. A low site score (e.g., 40) represents gross pollution and a high score (e.g., 140) represents very clean conditions (Table A1.2).

$$\text{MCI} \quad \frac{\text{of taxa scores}}{\text{Number of scoring taxa}} \text{ X } 20$$

Semi-quantitative MCI (SQMCI) (Stark 1998): The SQMCI uses the same approach as the MCI but weights each taxa score based on how abundant the taxa is within the community. Abundance of all taxa is recorded using a five-point scale (i.e., rare = 1-4 animals per sample, common = 5-19, abundant = 20-99, very abundant = 100-499, very very abundant = >500). As for MCI, SQMCI scores can be interpreted in the context of national standards (Table A1.2).

$$\text{SQMCI} \quad \frac{\text{Taxa coded abundance x Taxa score}}{\text{Total coded abundance}}$$

The MCI-sb and the SQMCI-sb use the same principles as the hard-bottomed MCI and SQMCI indices, however new taxon-specific tolerance scores (between 1 and 10) have been derived specifically for soft-bottomed streams (Stark and Maxted 2007). As for MCI and SQMCI, MCI-sb and SQMCI-sb scores can be assigned into classes corresponding to different levels of organic pollution (enrichment) (Table A1.2).

Table A1.2 *Interpretation of macroinvertebrate community index values from Boothroyd and Stark (2000) (Quality class A) and Stark and Maxted (2004) (Quality class B).*

Quality Class A	Quality Class B	MCI, MCI-sb	SQMCI, SQMCI-sb
Clean water	Excellent	> 120	> 6.00
Doubtful quality	Good	100 – 119	5.00 – 5.99
Probable moderate pollution	Fair	80 – 99	4.00 – 4.99
Probable severe pollution	Poor	< 80	< 4.00

Fish

To the public, fish are probably the most identifiable living component of river and lake ecosystems, having biodiversity, commercial, cultural, and recreational values. The New Zealand freshwater fish fauna is regarded as having low diversity. For example, in a national survey, Jowett and Richardson (2003) found an average of five species per survey site and three per site were found in the NZ Freshwater Fisheries Database.

Electric fishing

Fish communities were sampled qualitatively using a Kainga EFM 300 electric fishing machine. The machine operator moved through the site fishing to a second person with a downstream net. Sampling sites were selected to be representative of the different fish habitats present in the area. Stunned fish were captured and placed in a bucket to prevent further shock, and were later identified and measured before being returned to the area in which they were captured.

Appendix Two

Existing information on benthic macroinvertebrates

Table A2.1 *Absolute abundance (number of invertebrates per 0.1m²) of invertebrate taxa in the benthos of three headwater sites in the Shag and Waikouaiti catchments, 27-28 August 1996. Table from Glova (1996a).*

	Deepdell Creek (Historic Battery)			North Branch Waikouaiti River			Tipperary Creek (headwater tributary)		
	1	2	3	1	2	3	1	2	3
Aquatic organisms									
Platyhelminthes	-	-	-	4	-	-	-	-	-
Gastropoda									
Sphaerium spp.	-	-	-	-	-	-	4	4	-
Gyraulus corinna	-	-	4	-	-	-	-	-	-
Potamopyrgus antiopodarum	560	144	8	4	2	-	12	14	14
Amphipoda	-	-	-	-	-	-	16	8	8
Oligochaeta	176	32	12	8	2	6	28	16	56
Megaloptera									
Archichauliodes diversus	32	-	-	-	-	-	-	-	-
Mecoptera									
Nannochorista philpotti	-	-	-	-	-	-	8	2	-
Ephemeroptera									
Deleatidium spp.	1360	768	328	-	2	-	112	56	64
Plecoptera									
Zelandobius unicolor	-	-	-	-	-	-	8	4	6
Trichoptera									
Pycnocentrodes spp.	16	112	72	-	-	-	-	-	-
Aoteapsyche colonica	304	32	4	4	-	2	-	-	-
Hydrobiosis charadraea	-	16	-	-	-	-	-	-	-
Hydrobiosis harpidosa	-	-	4	-	-	-	-	-	-
Psilochorema spp.	-	-	4	-	-	-	-	-	-
Polyplectropus sp.	-	-	-	-	-	-	4	-	-
Oeconesus similis	-	-	-	-	-	-	-	-	2
Paroxyethira hendersoni	-	-	-	-	2	-	-	-	-
Coleoptera									
Elmidae - larvae	-	64	4	-	-	-	4	8	2
Hydrophilidae	-	-	-	-	-	-	-	4	4
Diptera									
Aphrophila neozelandica	32	-	8	-	-	-	-	-	-
Austrosimulium spp.	576	480	176	12	2	2	-	-	-
Eriopterini sp.	-	-	-	-	-	-	-	2	2
Chironomidae - larvae	1152	736	244	16	4	-	16	16	-
Muscidae	-	-	-	-	-	-	-	-	4
Copepoda	-	-	-	-	6	2	-	-	-
Rhadocoela									
Temnocephalus	-	-	-	-	-	-	24	-	-
Paranephrops zelandicus	-	-	-	-	-	-	3	1	-
Terrestrial organisms									
Collembola	-	-	-	-	2	-	-	-	-

Table A2.2 *Absolute abundance (number of invertebrates per 0.1m²) of invertebrate taxa in Tipperary Creek above and below the confluence with the headwater tributary sampled in Glova (1996a), 24 September 1996. Table from Glova (1996b).*

	Above tributary					Below tributary				
	1	2	3	4	5	1	2	3	4	5
Aquatic organisms										
Coelenteratas										
Hydra	-	-	-	-	-	-	1	-	-	-
Gastropoda										
Potamopyrgus antiopodarum	106	39	106	102	46	58	214	242	154	194
Oligochaeta	-	-	-	-	-	-	5	2	-	-
Megaloptera										
Archichauliodes diversus	22	16	17	22	9	12	33	40	30	28
Ephemeroptera										
Deleatidium spp.	82	31	80	45	60	41	90	212	594	186
Plecoptera										
Zelandobius unicolor	-	1	6	1	-	-	2	1	4	4
Acroperla spp.	7	-	4	-	1	-	-	-	-	-
Nesoperla fulvescens	-	1	-	-	-	-	-	-	-	-
Zelandoperla agnetis	1	-	-	-	-	-	-	-	-	-
Trichoptera										
Pycnocentrode auraeola	9	6	16	10	9	-	10	23	66	6
Aoteapsyche colonica	55	78	11	124	9	111	112	48	70	240
Beraeoptera roria	-	-	-	-	-	-		-	-	-
Hydrobiosis parumbripennis	-	-	-	-	-	-		-	-	2
Hydrobiosis frater	-	-	-	-	-	1		-	-	-
Hydrobiosis sp.	-	-	-	-	-	1	1	4	-	-
Hydrobiosidae	-	-	-	-	-	2	1	1	-	2
Psilochorema nemorale	1	5	4	3	2	-	-	2	2	8
Paroxyethira hendersoni	-	1	-	1	-	-	3	3	14	6
Oxyethira albiceps	-	-	7	1	-	-	4	5	4	2
Coleoptera										
Elmidae - larvae	25	21	24	16	17	3	5	79	68	146
Ptilodactylidae	-	-	1	-	-	-		-	4	4
Orchymontia sp.	-	-	-	-	-	-	1	-	-	-
Hydraenidae	-	-	-	-	-	2	-	1	-	4
Scirtidae	-	1	-	-	-	1	-	-	-	-
Diptera										
Aphrophila neozelandica	2	18	5	7	5	-	3	5	34	26
Austrosimulium spp.	4	2	-	-	1	2	4	11	-	14
Ceratopogonidae	1	3	2	5	-	-	-	2		2
Chironomidae - larvae	94	72	109	86	53	49	117	124	370	316
Chironomidae - pupae	5	4	7	2	11	2	5	11	10	46
Muscidae	-	-	-	-	-	1		-	-	-
Stratiomyidae	-	-	-	-	-	-	-	1	-	-
Tanyderidae	-	-	-	-	-	2	1	1	-	2
Linoria nigrescens	1	1	-	3	-	-	-	-	-	-
Copepoda	-	-	-	-	6	2		-	-	-
Terrestrial organisms										
Collembola	-	-	-	-	-	6	-	-	-	-

Table A2.3 *Absolute abundance (number of invertebrates per 0.1m²) of invertebrate taxa in two headwater sites in McCormicks Creek, 18 February 1997. Table from Glova (1997).*

	T1						T2					
Taxon	1	2	3	4	5	Total	1	2	3	4	5	Total
Aquatic organisms												
Platyhelminthes	7(3)	36	1	11	-	55	1	1	1	1	1	5
Ostracoda	13(3)	22	46	140	374	595	267	56	36	304	651	1314
Gastropoda												
Potamopyrgus antipodarum	743(4)	813	2492	1156	3077	8281	719	137	206	1742	1900	4704
Pelecypoda												
Pisidium casertanum	5(3)	10	19	23	82	139	13	5	4	15	140	177
Amphipoda	-	-	-	-	-	-	-	-	-	1(5)	-	1
Oligochaeta	97(1)	94	149	211	246	797	243	86	148	277	624	1378
Acarina	-	12(5)	8	-	-	20	-	-	-	-	8	8
Megaloptera												
Archichauliodes diversus	-	-	-	-	1(7)	1	-	-	-	-	-	-
Ephemeroptera												
Deleatidium spp.	129(8)	414	514	519	283	1859	31	11	4	74	10	130
Plecoptera												
Megaleptoperla diminuta	-	2(9)	4	1	-	7	-	-	-	-	-	-
Trichoptera												
Aoteapsyche colonica	3(4)	31	1	1	-	36	2	-	2	-	-	4
Aoteapsyche sp.	4(4)	-	-	-	-	4	-	-	-	-	-	-
Hudsonema amabilis	5(6)	2	18	15	20	63	2	1	1	4	14	22
H. aliena	-	-	-	1(6)	-	1	-	-	-	-	-	-
Hudsonema spp.	-	4(6)	-	16	-	5	-	-	-	-	-	-
Hydrobiosidae unidentified	8(7)	6	-	-	-	14	1	-	-	13	-	14
Hydrobiosidae pupae	-	4(7)	-	-	-	4	-	-	-	-	-	-
Psilochorema mimicum	3(8)	3	3	6	-	15	-	-	-	3	-	3
Psilochorema sp.	-	8(8)	-	-	-	8	-	-	-	-	-	-
Pycnocentrodes aeris	23(5)	123	74	118	92	430	11	7	9	36	6	69
P. evecta	-	8(7)	5	-	-	13	-	-	-	-	-	-
Pycnocentrodes spp.	40(5)	69	64	192	-	365	-	-	-	24	-	24
Pycnocentrodes pupae	3(5)	1	10	-	9	23	-	-	1	-	1	2
Pseudoconesus sp.	-	-	-	1(9)	1	2	-	-	-	-	-	-
Oxyethira albiceps	-	-	-	-	4(2)	4	2	3	2	8	7	22
Oxyethira pupae	-	-	-	-	-	-	-	-	1(2)	1	2	4
Polyplectropus spp.	-	-	-	-	1(8)	1	-	-	-	-	-	-
Hemiptera												
Sigara sp.	-	-	-	-	-	-	-	-	-	-	1(5)	1
Coleoptera												
Elmidae larvae	69(6)	80	56	60	29	294	2	2	5	25	-	34
Diptera												
Aphrophila neozelandica	1(5)	-	2	3	4	10	1	1	-	5	-	7
Austrosimulium spp.	1(3)	-	-	-	9	10	-	-	-	1	-	1
Chironomidae larvae	20(4)	8	22	6	4	60	133	49	31	83	93	389
Chironomidae pupae	-	4(4)	-	-	-	4	4	6	1	25	-	36
Paradixa sp.	1(4)	-	2	-	-	3	1	-	-	-	-	1
Paralimnophila skusei	-	-	-	1(6)	-	1	-	1	-	2	2	5
Tanyderidae	-	-	-	-	-	-	-	-	-	-	1	1
Copepoda	-	-	-	4(5)	-	4	-	-	-	-	-	-
Terrestrial organisms												
Collembola	16(6)	8	-	4	4	32	-	4	3	-	-	7
Diptera	6	12	-	-	-	18	4	7	15	3	-	29
Hemiptera	-	-	-	1	-	1	-	2	6	-	-	8
MCI value	95.7	105.8	96.2	104.3	97.8		84.7	88.9	84.2	91.8	83.5	

Appendix Three

Fish Species: Notes on distribution and significance

(photos by R. Allibone, G.A. Eldon, B. Ludgate, R.M. McDowall and S. Moore)

Shortfin eel (*Anguilla australis*)

Shortfin eels (Figure A3.1) are a native fish species that are very widespread throughout New Zealand and are the typical eels found in lakes, wetlands and low elevation rivers and streams. This species is usually secretive and nocturnal. In shortfin eels, the dorsal and anal fins are the same length so the ends are almost adjacent when the fish is viewed side-on. Shortfin eels may reach nearly 1200mm and weight 3.5kg. Shortfin eels mature at about 15 to 30 years of age and migrate to sea in autumn where they travel to subtropical Pacific Ocean locales where spawning occurs. Larval eels (Leptocephalus) hatch and return to New Zealand in spring where they enter rivers as transparent glass eels. Shortfin eel diet is comprised primarily of aquatic insects and significant amounts of fish when the eels reach lengths greater than 500mm. Activity and feeding is greatly reduced in cold temperatures (<10ºC). The shortfin eel is listed by Allibone *et al.* (2010) as being 'Not Threatened'.

Figure A3.1 *Photograph of shortfin eel (Photo: R.M. McDowall).*

Longfin eel (*Anguilla dieffenbachii*)

Longfin eels (Figure A3.2) are a native fish species that are widespread and common in a variety of habitats (streams, rivers, wetlands and lakes) throughout New Zealand where they are found from sea level up to 314km inland. This species has extraordinary climbing abilities and is often found above high and steep waterfalls. Longfin eels are distinguished from shortfin eels by the length of the dorsal fin; when viewed side-on, the dorsal fin is longer than the anal fin and extends well forward past the end of the anal fin. Longfin eels can reach up to nearly 2000mm in length and 25kg in weight. Longfin eels mature at about 25 to 35 years of age and migrate to sea in autumn where they travel to subtropical Pacific Ocean locales where spawning occurs. Larval eels (Leptocephalus) hatch and return to New Zealand in spring where they enter rivers as transparent glass eels. Longfin eel diet is comprised of stream insects, fish and even small birds. Activity and feeding is greatly reduced in cold temperatures (<10ºC). The longfin eel is listed by Allibone *et al.* (2010) as 'Declining'.

Figure A3.2 *Photograph of longfin eel (Photo: G.A. Eldon).*

Flathead galaxias *(Galaxias depressiceps)*

The flathead galaxias (Figure A3.3) is a species of non-migratory galaxiid found throughout the lower South Island. Genetic studies have been used to attempt to identify different populations, however the Department of Conservation is now managing many hybrid populations as flathead galaxias. This species favours cobble/boulder streams in tussock grasslands and their diet comprises mayflies, midge larvae and caddisflies. The flathead galaxias is listed by Allibone *et al.* (2010) as being 'Not Threatened', with a 'conservation dependent' qualifier.

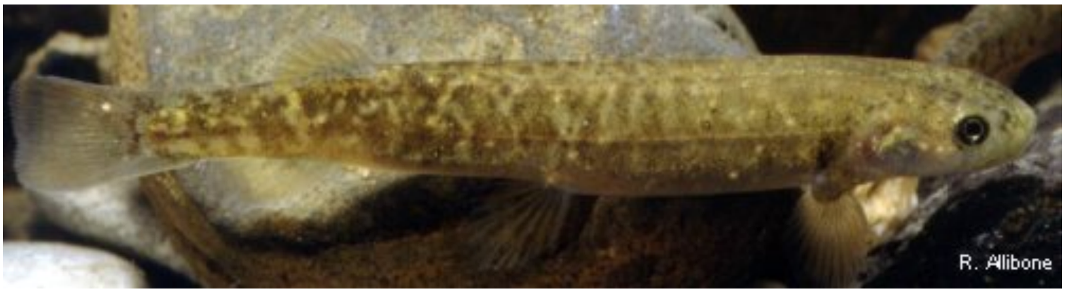

Figure A3.3 *Photograph of flathead galaxias (Photo: R. Allibone).*

Upland bully *(Gobiomorphus breviceps)*

The upland bully (Figure A3.4) is one of the non-diadromous members of the Eleotridae family native to New Zealand. They grow to an average length of 80mm. Upland bully are solitary and territorial with spawning occurring throughout spring and summer. As they do not have to go to sea as part of their life cycle, they occur well inland in many river systems, although they are also found close to the coast. Upland bully will tolerate a variety of habitats, from stony-bedded rivers to weedy streams, usually where the flow is gentle. The upland bully is listed by Allibone *et al.* (2010) as being 'Not Threatened'.

Figure A3.4 *Photograph of upland bully (Photo: S. Moore).*

Common bully (*Gobiomorphus cotidianus*)

Common bullies (Figure A3.5) are a native fish species that are widespread and common throughout New Zealand especially in lowland areas and inland lakes. This species occupies varied habitats, including margins of lakes and wetlands and throughout gravelly rivers and streams, is commonly observed moving throughout river and lake shallows but can be cryptic amongst rocks, vegetation and debris. Common bullies often reach 100mm in length with lake populations generally slightly smaller (about 60mm). Spawning occurs from spring to summer with hundreds to thousands of eggs produced in a single layer on nest substrate. Eggs hatch and larvae go to sea, returning approximately three to four months later. Landlocked populations complete life cycles (including spawning) in lakes, abandoning the marine life stage. Common bullies feed on a variety of stream insects, snails, crustaceans and small fish. The common bully is listed by Allibone *et al.* (2010) as being 'Not Threatened'.

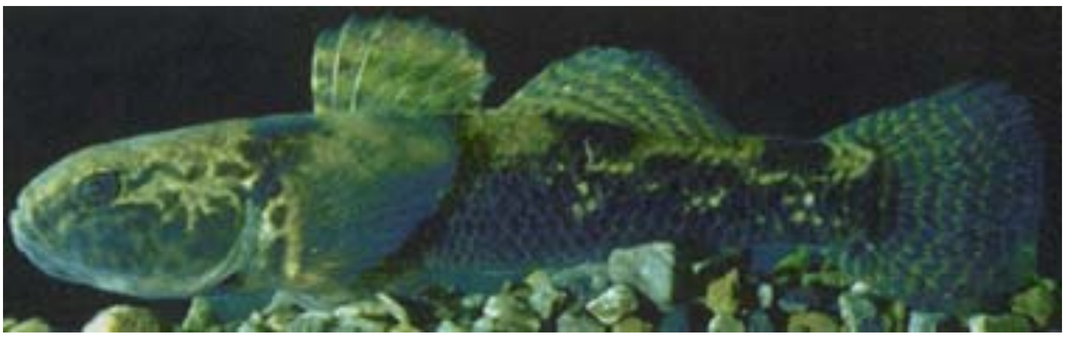

Figure A3.5 *Photograph of common bully (Photo: R.M. McDowall).*

Brown Trout (*Salmo trutta*)

Brown trout (Figure A3.6) were first introduced to New Zealand in 1867 and are now widespread throughout the country comprising a significant component of the New Zealand freshwater sports fishery. They are found in a variety of habitats from low elevation lakes to headwater streams and subalpine lakes. Adult brown trout in New Zealand may reach up to 950mm in length. Brown trout is an anadromous species, with breeding taking place in freshwater following migrations from the sea. However, land-locked populations also exist, with migrations from downstream areas rather than from the sea. Adult brown trout migrate upstream in autumn or early winter to reach spawning grounds located in gravely headwater rivers and streams. The females dig depressions in the gravel and deposit the eggs, which are fertilised by the male. The eggs develop for one or two months then hatch as fry to shoal around the stream margins. Some smolt move towards the sea for early growth, while others remain in freshwater areas. Unlike chinook salmon, adult brown trout usually survive spawning. Brown trout feed on a variety of stream insects, snails, crustaceans and small fish.

Figure A3.6 *Photograph of brown trout (Photo: B. Ludgate).*