

Before a joint hearing of the

Dunedin City Council
Otago Regional Council
Waitaki District Council

**LUC-2016-230 and LUC-2013-225/A
RM16.138
201.2016.779 and 201.2013.360-1**

Under the Resource Management Act 1991

In the matter of applications by Oceana Gold (New Zealand) Limited for
resource consents for the Coronation North Project

Statement of evidence of Gregory Ryder for Oceana Gold (New Zealand) Limited

14 October 2016

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**anderson
lloyd.**

Qualifications and experience

- 1 My name is Gregory Ian Ryder.
- 2 I am a water quality scientist and aquatic ecologist and hold BSc. (1st Class Honours) (1984) and PhD. (1989) degrees in Zoology from the University of Otago.
- 3 I am an Environmental Scientist at Ryder Consulting Limited, a company I established 21 years ago, with offices in Dunedin, Christchurch and Tauranga. Prior to this I held positions at the Otago Regional Council (**ORC**) and the University of Otago.
- 4 For approximately 30 years I have conducted a wide variety of studies on freshwater ecology and water quality throughout New Zealand. I have been project manager for major studies on New Zealand river ecosystems and have had a lead role in a number of multidiscipline studies involving aquatic and terrestrial ecosystems. Regional councils and government departments have engaged me to peer review environmental studies and resource consent applications, and I have held the position of an independent commissioner on a number of major resource consent hearings associated with hydro-electric development, irrigation, marine farming, ski-field development, water abstractions and wastewater discharges.
- 5 In 1995 I designed, and for a number of years ran, Environment Southland's State of the Environment Freshwater Monitoring Programme and my company continues to be involved with this programme. For six years Ryder Consulting has undertaken the ORC's annual State of the Environment Freshwater biological monitoring programme, and has previously been engaged by West Coast Regional Council to analyse and prepare a report on its state of the environment monitoring data. I have assisted both Environment Southland and ORC in developing their respective regional water plans, and was the principal author in developing water quality standards for Southland's Draft Regional Water Plan (Ryder 2004).
- 6 Our company maintains an environmental laboratory in Dunedin and we regularly process benthic algae, plankton and macroinvertebrate samples from a range of private companies, local and regional authorities throughout New Zealand.
- 7 I am a member of the following professional societies:
 - (a) New Zealand Freshwater Society;
 - (b) New Zealand Water and Wastes Association;
 - (c) Royal Society of New Zealand; and

- (d) Society of Freshwater Science (North America).

Background information

- 8 My association with the Macraes area goes back to the mid 1980s when I was completing my PhD degree. I was subcontracted by the Otago Fish and Game Council to assist them with baseline surveys of aquatic ecology, which were undertaken at the request of the then owners of the mining licences for the area. These surveys were undertaken well before the commencement of modern mining operations. The work included fish and benthic surveys, macroinvertebrate sample processing and data interpretation. The mine owners then commenced a detailed monitoring programme in 1990 after resource consents were granted, and my personal involvement in the consent monitoring programme recommenced in 1995. Ryder Consulting has been monitoring surface waters of the area since then. Consequently our Company's collective knowledge of the aquatic ecology of the area is extensive and based on a combination of understanding the ecology and landscape prior to mining operations commencing, and building a long term record of surface water ecology. I can confidently state that the monitoring programme I have been associated with in the Macraes Mine area remains the most comprehensive freshwater ecological dataset in Otago and Southland. This association with a long term monitoring programme has allowed me to observe the aquatic ecology under a broad range of seasonal conditions, ranging from wet years with frequent floods to very dry years when creeks have literally dried up for months on end.
- 9 As part of the resource consents applications for OceanaGold's Coronation Project I was involved in ecological assessments and the development of suggested mitigation and monitoring approaches and conditions.
- 10 In association with my colleagues I have been involved in the following work in relation to OceanaGold's Coronation North project:
- (a) Surveys of the Coronation North Project area and preparation of an aquatic ecology assessment, which was included in Appendix 8 of the Assessment of Environmental Effects (**AEE**) submitted in support of the resource consent applications;
 - (b) Attending a meeting with ORC and responding to section 92 request for further information; and
 - (c) The development of suggested mitigation and monitoring measures with OceanaGold.
- 11 In preparing this evidence I have reviewed:

- (a) The AEE lodged as part of the application for the Coronation North Project;
 - (b) The reports of other experts giving evidence relevant to my area of expertise; and
 - (c) The submissions lodged on behalf of the Director General of Conservation and KTKO Ltd on behalf of the three Runanga.
- 12 Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

Scope of evidence

- 13 I have been asked by OceanaGold to prepare evidence in relation to aquatic ecology for the Coronation North Project. In my evidence I discuss:
- (a) A summary of the existing information on aquatic values in the Coronation North Project area and the results of further surveys we carried out;
 - (b) An assessment of the potential effects of the Coronation North Project on the identified aquatic values;
 - (c) Recommendations on options for mitigating any significant effects on aquatic values;
 - (d) Recommendations on monitoring;
 - (e) Consideration of submissions raising issues relating to aquatic ecology;
 - (f) Conclusion on the effects of the Coronation North Project on aquatic ecology; and
 - (g) Overall recommendations regarding consent conditions.

Existing information

- 14 A review of published and unpublished literature and relevant databases was undertaken to obtain existing information on aquatic communities within the vicinity of the Coronation North Project Area. Aquatic communities in the Mare Burn catchment were first surveyed in 2011 and 2012 as a part of investigations for the Coronation Project. For the Coronation North Project, emphasis was placed on lower sections of the tributary catchments.

- 15 Tributaries within the Mare Burn catchment have been surveyed on repeated occasions since November 2012 as a part of the Coronation Project consent monitoring requirements. Most recently, several surveys have occurred between November 2015 and February 2016. The primary purpose of these surveys has been to assess algae, macroinvertebrate (including crayfish) and fish communities, general habitat quality and flow conditions throughout the summer period (particularly over the 2015 - 16 summer).
- 16 A site known as TG01 on lower Trimbells Gully was established in August 2014 and is surveyed quarterly for benthic macroinvertebrates (using the Surber sampler method) and electric-fished annually, as a part of consents associated with the existing Coronation Project. This data was reviewed.
- 17 OceanaGold monitor water quality in the Mare Burn downstream of all mining operations (at a site known as MB01) and this data was reviewed.
- 18 Fisheries records from the New Zealand Freshwater Fish Database (**NZFFD**) for the wider Macraes area, and records for the distribution of non-migratory galaxiids in Otago, were obtained (March 2016) and plotted onto a GIS map of the area.
- 19 Site-specific surveys were undertaken in areas potentially directly affected by the Coronation North Project.
 - (a) Representative aquatic habitats in the Mare Burn catchment were surveyed by walking sections, noting physical characteristics such as riparian margin intactness, vegetation cover, bank and bed composition, wetted width, water depth and current. Instream habitat was recorded, including substrate composition, fine sediment cover, and periphyton and macrophyte cover. Some samples of algae were collected for microscopic identification in the laboratory. Representative benthic macroinvertebrate samples were collected using the kick-net method. The most recent samples were collected in November 2015, December 2015 and February 2016, with additional samples collected from the Coal Creek catchment in April 2016. Macroinvertebrate community health was assessed. An extensive photo record was collected;
 - (b) Aquatic communities in the Coal Creek catchment were surveyed. Representative benthic macroinvertebrate samples were collected from the Coal Creek catchment in April 2016 using the kick-net method;
 - (c) Fish have been surveyed in both the Mare Burn and Coal Creek catchments using a variety of techniques including electric fishing, minnow traps and visual observations. The latter method was most suitable over the summer period when flows and water depth were generally too low to

effectively sample with other methods. Provided the water surface remains calm, fish, including small juveniles (which are common around November-December), can be observed quite easily and effectively, so this was the method used in December and February surveys. Freshwater crayfish (koura) distribution was also assessed using these methods;

- (d) Some water quality information was collected during the above surveys using a YSI hand - held meter; and
- (e) A visual inspection of tributaries of Trimbells Gully was undertaken.

Existing aquatic habitat

- 20 The existing consented Coronation Project Area is located in the headwaters of Camp Creek, a major tributary of Deepdell Creek, situated adjacent to the existing Macraes Gold Project mining operation, and in the headwaters of Maori Hen Creek and a major tributary of Trimbells Gully, known as Trimbells Gully Tributary (or Trimbells Gully Trib.). Both Maori Hen Creek and Trimbells Gully are tributaries of the Mare Burn, which flows into the Taieri River (Figure 1, Appendix 1).
- 21 The Coronation North Project is confined to the Mare Burn catchment.
- 22 The headwaters of Maori Hen Creek are situated in the vicinity of the Sister Peaks at an altitude of approximately 680 metres above sea level (**asl**). The headwaters of Trimbells Gully Tributary are in the vicinity of Highlay Hill, at elevations up to approximately 820 metres asl. Both catchments drain in a north-westerly direction and join several other named and unnamed tributaries flowing into the Mare Burn (Figure 1, Appendix 1).
- 23 The Mare Burn enters the Taieri River approximately 12 kilometres downstream of the confluence of Maori Hen Creek and Trimbells Gully. The Mare Burn catchment is approximately 6,550 hectares in area, or about 1.15 % of the Taieri River catchment.
- 24 Descriptions of individual sub-catchments follow.

Maori Hen Creek

- 25 The consented boundary of the current Coronation Project lies within the upper Maori Hen Creek catchment. The Coronation North Project would envelope almost the entire catchment of Maori Hen Creek (principally by land needed for the Coronation North waste rock stack).

- 26 Maori Hen Creek lies within a relatively narrow gully with steeply-sided faces throughout most of its length. Its catchment is approximately 152 ha in size, representing about 2.4 % of the total Mare Burn catchment. The wetted channel is narrow throughout most of its length, typically varying from about 50 to 20 cm wide. While the creek typically carries a small flow through summer (a few litres per second), some sections have reasonable water depth due to the confined nature of the channel, brought about by the step sided gully faces often coupled with underlying bedrock. There are some areas where the flow spreads out and the channel becomes unconfined, resulting in little obvious surface flow, and more akin to wetland habitat as opposed to stream habitat. In these places, the bed is typically comprised of damp mud covered with plants capable of tolerating wet feet.
- 27 Downstream, the creek flows through a gully dominated by tussocks and pasture grasses, grazed by cattle and sheep. Instream habitat through the gully is comprised of shallow riffles, runs and small drops and pools. Bed substrate is dominated by gravels and cobbles, with some areas of boulders and bedrock. There is evidence of stock damage to the channel particularly in the lower reaches.
- 28 A kick-net sample collected from the lower section of Maori Hen Creek in December 2015 included 17 invertebrate taxa including seven dipteran taxa. The fauna was dominated by small chironomids and ostracods, and *Potamopyrgus* snails. Other abundant taxa included a small bivalve (Sphaeriidae), a small stonefly larvae (*Zelandobius*), the purse caddisfly *Oxythira* and aquatic worms. *Deleatidium* mayflies were present but uncommon. Juvenile galaxiids were abundant in small pools and adults were observed also.
- 29 The creek was inspected again in February 2016. Water temperature was moderate (16 – 17 °C) given the time of the year, and dissolved oxygen saturation was moderate to good also (8.12 - 8.72 mg/L). The upper area carried a small flow, similar to that observed in December, and patches of filamentous green algae were present. Flow increased slightly downstream and filamentous green algae abundance was less pronounced. The February 2016 survey found the invertebrate community to be heavily dominated by *Potamopyrgus* snails at the two sites sampled. *Deleatidium* mayflies were abundant in the sample collected from the upper site, but uncommon in the sample collected just upstream of the ford. A range of other invertebrate taxa were present (32 in total) and the community was generally indicative of slow moving water and similar to that found in December.

- 30 Crayfish were observed in small pools throughout the creek, and, further downstream, both galaxiids and crayfish were observed in pools in significant numbers.

Trimbells Gully Tributary

- 31 The existing footprint of the Coronation mine lies in the headwaters of Trimbells Gully Tributary (Figure 1, Appendix 1). This tributary drains a catchment of approximately 250 ha representing about 3.9 % of the total Mare Burn catchment. While technically a tributary of Trimbells Gully, Trimbells Gully Tributary typically has more water in it over the summer period. This appears to be due in part to the tributary having a slightly larger catchment (Trimbells Gully drains a catchment of approximately 197 ha). The Coronation North Project will envelope the majority of the Trimbells Gully Tributary catchment.
- 32 The catchment of this tributary has similar characteristics to other tributaries in this area of the Mare Burn catchment. The sides of the gully are relatively steep and narrow with rocky outcrops in places. The stream channel is typically bordered by tussocks and pasture grasses. Channel morphology varies throughout its length and is governed to some degree by the presence of surface bedrock, which acts to constrain the wetted channel in places. Where bedrock is absent on the surface, the wetted channel is less defined, particularly where the valley floor is wider, and surface flow is often difficult to detect.
- 33 The bed of Trimbells Gully Tributary ranges from bedrock to fine sediment. Visible algae was generally uncommon in December 2015. There was evidence of significant stock pugging of the bed and channel margins.
- 34 Further downstream, the stream channel is more defined and incised in places. Several bedrock sections create small waterfalls and steep drops. Small pools (up to 35 – 45 cm deep) form downstream of bedrock sections, however overall, water depth is shallow. The side gullies in December 2015 were generally devoid of surface water.
- 35 Kick net samples were collected from three sites in February 2015, extending upstream from just upstream of the ford in the lower reach to about 500 metres downstream of the existing mine's silt pond. Thirty three taxa were identified from the three sites, with dipteran larvae being the most diverse group with 15 distinct taxa. Abundant taxa included the mayfly *Deleatidium*, the purse caddis *Oxythira albiceps*, the snail *Potamopyrgus antipodarum*, small crustaceans called ostracods, aquatic worms and the small stonefly

Zelandobius. The MCI invertebrate community health index¹ ranged between 85 and 92, which can be regarded as indicative of 'Fair' habitat quality, however the semi-quantitative version of this index (SQMCI) produced scores ranging between 2.6 and 4.4, which are indicative of 'Poor' to 'Fair' habitat quality.

- 36 The follow up survey in February 2016 found an estimated flow of less than 0.5 L/sec. Small pools were still present in places, however in some sections surface water was barely visible. Water temperature was measured at 17.4 °C and dissolved oxygen concentration was healthy at 9.79 mg/L. Kick-net samples collected in February in the lower section of the creek found a slightly less diverse fauna (30 taxa), but similar in composition, dominated by snails and to a lesser extent by ostracods, *Deleatidium* mayflies, *Oxythira albiceps*, and the stonefly *Zelandobius*.
- 37 Crayfish are common throughout most of the length of Trimbells Gully Tributary. Adults and juveniles are observed in most sections often in large numbers. Galaxiids are also common. Young juveniles (whitebait-sized and smaller) were observed in most pools in December, along with adults. Galaxiids were also observed in the February 2016 survey, although the low flow meant that available habitat had reduced considerably.
- 38 The most striking difference to the stream in February compared to earlier in the summer was the extensive rafts of filamentous green algae that were found in many reaches between the confluence of Trimbells Gully tributary with Trimbells Gully and upstream towards the mine's silt pond. An algae sample, collected in December 2015, and identified under the binocular microscope, found the only filamentous algae taxa present was *Parallela*, which is described as found in streams and rivers of 'moderate to good water quality'. However, samples of the filamentous algae collected in February 2016 found they were dominated by *Mougeotia*, with *Oedogonium* also common. *Mougeotia* was previously found in Trimbells Gully Tributary in a November 2012 survey. It is described as being found in slow-flowing waters of 'moderate to good water quality'.

¹ The MCI index of stream invertebrate community health is based on the presence/absence of individual taxa at a site, and theoretically can range between 200 and 0. Scores >120 reflect a community dominated by taxa indicative of pristine conditions while a score of <80 reflects a community indicative of very poor water quality and habitat conditions. There are two well used variations to the MCI, the SQMC, which takes into account the relative abundance of the various taxa found at the site, and the QMCI, which is also takes into account the abundance of each taxa when quantitative sampling methods are employed. Typically, SQMCI scores are calculated when a kick-net sampler is used and QMCI when a Surber sampler is used. These indexes range between 10 and 1.

Trimbells Gully

- 39 The Trimbells Gully catchment (197 ha) starts at the top of Highlay Hill (820m asl). In its lower reaches in December 2015, the Trimbells Gully creek had a largely narrow wetted width (30 - 50 cm wide) and water depths ranging between 5 - 20 cm. The flow was very sluggish with no discernible flowing water in many places except over shallow bedrock. Flow was estimated by eye to be less than 0.1 - 0.15 L/sec. The bed had a thin layer of fine silt or organic matter over rock and gravels. Tussock and grass foliage often spilled over the channel. There was evidence of heavy grazing by cattle and/or sheep, and the margins and channel were well tramped in places.
- 40 Crayfish were observed in the lower reaches. Juvenile galaxiids were caught by kick-netting and via electric fishing. Small shoals of juvenile galaxiids were observed in this creek all the way up to and just above the fence-line at map reference N 4979211 E 1396618, a distance of approximately 1.1 km. Beyond this point, the bed of the watercourse was wet, but with no discernible surface flow.
- 41 The benthic invertebrate fauna in Trimbells Gully in December 2015 was varied and dominated by taxa that were suited to slow moving water with variable water quality and fine sediment. Chironomid larvae, small crustaceans (e.g., ostracods) and the stonefly *Zelandobius* were abundant or common at both sampling sites. *Sigara* beetles were also abundant at the downstream sampling site while *Potamopyrgus* snails were abundant at the upstream sampling site. Nineteen taxa in total were found in samples collected from two sites.
- 42 Community health indices were low reflecting the dominance of taxa suited to slow water movement, fine sediment and moderate to low water quality. Higher daily peaks in water temperature at this time of the year may also have played a role in invertebrate community structure. However, on the day of the survey, water temperature was moderate (15.4 – 18.4 °C) and dissolved oxygen concentration was good (8.3 – 9.89 mg/L).
- 43 In February 2016, Trimbells Gully creek was virtually dry. Pools of standing water were still present, but appeared stagnant, and sections of dry channel were common. There was evidence of stock disturbance throughout the channel. Water temperature was moderate (14.4 °C). No fish were observed in the creek, but some may have been present in the pools. Habitat was unsuitable to collect invertebrate kick-net samples.

Long-term monitoring of Trimbells Gully creek

- 44 A long-term fish and invertebrate monitoring site (TG01) has been established on Trimbells Gully creek downstream of the confluence with Maori Hen Creek. This site is surveyed for macrophytes, periphyton and fish, and sampled quantitatively for macroinvertebrates. Monitoring commenced in August 2014. The site is very open, with limited shading from surrounding hills and from the riparian vegetation, which consists of tussocks and pasture grass, with some matagouri, sedges and rushes. There is evidence of stock access throughout the site. The substrate consists of small gravels and cobbles, with bedrock in pools immediately upstream of the site.
- 45 Surveys were conducted between the winter of 2014 and autumn of 2015. Macrophyte cover was low in both winter and spring (less than 3%). Mat algae cover was very high in winter with 81 % cover, although declined to less than 2 % in spring. Filamentous algae cover was lower although still reaching 23 % cover in spring.
- 46 The fauna was found to be dominated in winter and spring by mayflies, snails, small dipteran larvae and worms. In spring 2014, *Oxythira albiceps* caddisfly larvae and *Zelandobius* stonefly larvae were common also. In summer, the site was dry and could not be sampled. In the following autumn (2015), mayflies were absent, and the fauna was less diverse and in lower abundance than in the previous winter and spring. The QMCI health index declined between winter (average of 5.0, indicative of 'Fair to Good' habitat quality) and autumn (average of 2.7, indicative of 'Poor' habitat quality).
- 47 The TG01 site was dry in the summer (February 2015) and again in February 2016, and so was not sampled for fish. However, galaxiids have been observed at this site at other times.

Coal Creek

- 48 Part of the Coronation North project footprint would lie within the eastern side of the Coal Creek catchment and a reservoir to store freshwater is proposed for part of the lower catchment (Figure 2, Appendix 1). At approximately 700 ha, its catchment is greater than the total area occupied by the Maori Hen, Trimbells Gully and Trimbells Gully Tributary catchments. Despite this significantly greater catchment area, its flow in the lower catchment is modest and much less than observed in the other catchments over the 2015-16 summer. In December 2015, this creek had a very small flow and was almost dry between pools in its lower section.

- 49 Galaxiid larvae were observed in the pool immediately downstream of the farm bridge in December 2015, however, by late February 2016, the flow in the lower section of Coal Creek had ceased and the channel was completely dry.
- 50 A more extensive survey of the Coal Creek catchment was undertaken in April 2016 with particular emphasis on watercourses within and immediately surrounding the footprint of the proposed freshwater reservoir. Prior to the survey, weather conditions had been relatively stable with only a small amount of rain falling in the weeks prior. The survey involved a walkover of watercourses accompanied by extensive electric fishing and in some cases macroinvertebrate sample collection. The survey area is identified in Figure 2, Appendix 1.
- 51 The first watercourse examined (labelled as Trib. A in Figure 2, Appendix 1) carried the greatest flow and we have assumed this to be the main tributary in the Coal Creek catchment. In its lower reaches, from the reservoir footprint to an upstream distance of approximately 800 metres, the watercourse flowed through a gully floor characterised by grazed sedges, tussock grasses and pasture grasses. There was extensive evidence of historic mining activity and it seemed that significant parts of the channel had been realigned and straightened over time.
- 52 We observed flowing water and a continuous wetted channel throughout this reach, although the flow was modest and estimated at less than 1 litre/second. However, this was sufficient to create small riffle and slow run habitat, and support deeper pool habitat.
- 53 One of the main characteristics of the gully floor and associated watercourse channel was the extensive trampling and pugging by stock. This damage was observed right throughout the length of the channel surveyed and was severe in places, resulting in deep soft muds on the bed that quickly resuspended and discoloured the water when walked on. Cattle were present in the vicinity of the creek on the day of the survey. Cattle faeces were common in and around the wetted channel and long filamentous green algae was present in some areas.
- 54 Despite this physical disturbance, galaxiids and crayfish were common throughout the reach surveyed. Some of the fish were large (80 - 90 mm long) and possibly gravid (carrying eggs). Small and medium sized fish (15 – 50 mm long) were also captured indicating that the population was recruiting. Crayfish also varied in size indicating active recruitment to the population. During electric-fishing, most fish were observed to come from under rocks. Few fish were located within the water column or lying above the soft mud sections of the bed.

- 55 A kick-net benthic invertebrate sample collected from this section of Trib. A was dominated by snails, small crustaceans (ostracods), small Sphaeriidae bivalves and the larval trichopteran *Oxythira albiceps* (purse caddisfly). Other taxa indicative of still water, soft bed, and degraded water quality were common. Invertebrate community health index scores were low (MCI of 83 and SQMCI of 3.4, indicative of 'Fair' and 'Poor' habitat quality respectively).
- 56 The next gully to the southeast (Trib. B, Figure 2, Appendix 1) was then surveyed. It was dry throughout its mid reaches and surface water was not observed until some distance downstream toward the reservoir footprint. Even then, there was no obvious surface flow.
- 57 The next watercourse surveyed was the reach through the reservoir footprint (Figure 2). The channel in this section of the catchment is confined due to the physical nature of the surrounding land, being dominated by narrow, steep rock faces creating a gorge. Small pool habitat is more common in this reach and these pools were deeper than those further upstream. Having said that, fish (galaxiids) abundance was lower than that found further upstream in Tributary A. Reasons for this were not readily apparent, but may be due to less rock cover relative to that in some pools surveyed upstream. The fish caught ranged in size from small to large. Crayfish abundance appeared similar to that in Tributary A further upstream.
- 58 Stock damage to the banks and channel was apparent throughout this reach, however, while significant, it was not as severe as upstream, probably due to the presence of more bedrock and hard surfaces restricting erosion and pugging. Long filamentous algae was common.
- 59 A kick-net benthic invertebrate sample collected from the main channel within the reservoir footprint was dominated by aquatic worms and ostracods. Other taxa indicative of still water habitat were common. Invertebrate community health index scores were low (MCI of 88 and SQMCI of 2.3, indicative of 'Fair' and 'Poor' habitat quality respectively).
- 60 Another gully to the east (Trib. C, Figure 2, Appendix 1), which enters the main channel within the gorge, was surveyed. It consisted of a series of small pools separated by sections of channel dominated with grasses and almost no surface flow. Five galaxiids (4 medium size and 1 large size) and one crayfish were caught in four pools surveyed in this tributary. The water in this tributary was very clear relative to that in the other tributaries surveyed.
- 61 The bottom end of Coal Creek (downstream of the dam footprint) was previously examined in February 2016. On that occasion, the creek channel at the ford was dry downstream of the bridge. Upstream of the bridge, the channel was primarily dry also, although there were some isolated pools of water. When this

site was visited in April 2016, the channel below the bridge held water again and was relatively deep. Immediately upstream of the bridge, the channel had small pools of water with no discernible flow. These were separated by sections of boggy wetland habitat with little discernible surface flow.

- 62 Gullies in the sub-catchment draining the western side of the Coal Creek catchment (we named Trib. D, Figure 2, Appendix 1) were dry in April.
- 63 In summary, the Coal Creek catchment suffers from heavily degraded physical habitat, due largely to cattle and to a lesser extent sheep trampling and pugging. Historic mining and farming activities also appear to have significantly modified watercourses through straightening and diverting channels, and damming of gullies. Water quality is likely to be characterised by elevated sediment loads (particularly during rain events) and nutrient concentrations. Long filamentous green algae was common and indicative of high nutrient levels. A lack of flowing water is also a characteristic of large parts of this catchment, at least during the summer-autumn seasons, further restricting habitat for fish and invertebrates favouring flowing water.

Mare Burn catchment above Trimbells Gully confluence

- 64 True left tributaries of the Mare Burn upstream of the confluence with Trimbells Gully were inspected in February 2016. This involved a walkover and observation of the creek beds and surrounding riparian margins.
- 65 The stream channels were small with good bank and riparian cover dominated by tussock grasses. Sheep had been grazing the surrounding land, but not heavily in the channel. Sections of the channel were dry or consisted of damp mud. Some isolated pools remained. Stream habitat potential appeared high, however a lack of water significantly limits the ability to support valued stream biota all year round.

Summary of existing algae cover within the Mare Burn catchment

- 66 As previously mentioned, there is evidence of high algae cover already occurring at times in the tributaries proposed to be affected by the Coronation North project:
- (a) In February 2016 the upper area of Maori Hen Creek had patches of filamentous green algae but where flow increased slightly downstream algae abundance was less pronounced;
 - (b) Visible algae was generally uncommon in Trimbells Gully Tributary in December 2015. However, in February 2016 the flow was lower and there were extensive rafts of filamentous green algae found in many reaches

between the confluence with Trimbells Gully and upstream towards the mine's silt pond;

- (c) At the Trimbells Gully long-term monitoring site (TG01) mat algae cover was very high in winter 2014 with 81% cover and filamentous algae cover reached 23% cover in spring 2015; and
- (d) Long filamentous green algae was common throughout Coal Creek.

Summary of existing macroinvertebrate communities within the Mare Burn catchment

- 67 The tributaries of the Mare Burn that we have surveyed contain a surprising number of benthic invertebrate taxa given they are probably impacted by a lack of surface flow at times in most years and their habitats are not protected from grazing stock. This has resulted in significant impacts in tributaries within the Coal Creek catchment in particular. None of the taxa we have identified are uncommon, indeed all are commonly found throughout large areas of the country. However, diversity is relatively high in Maori Hen Creek and Trimbells Gully Tributary given there appears to be nothing particularly unique about their instream character.
- 68 Freshwater crayfish (*Paranephrops zealandicus*) are widespread and relatively common in Coal Creek, Maori Hen Creek, Trimbells Gully tributary and Trimbells Gully mainstem. Their relatively high abundance in these creeks is surprising given that habitat appears limited by a lack of flow and wetted area. They are likely to be present in other tributaries of the Mare Burn, and in the Mare Burn itself. The species is classified as 'At Risk – Declining' by New Zealand Threat Classification System (NZTCS).

Summary of existing fish communities in the Mare Burn

- 69 The New Zealand Freshwater Fish Database (NZFFD) was reviewed to obtain existing information on fish communities in the Mare Burn catchment. Four species have been recorded in the Mare Burn catchment; brown trout, unidentified galaxias, longfin eel and shortfin eel. All except one of the NZFFD records from the Mare Burn catchment are for the mainstem of the Mare Burn within 2 km of the Taieri River confluence and therefore well downstream of the existing Coronation Project and proposed Coronation North Project area.

Galaxiids

- 70 The area of the Mare Burn that will be affected by the Coronation North Project contains non-migratory galaxiid populations. Our fish surveys have caught or observed galaxiids in Trimbells Gully, Trimbells Gully Tributary, Maori Hen Creek

and Coal Creek. Despite the small size of these streams, galaxiids appear widespread and abundant in some places, particularly the mid and lower reaches of Trimbells Gully Tributary and Maori Hen Creek. Taieri Flathead galaxias (*Galaxias depressiceps*) are classified by the NZTCS as 'threatened – nationally vulnerable'.

Eels

- 71 Eels have not been recorded or observed in the vicinity of the tributaries subject to existing and proposed mining operations. Therefore no eel populations are at risk from the Coronation North project.

Salmonids

- 72 Our assessments over recent years have not identified the presence of any suitable salmonid spawning habitat, nor were any salmonids caught in Mare Burn tributaries within the areas surveyed. A potential trout barrier exists on Trimbells Gully at a point approximately 230 m downstream of TG01 (i.e., downstream of the confluence with Maori Hen Creek). It consists of a bedrock block with a near vertical downside face approximately 1.5 m high. While the height is not that challenging to trout, the feature is made more of an upstream barrier by having a shallow bedrock platform immediately downstream of it, that provides little opportunity for trout to gain upward momentum when attempting to leap (due to a lack of water depth). This potential barrier, in conjunction with very low flow and potential dry sections for considerable times of the year, may contribute to no trout being present in this section of the Mare Burn catchment. Other barriers to upstream passage in the Mare Burn are also known to exist further downstream.

Potential adverse effects

Stream habitat - General

- 73 The Coronation North Project will result in the loss of small stream habitat that supports populations of Taieri flathead galaxias. Most of Maori Hen Creek and Trimbells Gully Tributary catchments, and part of the Coal Creek catchment, will be altered through excavation associated with the pit and deposition associated with the waste rock. We estimate that about **4.4 km** of small stream galaxiid habitat will be lost. The significance of the aquatic habitat loss varies depending on its permanence, with reaches of streams that have permanent flow likely sustaining higher value communities that may include fish. This appears to be the case for Maori Hen Creek, Trimbells Gully Tributary, and parts of the lower Coal Creek catchment.

- 74 Similar stream communities are likely to present elsewhere in the Mare Burn catchment, but we did not survey areas outside of land owned by OceanaGold. Therefore, it has not been possible to 'rank' the relative habitat quality of these tributaries against that found throughout the catchment. Assuming that other tributaries within the Mare Burn catchment have similar qualities to those we surveyed and support flathead galaxias populations, we have quantified the loss of galaxiid habitat due to the Coronation North Project (having established that there is a total length of 50.7 km order 2 - 4 streams within the Mare Burn catchment)². Based on this, the maximum loss of galaxiid stream habitat due to Coronation North (4.4 km) would be **8.7%** of that which potentially exists in the Mare Burn catchment.
- 75 The creation of the Coal Creek freshwater reservoir in the lower reaches of the Coal Creek catchment would also result in the loss of approximately **1.5 – 2 km** of small stream and ephemeral stream habitat of relatively poor quality (it has been modified historically through mining activities and more recently by stock having widespread access to the watercourses) but some sections still support small flathead galaxiid and crayfish populations. The density of fish and crayfish observed in this section of the catchment was relatively modest and lower than that observed further upstream in the main tributary (Trib. A), and also lower than that observed in the lower sections of Maori Hen Creek and Trimbells Gully Tributary. This loss of habitat may be mitigated by the potential benefits of an augmented flow to the Mare Burn.
- 76 Mitigation is recommended for the direct loss of non-migratory galaxiid fish habitat and associated populations, and this is discussed later in my evidence.

Coal Creek Reservoir

- 77 The proposed dam will result in the conversion of approximately 1.2 - 1.5 km of small stream and ephemeral stream habitat into lake habitat. That habitat will not be suitable for flathead galaxiids, but will provide habitat for crayfish and benthic invertebrate taxa that prefer still water, macrophytes and/or soft substrate habitat (although its quality and availability will be affected by how the reservoir is operated).
- 78 Flathead galaxiids are found throughout the Macraes area, and the loss of creek habitat associated with the Coal Creek reservoir is minor relative to the wider galaxiid population. However, the loss is cumulative and the distribution of this species is restricted to only a part of the Otago region.

² Order 1 streams were excluded from our analysis, as we know that many of the order 1 streams identified in Mare Burn sub-catchments that we have surveyed do not support galaxiid populations (typically because they have no surface flow).

Stratification

- 79 Reservoirs can stratify into layers of markedly different temperatures during the warmer months of the year. Cold water entering the reservoir from the river sinks to the bottom. During warm summer months, the sun warms the upper layer and that layer becomes warmer than the reservoir as a whole. Eventually the reservoir water divides: warm water (called the epilimnion) floating above the cold water (called the hypolimnion) resting below. Between these two layers is a transitional layer, the metalimnion, in which temperature decreases rapidly as one moves deeper. This 'thermocline' is important to the biology and water quality of a reservoir. It acts as a barrier to the movement of dissolved oxygen and dissolved materials (e.g. bioavailable nutrients), and the distribution of heat between the epilimnion and the hypolimnion.
- 80 When full, the reservoir would have an average depth of about 0.5 m, indicating that a significant proportion of it would be very shallow. Ignoring other potential influences, the predicted epilimnion depth of 4.84 metres is much greater than the average reservoir depth, but towards the dam face the water depth deepens significantly, reaching up to 20 m. This suggests there is a risk that water in the lower end of the reservoir could 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 reservoir. This water would be discharged to the lower section of Coal Creek.
- 81 To address this I understand OceanaGold intend to use a floating decant system to enable oxygenated water from the surface of the reservoir to be discharged, and propose to ensure that the released water gets as much aeration as possible in the area immediately downstream of the toe of the dam. I support these measures.
- 82 As the water level in the dam is drawn down over summer, the risk of stratification is reduced as the water depth reduces and wind-induced mixing increases.
- 83 At the time of writing this evidence I understand that OceanaGold plans to offer a consent condition to monitor dissolved oxygen after the reservoir is filled and then for a period each year. I also support this measure.

Water quality

- 84 Given the current state of tributaries in the catchment, reservoir water quality may initially be enriched with nutrients and sediment due to farming practices. The temperature of the reservoir water may differ from that in the creek due to the energy buffering capacity of a large body of water relative to water in the creek, which is more likely to closely reflect ambient temperature conditions.

The effect of this on downstream fish, crayfish and benthic invertebrates is unlikely to be significant as these are accustomed to a range of temperatures. Potentially cooler water discharged in summer will, if anything, benefit downstream stream communities, provided it is sufficiently oxygenated.

- 85 Assuming the Coal Creek Dam is built and operated to the maximum specification in the application is proposed to release a minimum flow of 5 litres/second to the creek below the reservoir. This is significantly higher than what has been observed in lower Coal Creek. Given the size of the channel, such a flow would easily be accommodated and would increase the area of flowing water considerably. This is expected to improve the overall physical habitat available for stream biota and reduce the critical extreme low flow periods observed over summer and autumn 2015/2016. It is estimated this would benefit approximately 860 metres of the lower Coal Creek and a significantly greater length of the Mare Burn. This proposed increase in the minimum flow would not increase the risk of trout invasion as the Mare Burn has trout barriers further downstream that would not be affected by a flow increase of this magnitude.

General Water Quality

Turbidity, suspended solids and water clarity

- 86 Over two decades of visual monitoring at the Macraes Gold Project I have found background water clarity to usually be good, with no evidence of water clarity declining over time as a result of mining, and no obvious sediment accumulation. Occasional turbidity can be caused by high rainfall events. OceanaGold does not presently monitor for sedimentation, for instance by using the black disc clarity method, because there does not appear to be much sediment load. Below I recommend that erosion and sediment control measures be implemented to minimise sedimentation, and I support measures OceanaGold is offering to include visual clarity and sediment accumulation monitoring in quarterly biological monitoring.

Contaminants

- 87 I have not seen a long-term downward trend in galaxiid abundance in the surveys I have conducted at the Macraes Gold Project area since the 1990s. Galaxiid populations are present in locations where mine impacted water discharges occur, for example Murphy's Creek and Deepdell Creek.
- 88 Water quality modelling undertaken by Golder Associates indicates that OceanaGold will need to manage and monitor sulphate from Waste Rock Stack seepage, and that is why the Coal Creek Dam is proposed (i.e., to provide a supply of water to dilute contaminants).

- 89 To the best of my knowledge there is no existing sulphate toxicity data for Taieri Flathead galaxias or any of its close relatives (other Otago non-migratory galaxiids) to inform the setting of sulphate toxicity limits.
- 90 Toxicity trials could be useful to help our understanding of the species' sensitivity to sulphate.

Recommended mitigation and monitoring

Loss of fish habitat

- 91 For the Coronation project, Ryder Consulting suggested the transfer of fish and crayfish where their habitat was likely to be lost or significantly affected by mining. It is difficult to assess the effectiveness of such measures without long term monitoring of populations in the areas where fish and crayfish are relocated. Monitoring of populations prior to relocation would also be necessary to determine whether relocations have successfully increased populations. Transferring to stream habitat where no fish or crayfish are currently present also raises issues around the appropriateness of the new habitat. Further, finding appropriate habitat requires intensive investigation work, and access to land outside of OceanaGold's control presents further challenges.
- 92 Given the above, I am of the view that fish and crayfish translocation may not represent the best form of mitigation for loss of habitat and I do not recommend it.
- 93 Habitat creation and protection in areas that already support flathead galaxiid populations are worth exploring further. The population has a limited distribution and is under threat from invasive fish, particularly brown trout. This threat can be reduced through the establishment of trout barriers. I understand that OceanaGold may volunteer a consent condition around this and I would support that.
- 94 It is recommended the Coal Creek freshwater reservoir be fenced from stock and the development of ungrazed riparian margin encouraged. This will assist in the filtering of sediment and nutrients prior to reaching the reservoir.
- 95 Galaxiid habitat in the lower Coal Creek catchment, and in the Mare Burn downstream of the Coal Creek confluence, may benefit from the proposed minimum flow of 5 litres/second released from the proposed Coal Creek reservoir. Providing water quality is reasonable (in particular dissolved oxygen levels are adequate to support fish life stages), the additional water should result in a more stable fish population less affected by a loss of habitat (quality and quantity) and associated stress under summer-autumn low flow periods.

Loss of crayfish habitat

- 96 As already noted, crayfish relocations may have limited benefit. Crayfish are more widespread in their distribution than flathead galaxiids, and are able to inhabit both stream and pond environments. Consequently, their population can be maintained and enhanced through habitat creation (e.g., man-made ponds), and this has shown to be successful in the South Island.
- 97 We also note that crayfish and flathead galaxiids appear to co-exist quite well in tributaries of the Mare Burn, and so any mitigation provided for these fish are likely to have benefits for local crayfish populations as well. A number of small ponds already exist in the Coal Creek catchment. These could be protected and enhanced to improve habitat for crayfish. De-stocking the catchment would have significant benefits to pond and stream habitat. Such measures would also act to improve downstream water quality.

Sediment mobilisation and run off

- 98 Fine sediment is already present in most reaches of the tributaries we assessed. However, excessive cover is usually detrimental to stream communities, particularly if flow variability is insufficient to regularly flush the excessive cover away. Therefore, an expanded mining operation poses some risk to downstream communities unless measures are implemented to avoid the introduction and downstream transport of sediment. Erosion and sediment control measures are routinely employed by OceanaGold at the Macraes Mine and will be utilised for the Coronation North project. They are summarised in the reports and evidence of Jeremy Yeats and I do not repeat them here.

Accidental contaminant spills

- 99 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. These issues can, and are addressed by OceanaGold in an on-site contaminant management plan. As a general rule, any possible contaminants stored on site are kept away from watercourses and bunded. Refuelling of machinery takes place away from watercourses. Such measures are addressed by proposed consent conditions for the Coronation North Project.

Nuisance aquatic weed/algae introduction

- 100 Machinery and personnel involved in construction can potentially transfer nuisance weeds/algae (e.g., *Didymosphenia geminata* - didymo) to local watercourses. Didymo has been recorded in the Shag River catchment by my colleague Mr Ludgate, and the ORC has recorded microscopic levels of didymo in

the Taieri River. Many streams within the mining area may not be suitable for didymo establishment, however if didymo was to enter these streams it may be able to travel downstream to establish at more suitable locations in the lower Taieri River. To address this, OceanaGold complies with notices and guidelines issued by Biosecurity New Zealand regarding didymo, and should continue this practice for Coronation North.

Proposed aquatic biological monitoring

- 101 OceanaGold is committed to engaging a suitably qualified and experienced freshwater biologist to design and undertake an aquatic biological monitoring programme for Coronation North, which can be incorporated into the existing programme in place for the Macraes Gold Project and Coronation. It is proposed that monitoring will be undertaken at a new site MB02, provided suitable habitat is available for sampling. Monitoring of stream macroinvertebrates and periphyton will continue to be carried out quarterly and fish will continue to be surveyed annually.
- 102 At the time of writing this evidence I understand that to address the ORC's concerns about water quality OceanaGold intend to incorporate visual clarity into the quarterly monitoring programme and also qualitative visual assessments of the surface area of the stream bed covered by sediment. I would support this.

Response to submissions

DOC

- 103 I have read the Director-General's submission in opposition and his concerns regarding the effect of the Coronation North project on native fish and aquatic life and water quality. I consider that if OceanaGold carry out my mitigation recommendations this should address his concerns.
- 104 At the time of writing this evidence OceanaGold is consulting with DOC on an appropriate suite of management and mitigation options acceptable to both, but this has not been finalised.

KTKO Ltd

- 105 I have read KTKO's neutral submission on behalf of the three runanga regarding effects of the project on water, native fisheries and lost aquatic habitat. I note that they support my recommendation for the use of trout barriers and freshwater crayfish (koura) ponds to protect and enhance aquatic habitat.
- 106 At the time of writing OceanaGold is also discussing management and mitigation options with KTKO and this is ongoing.

ORC Recommending Report

107 I have not reviewed the ORC's Recommending Report in the preparation of this evidence as it will be produced in early October while I am away overseas. I will review it and if necessary comment on it in supplementary evidence at the hearing.

Conclusion

108 Watercourses within the Coronation North Project area have no special features with respect to stream communities, aside from the presence of freshwater crayfish and Taieri Flathead galaxias. Potential adverse effects on aquatic communities associated with the Project include the direct loss of crayfish and galaxiid habitat and populations, and water quality reductions in the remaining habitat. I have therefore recommended the following mitigation and monitoring in relation to these potential effects:

- (a) Galaxiid habitat creation and protection, including fencing of the Coal Creek reservoir;
- (b) Creation of freshwater crayfish ponds, protection and enhancement of existing small ponds;
- (c) Development and implementation of management plans to reduce the risk of nuisance plants, sediment and accidental contaminant spills entering watercourses; and
- (d) Implementation of an aquatic biological monitoring programme within the Coronation North Project area.



Gregory Ryder

14 October 2016

Appendix 1 – Figures

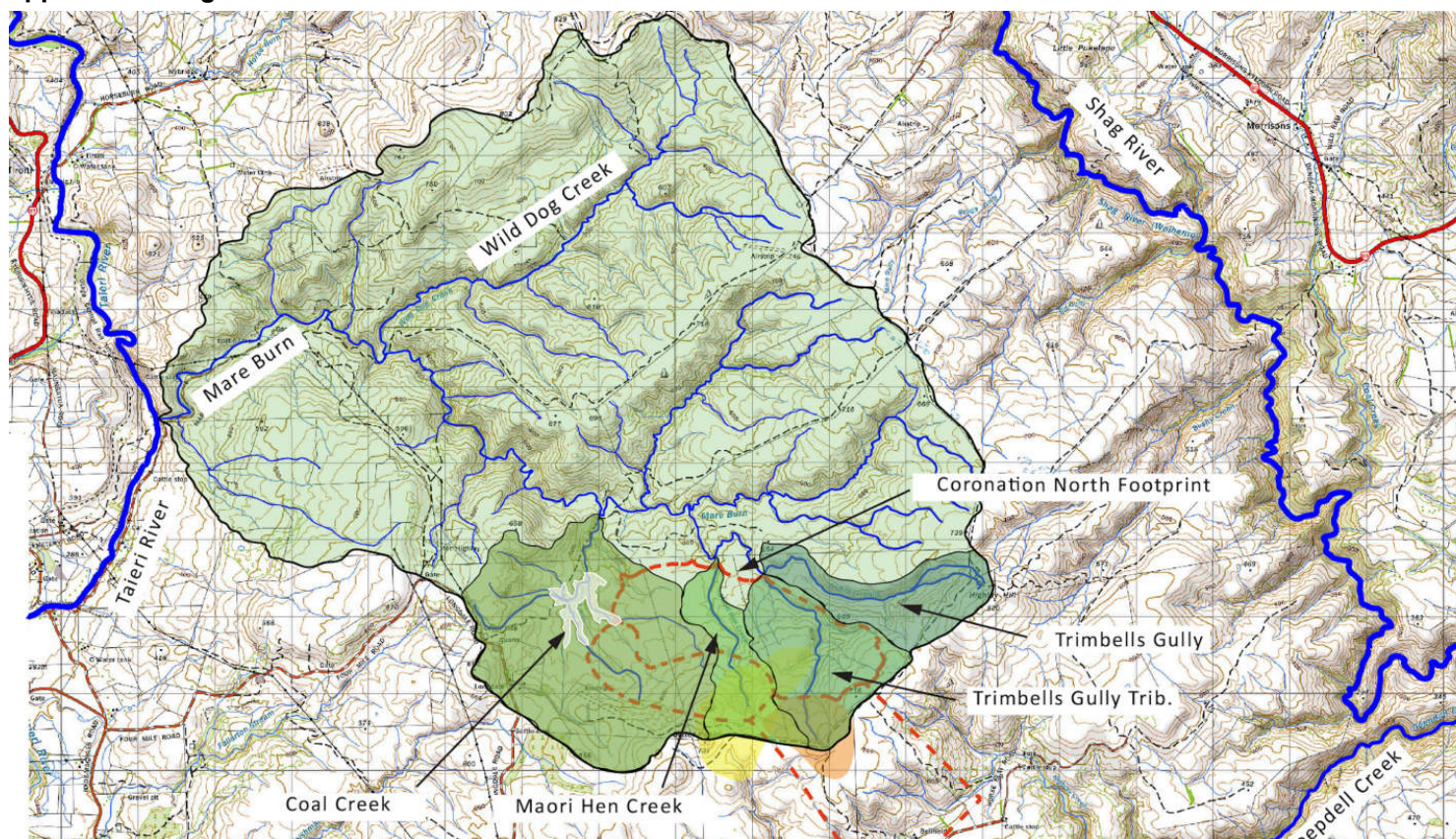


Figure 1. Map of Mare Burn catchment and surrounds showing location of key tributaries in relation to the existing (shaded) mining footprint and the proposed (dotted line) mining Footprint of the Coronation North Project. The approximate extent of the proposed Coal Creek freshwater reservoir is also indicated.

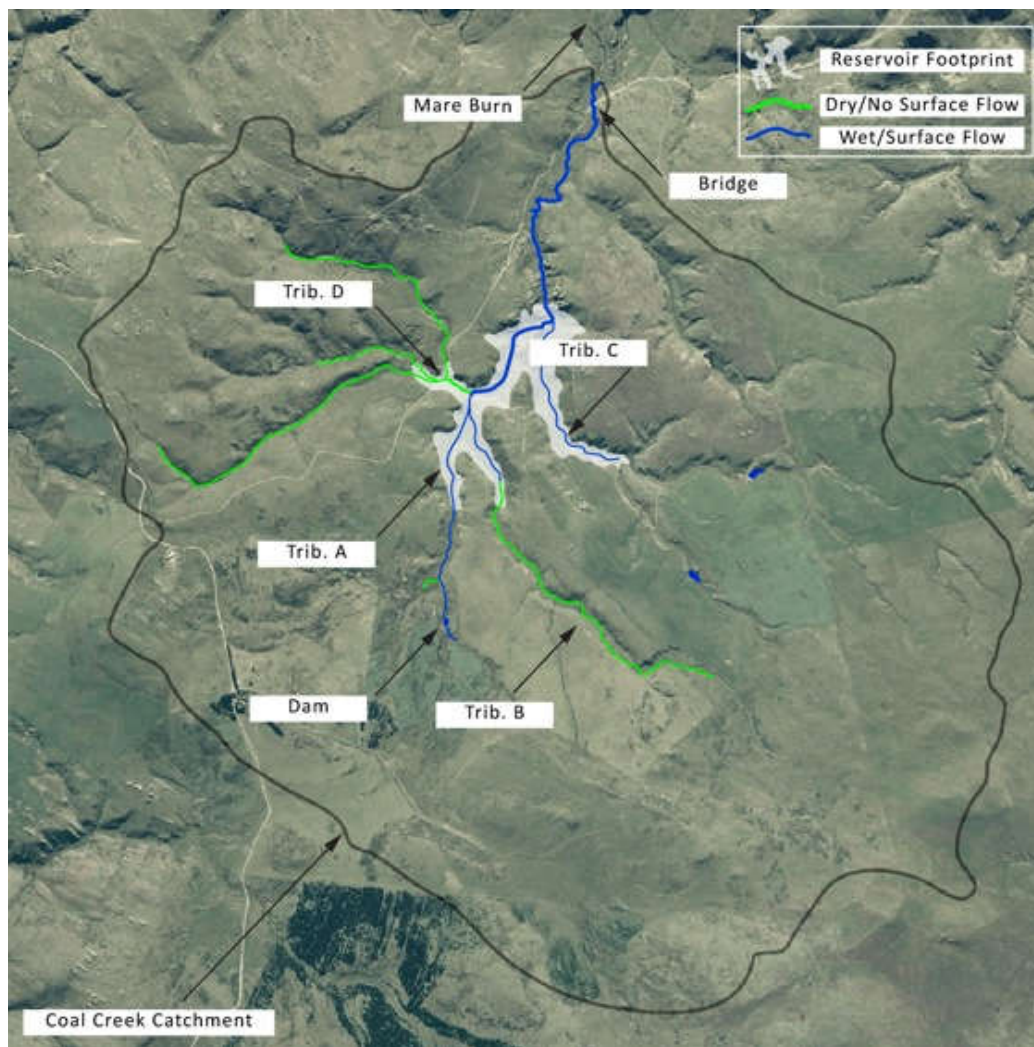


Figure 2. Aerial Map of the Coal Creek catchment showing areas surveyed in April 2016 and the approximate footprint of the proposed freshwater reservoir.