Before a joint hearing of the

Otago Regional Council
Waitaki District Council

RM 20.024

Under	the Resource Management Act 1991
In the matter of	applications by Oceana Gold (New Zealand) Limited for resource consents for the Deepdell North Stage III Project

STATEMENT OF EVIDENCE OF GREGORY IAN RYDER FOR OCEANA GOLD (NEW ZEALAND) LIMITED

4 AUGUST 2020

1. INTRODUCTION

Qualifications and experience

1.1 My full name is Gregory Ian Ryder. I reside in Dunedin. I am an Environmental Scientist at Ryder Environmental Limited and have worked as a consultant for approximately 28 years. Prior to consulting, I worked at the Otago Regional Council and the University of Otago. I work largely in the fields of surface water quality and aquatic ecology. I have presented evidence as an expert witness at 38 council hearings, 8 plan or plan change hearings, 4 board of inquiry, EPA and WCO hearings, and 9 Environment Court hearings. I also fulfil the role of an independent commissioner and have sat on 30 resource consent and plan change hearings and one EPA board of inquiry.

1.2 I hold BSc. (First Class Honours) (1984) and PhD. (1989) degrees in Zoology from the University of Otago. Both my honours dissertation and PhD. thesis focused on stream benthic invertebrate communities in Otago streams and rivers. Specifically, my PhD. thesis examined the effects of fine sediments on benthic invertebrates.

1.3 I am accredited under the Making Good Decisions Program to sit on RMA hearing panels (chair certification).

1.4 I am a member of the New Zealand Freshwater Society and since February 2020 a Board member of the Environmental Protection Authority.

1.5 I have worked on a number of projects relating to mining and gravel abstraction, including alluvial gold mining and hard rock gold mining. These include aquatic investigations and surveys associated with existing gold mining in the Fraser River catchment (Central Otago), Waikaia River catchment (Southland), Macraes District (North Otago) and Waihi District (Waikato), and proposed lignite mining in the Waituna catchment (Southland), Tuakitoto-Kaitangata area (South Otago) and Hawkdun area (Central Otago).

1.6 I have been involved with a number of large scale projects that have required the disturbance of land and surface water habitats and which included a range of mitigation, offset and compensation packages. These include the proposed Wairau Hydro-electric Power Scheme (Marlborough), the proposed enhancement of the Arnold Hydro-electric Power Scheme (West Coast), the Klondyke Water Storage Project (Mid Canterbury), the Mahinerangi Wind Farm (Otago), reconsenting of Contact Energy's Clutha Hydro-Electric Power Scheme, various reconsenting projects of other hydro-electric power schemes throughout New Zealand, and a number of land use conversions associated with large-scale irrigation in Canterbury.

1.7 I have acted as an independent commissioner on at least two large scale proposals that would have resulted in significant areas of land disturbance and/or inundation (Mohikinui Hydro-electric Power Scheme – West Coast, and Porter Ski Area Private Plan Change 25 to the Selwyn District Plan – Canterbury). Both these applications included packages associated with avoiding, remedying and mitigating adverse effects, and biological offsetting and compensation. In 2018 I appeared on behalf of the Otago Regional Council as an expert witness at an environment court appeal relating to the Otago Regional Policy Statement[1]. The appeal dealt with the issue of mining effects on biodiversity and the ability to avoid, remedy, mitigate, offset or compensate for those effects.

1.8 I have also undertaken or been associated with a large number of investigations that have assessed the effects of abstractions and discharges on surface water ecosystems, the effects of existing and proposed impoundments, and the effects of land use activities that produce point source and non-point source discharges.

1.9 My PhD. included studies of the Shag River benthic invertebrate community and since becoming a consultant I have been involved in several projects associated with the river's water quality and freshwater ecology[2]. I have previously undertaken trout spawning surveys of the river with Fish & Game staff.

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1 Decision No. [2019] NZEnvC41.

2 1992. Palmerston Sewage Treatment System: Environmental Impact Assessment. 2005. Investigations into the ecological effects of a water storage dam in the Shag Valley Catchment.

1.10 Since February 2019, my company has been contracted by the ORC to undertake monthly monitoring of macroinvertebrate communities and periphyton biomass in rivers throughout Otago. One of the sites is located on the lower Shag River at Goodwood.

Code of Conduct for expert witnesses

1.11 I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court's Practice Note as updated in 2014. My evidence has been prepared in compliance with that Code. Unless I state otherwise, this evidence is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Experience with monitoring of OceanaGold mining operations

1.12 My association with the Macraes Gold Mine area goes back to the mid 1980s when I was undertaking my PhD degree at the University of Otago. I was subcontracted by Fish and Game Otago to assist them with baseline surveys of the aquatic ecology of the area, prior to the commencement of large-scale open pit mining. These surveys were undertaken at the request of the then owners of the mining licences. The work included fish and benthic macroinvertebrate surveys and general habitat assessments, macroinvertebrate sample processing and data interpretation. The mine owners then commenced a detailed freshwater monitoring programme in 1990 after resource consents were granted, and my personal involvement in the consent monitoring programme recommenced in 1995. My company has been monitoring surface waters of the area since then. Consequently, our 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.

1.13 The freshwater ecology monitoring programme at the Macraes Mine area is probably the most extensive of its kind in Otago and Southland. This long-term monitoring programme has provided me and my colleagues opportunities to observe the freshwater ecology of the area under a broad range of seasonal conditions, ranging from wet years with frequent floods to very dry years when sections of creeks have dried up for months on end.

1.14 In preparing this evidence I have reviewed submissions on behalf of the Director General of Conservation, Aukaha on behalf of Kāti Huirapa Rūnaka ki Puketeraki and Te Rūnanga o Ōtākou, and the submission and recommending reports prepared for the Otago Regional Council ("ORC").

Scope of evidence

1.15 In my evidence I discuss:

- A summary of the existing information on aquatic values in the DDNth Project area and the results of further surveys carried out;
- An assessment of the potential effects of the Project on the identified aquatic values and receiving water quality;
- Recommendations on options for mitigating any significant effects on aquatic values;
- Recommendations for monitoring;
- Consideration of submissions raising issues relating to aquatic ecology; and
- Conclusion on the effects of the Project on aquatic ecology;
- Overall conclusion and recommended consent conditions.

1.16 The footprint of DDN, and related mining operations, are described in the application and supporting documents. In summary the key elements of the proposal are:

- A new pit (Deepdell North Stage III Pit) covering an area of approximately 38 ha, that includes excavation of 18.7 ha of existing rehabilitated waste rock stack.
- A new waste rock stack (Deepdell East Waste Rock Stack), that would back-fill the existing Deepdell South Pit, extending north from the Deepdell South Pit to beyond Horse Flat Road, covering a total area of 70.8 ha.

- A short haul road will be required between the Deepdell North Pit and the Deepdell East Waste Rock Stack.
- Associated diversion drains, silt and sediment control structures.

1.17 An overview of the Project footprint area is shown in Figure 1.

1.18 I assessed the aquatic ecology and water quality of the Project footprint and surrounding area by:

- Reviewing previous freshwater surveys of Camp Creek, Highlay Creek and Deepdell Creek catchments (Ludgate *et al*. 2011, Ryder Consulting 2013, Ryder Consulting 2018). These surveys included assessments of physical habitat, benthic communities (macroinvertebrates, macrophytes and periphyton), fish and riparian cover. Some sites have been monitored regularly for many years as a part of consent requirements.
- While these surveys are comprehensive, I accessed additional information from the New Zealand Freshwater Fish Database (NZFFD), which contains records from other surveys undertaken in the general Macraes area by the Department of Conservation (DOC), Fish and Game Otago, NIWA and the University of Otago.
- I examined some of OceanaGold's water quality monitoring data for Deepdell Creek and Highlay Creek. OceanaGold has monitoring sites in Deepdell Creek upstream and downstream of the Highlay Creek confluence and in Highlay Creek at the Horse Flat Road ford.
- OceanaGold has commenced water quality monitoring at two sites in the Shag River upstream (Control) and downstream (Loop Road) of the Deepdell Creek confluence. I have examined this data along with ORC monitoring data for another two sites further downstream of the Deepdell Creek confluence (Craig Road and Goodwood).
- I inspected waterbodies in and around the Project footprint in 2018 and 2019. I collected benthic samples and set minnow traps in some watercourses within the Project footprint.
- I also mapped the watercourses and attempted to categorise them into ephemeral, intermittent or stream habitats. The definitions uses are

presented in Appendix 1. I used these categories to help determine the types and significance of aquatic communities they may support. I also took into consideration the surrounding land use and riparian vegetation, and whether they were protected from stock.

1.19 The bulk of the Project's footprint lies within the Highlay Creek catchment (a sub-catchment of the Deepdell Creek catchment). The Deepdell East Waste Rock Stack (WRS) is situated in the Highlay Creek catchment, and runoff and seepage from it will flow into Highlay Creek and a small tributary of Highlay Creek. Depending on how the WRS is contoured, the southern side could also potentially drain to the headwaters of Camp Creek (another sub-catchment of the Deepdell Creek catchment). The Deepdell North Stage III Pit and Deepdell South Backfill footprints lie within the Deepdell Creek catchment and surface water from these sites would flow into Deepdell Creek via the existing Deepdell North Silt Pond and the Deepdell South Silt Pond. These flow pathways are shown in Figure 2.

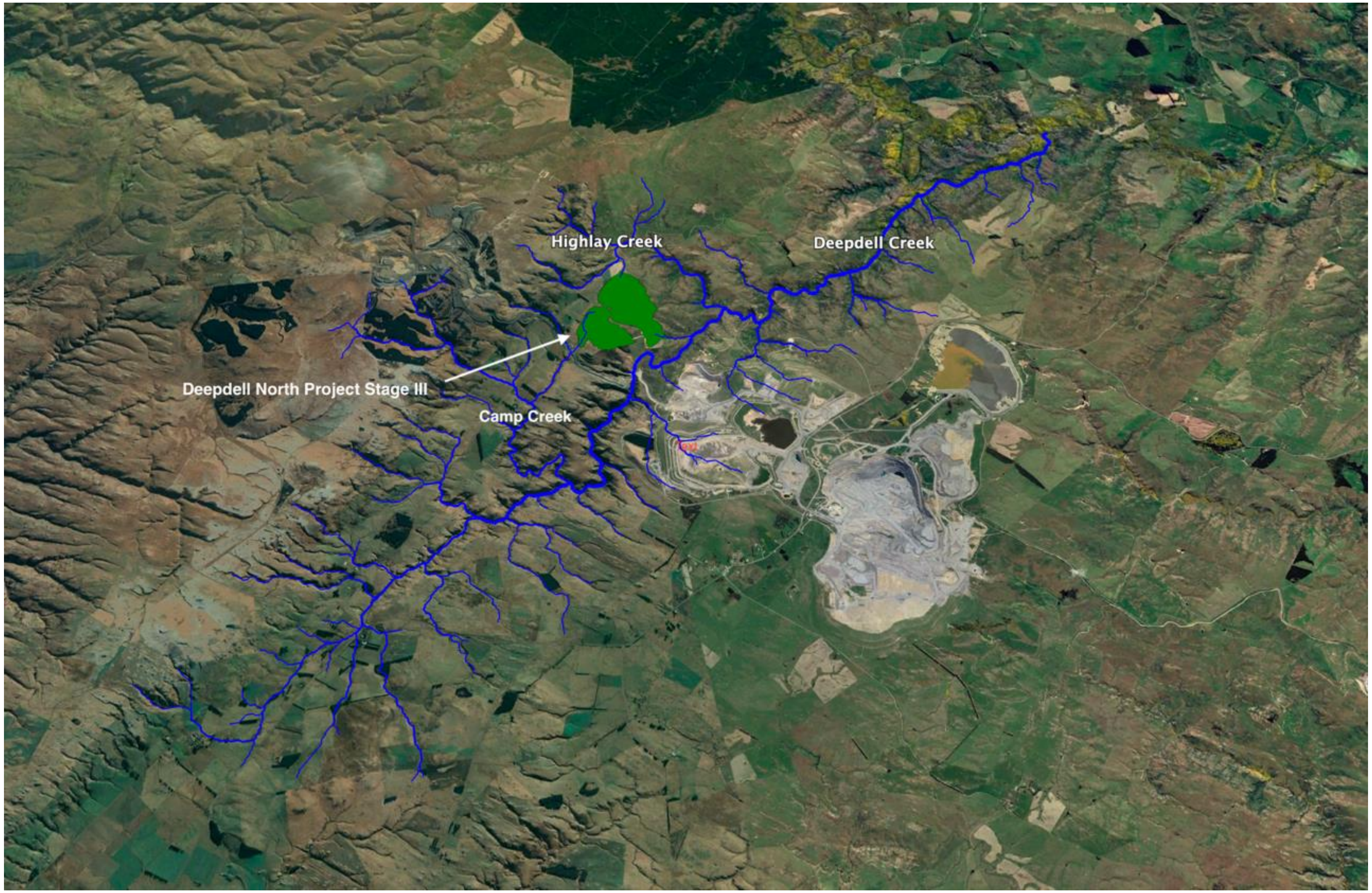

Figure 1: Map showing location of the DDNth Project area in relation to surface waters of the Deepdell Creek catchment.

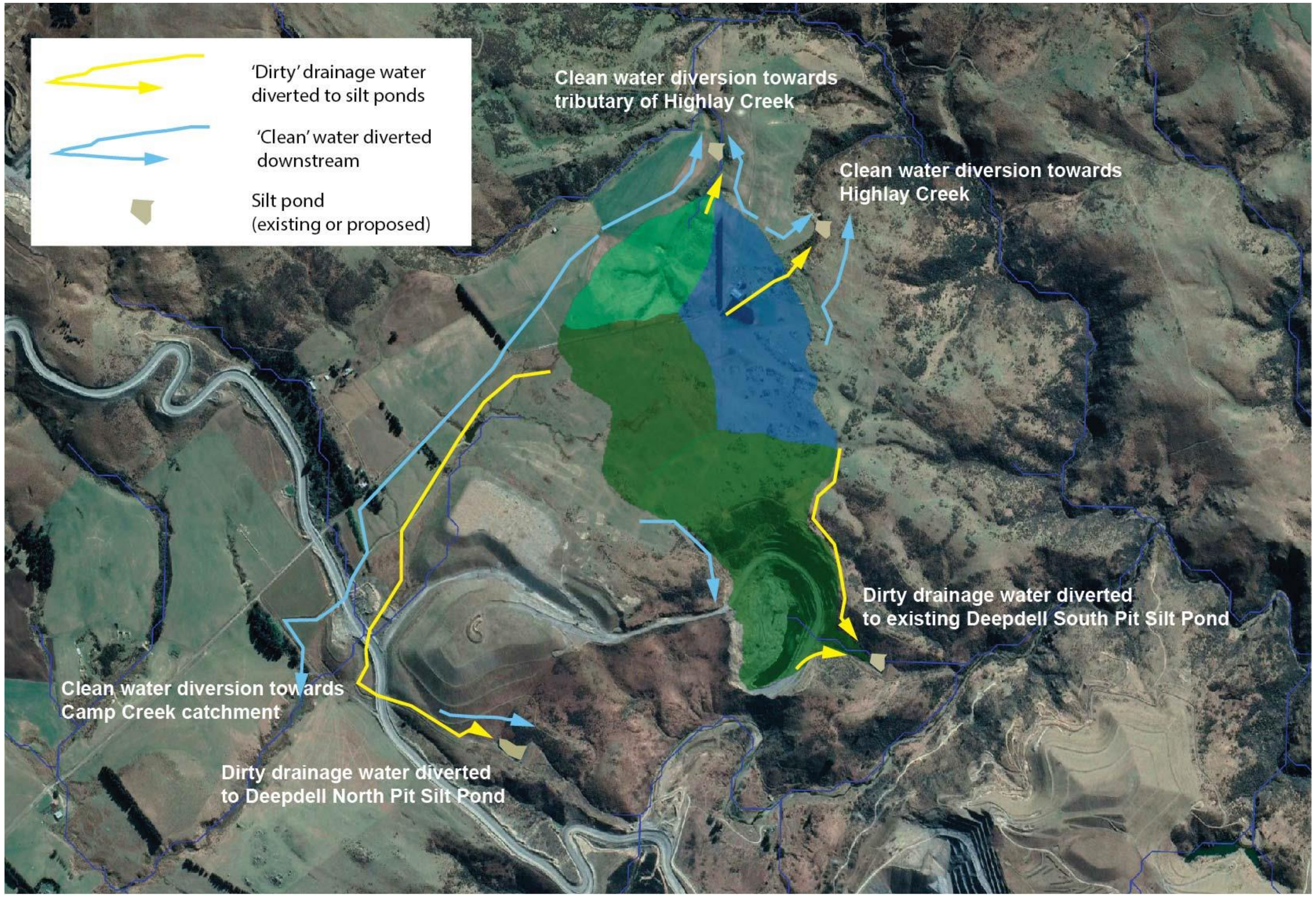

Figure 2: Aerial photo showing existing drainage patterns and proposed diversions of 'clean' water and 'dirty' drainage water on land within and adjacent to the proposed Deepdell North III Project.

2. SURFACE WATER ECOLOGY

Highlay Creek catchment

2.1 Highlay Creek is a third order tributary of Deepdell Creek (Figure 1). The area of catchment within the Project footprint consists largely of gently sloping land, with shallow gully systems, and watercourses that may have once had a natural channel but over time have been channelled to divert surface flows. The watercourses are ephemeral in their upper reaches and have intermittent flow in their lower reaches, or at least carry very little surface flow in drier months of the year, given the very small size of their watersheds.

2.2 I inspected surface waters in the general area of the Project in February 2018 and September 2019. Under summer conditions, surface flow in small tributaries of the upper catchment (upstream of the project footprint) was minimal and barely covered the bed of the gully. Stock trampling was evident at many sites along the gully, often resulting in pugging and surface mud. Tracks where stock had crossed the creek areas were common. Schist gravels, large rocks and occasional bedrock were common, often covered with moss. Bedrock often created short, steep waterfalls although the movement of water over these was more of a slow trickle than a steady flow.

2.3 The gully that would receive runoff and seepage water from the northern part of the WRS is a shallow ephemeral drainage system with seepage habitat. Gullies within the Project footprint are contained within farmed land and stock have access to them. I observed severe pugging in them during my September 2019 site inspection.

2.4 Overall, macroinvertebrate communities in flowing sections of Highlay Creek are relatively healthy, with communities dominated by sensitive mayflies and *Potamopyrgus* snails. Approximately sixty benthic invertebrate taxa have been identified from three benthic invertebrate surveys of the Highlay Creek catchment (Ludgate *et al*. 2011, Ryder Consulting 2013, Ryder 2018). The most recent survey (February 2018) of the Highlay catchment found the number of taxa per site ranged between 17 and 25. Benthic invertebrate habitat is variable in the Highlay Creek catchment, ranging from small seepages through to creeks. Habitat is widely affected by algal blooms and stock damage. None of the taxa we have identified from our surveys are uncommon, and most are typically found throughout large areas of the country.

2.5 Invertebrate communities are of poorer quality in the tributary that would receive runoff and seepage water from part of the Project's proposed WRS.

2.6 A survey undertaken in February 2011 on behalf of OceanaGold found flathead galaxias (*Galaxias depressiceps*) throughout Highlay Creek and in the lower section of the tributary that would receive runoff and seepage from the new waste rock stack. Flathead galaxias were also captured in lower Highlay Creek in April 2013. I observed numerous adults and sub-adult galaxiids in the February 2018 survey at the Horse Flat Road ford.

2.7 The Department of Conservation surveyed sections of the Highlay Creek catchment in May 2018 (Jack 2018) including the tributary in a section just upstream of the Project's proposed WRS, and the mainstem of Highlay Creek upstream of the WRS area. The Highlay Creek tributary traps captured two adult flathead galaxias, along with 14 adult and juvenile koura. The Highlay Creek mainstem traps captured two flathead galaxias and 10 adult koura.

2.8 I set minnow traps in the second order tributary overnight in September 2019, downstream of Jack's (2018) traps. No flathead galaxias or koura were captured in this early spring survey.

2.9 The mid and lower reaches of Highlay Creek appear to support a good population of flathead galaxias, and koura are common also. Some individuals galaxiids have been recorded in the tributary upstream of the Project footprint, but none have been found within the mine footprint and the gullies in the footprint support mainly ephemeral watercourses within farmed land which are freely accessible to stock.

Camp Creek catchment

2.10 Camp Creek is another major tributary of Deepdell Creek (Figure 1). Its catchment is situated upstream of the OceanaGold's mining operations, on the true left. Several small watercourses associated with the Camp Creek catchment are situated within or adjacent to the proposed Project footprint. The mid reaches of a modified watercourse that runs close to and parallel to the existing haul road will be surrounded by the Project footprint, but will not be physically modified. Within the proposed Project footprint area, the watercourse below Horse Flat Road has been highly modified and has been straightened. It flows into a cut-off drain that has been constructed around the upper perimeter of the existing waste rock stack. It then discharges into a small ponding area on the northern side of the haul road. Discharge into the upper Camp Creek catchment is then via a small culvert under the haul road.

2.11 This small tributary in the Camp Creek catchment was surveyed by Ryder Consulting in the general vicinity of the haul road in October 2010 (Ludgate, Ryder & Dale 2011). At that time, the tributary was described as having a low gradient, bordered by pasture grasses and with unrestricted stock access, and very little surface flow.

2.12 I inspected this watercourse again in September 2018. The channel was willow-infested down as far as the cut-off drain, and had a significant cover of algae covered with iron-staining bacterial flocs. The bed was also clogged with willow branches and willow roots.

2.13 A man-made pond is located between Horse Flat Road and the existing waste rock stack. It discharges into a cut-off drain which runs for approximately 460 metres before reaching the confluence of the modified watercourse described above. Approximately 100 metres of its lower section will be lost due to pit infrastructure.

2.14 The pond is fed by a small catchment (currently in pasture) that contains several gullies that potentially support ephemeral watercourses. The pond will be surrounded by the Deepdell North Pit to the east and additional pit infrastructure to the west (towards Horse Flat Road). These gullies will be lost to the new pit and some stockpile area. The loss of these ephemeral watercourses is estimated at 450 metres.

2.15 The cut-off drain into which the pond flows into will be converted to a drain for the diversion of 'dirty' drainage water to the existing Deepdell North Silt Pond and will cease flowing towards the Camp Creek catchment. The loss of this highly modified intermittent flowing drain is estimated at approximately 360 metres.

2.16 OceanaGold have a monitoring site on Camp Creek (CC02). Invertebrate health index scores from this site in the summers of 2018 and 2019 were indicative of 'fair' quality conditions, while in winter average scores were indicative of 'good' quality conditions, using the narrative terminology of Stark and Maxted (2007).

2.17 In general, the benthic ecology of Camp Creek is similar to that found elsewhere in the Macraes area. The quality of benthic macroinvertebrate communities is variable, but generally healthy throughout, with some degradation in community health in the small tributaries that flow through farm land. I expect invertebrate communities in the tributaries such as the one adjacent to the haul to be dominated by low quality taxa more typical of those found in soft bottomed habitat.

2.18 Flathead galaxias are present throughout Camp Creek with higher abundance in the lower and middle reaches. Some longfin eel have previously been found in the lower and middle reaches of Camp Creek, however eels have not been found further upstream.

2.19 In September 2019, I set baited minnow traps overnight in deeper water within the tributary below Horse Flat Road. No fish or crayfish were captured.

2.20 Electric fishing was undertaken in Camp Creek in summer 2019 at the CC02 monitoring site. No fish were caught or observed during the multiple pass electric fishing survey, however several galaxiids were observed in pool and run habitats during spot fishing. Fishing at this site has produced variable results in previous years, with only three galaxiids caught in summer 2017, while 21 galaxiids were caught in summer 2018, including larval and adult galaxiids. This creek often has dry sections upstream of the sampling site in summer, which are likely to affect fish abundance.

Deepdell Creek catchment

2.21 The DDNth Project includes backfilling the existing Deepdell South Pit and creating a new pit on a rehabilitated rock stack. These areas border land that drains directly into Deepdell Creek. The section of Deepdell Creek that would potentially receive runoff and seepage water from this land, and the discharge of Highlay Creek water, has been monitored at several sites for many years, and thus the creek's ecology is well understood.

2.22 Deepdell Creek in the vicinity of the Project is contained within a confined channel that is surrounded by relatively steep-sided land throughout most of its length. Shading is common due to the steep topography and overhanging riparian vegetation (particularly broom). Stock and pig disturbance is evident in places.

2.23 Biological surveys of Deepdell Creek and tributaries were first undertaken in 1987. Following on from these initial surveys, aquatic monitoring has been undertaken on a quarterly basis in Deepdell Creek since 1990. This monitoring has included surveys of fish (since 1990), benthic macroinvertebrate (since 1991) communities and plant and periphyton cover.

2.24 The most recently completed analysis of Deepdell Creek monitoring data (March 2019) found the invertebrate community composition at monitoring sites DC03, DC05 and DC07 to be dominated by snails (particularly *Potamopyrgus antipodarum* but also *Physa*), chironomid larvae and various Trichoptera, with lessor contributions from small crustaceans, mayflies and worms. This assemblage is broadly similar to that observed over many years of monitoring. Benthic invertebrate health index scores are typically indicative of 'poor' to 'fair' water quality using the narrative terminology of Stark and Maxted (2007). This ranking reflects the dominance of taxa (e.g., snails) that are relatively insensitive to poor water quality and habitat conditions including elevated periphyton biomass. Koura have been observed at sites DC03, DC05 and DC07. Overall, invertebrate diversity was generally similar between Deepdell Creek sites, but DC08 had lower diversity than all other sites in autumn. The lower diversity at DC08 is likely to be heavily influenced by the frequent loss of surface flow at this site.

2.25 In general, the benthic invertebrate community of Deepdell Creek is similar to that of Highlay Creek, but composition varies between sites and seasons, often influenced by climate, flow history and local physical habitat features. Again, as for Highlay Creek, most taxa in Deepdell Creek are common and found throughout the country.

2.26 Flathead galaxiids are by far the dominant fish in Deepdell Creek, and site DC07, located downstream of the Highlay Creek confluence, typically supports a large population (Table 1). Annual fluctuations in the galaxiid population have been a feature since regular monitoring commenced back in the 1990s, and probably relates to variations in reproduction, food availability and physical habitat including the frequency and magnitude of floods and low flow events. Error associated with sampling efficiency and model assumptions also affect population estimates.

Table 1: Results of fish surveys and fish population estimates, Deepdell catchment sites, 1998-2019. – = unable to be sampled due to low flows. Note 2018 data is from fishing undertaken in winter 2018.

Year	Downstream of mine operations				Upstream of mine operations		
	DC08	DC07	DC05	DC03	DC02	DC01	DC00
	Pop'n estimate	Pop'n estimate	Pop'n estimate	Pop'n estimate	Pop'n estimate	Pop'n estimate	Pop'n estimate
1990							30
1991				-	-	-	49
1992				-	-	-	10
1993				-	-	-	7
1994				-	-	-	25
1995		143		114	321	121	31
1996		125		57	142	98	38
1997		127		41	27	12	
1998		39		17	65	*	
1999		4		4	-	-	
2000		45		36	15	14	
2001		84		36	31	85	
2002		86		49	101	62	
2003		97		29	60	71	
2004		33		*	69	29	
2005		33		7	53	12	
2006		42		108	99	71	
2007		125		118	72	105	
2008		926		41	62	85	
2009		81		39	62	45	
2010		115		18	42	42	
2011		148		617	56	305	
2012		63		44	69	107	
2013	250	49	65	53	1361	107	
2014	131	178	54	76	197	533	
2015	66	93	54	101	74	83	
2016	20	36	16	36	36	19	
2017	25	52	12	40	51	105	
2018	16	44	53	53	91	145	
2019	0	58	14	23	81	104	

2.27 Brown trout and longfin eel have occasionally been caught in Deepdell Creek since regular monitoring commenced in the 1990s, however they are uncommon. This is probably due to limited access from downstream populations (Deepdell Creek often flows underground in a short section near monitoring site DC08) and frequent low flows in summer provide limited habitat availability.

3. KEY FRESHWATER VALUES

3.1 As noted above, Taieri Flathead galaxiids are common and widely distributed in the Highlay Creek catchment and to a lesser extent in Camp Creek. Headwaters of both creeks drain small catchments, are very steep and carry little surface water under normal summer flow conditions.

3.2 Flathead galaxiids are common in the mainstem of Deepdell Creek and monitoring over many years has indicated that the population is large (although can fluctuate widely in density) and resilient to algae blooms, disturbance (e.g., large floods and stock damage) and drought conditions.

3.3 The Taieri flathead galaxias has been classified by the Department of Conservation as 'Threatened – Nationally Vulnerable', with criteria C (3) (moderate population, with population trend that is declining, total area of occupancy ≤ 100 ha (1 km2), predicted decline 10–50%) and the qualifiers 'Conservation Dependent' and 'Data Poor' (Dunn *et al.* 2018).

3.4 Freshwater crayfish or koura (*Paranephrops zealandicus*) are widely distributed throughout the Highlay Creek catchment and in the mainstem of Deepdell Creek, and they are generally common in many of the small streams of the Macraes Flat area. They are also likely to be widespread in the Camp Creek catchment. Their relatively high abundance in these creeks is surprising given that habitat appears limited by a lack of flow and wetted area at times, particularly during late summer and into autumn. A lack of predators (trout and birds – both restricted by a lack of suitable foraging habitat and, in the case of trout, upstream passage) and good cover amongst the schist slab substrate may in part explain the success of crayfish at Macraes. *Paranephrops zealandicus* has been classified as 'At Risk –

Declining' using New Zealand Threat Classification System (NZTCS) criteria (Townsend *et al.* 2008).

3.5 Longfin eel are found occasionally in monitoring of surface waters in the Macraes area, however they are generally uncommon. Longfin eel are classified by the Department of Conservation as 'At Risk – Declining' (Dunn *et al.* 2018).

3.6 To summarise, the three key aquatic species identified in the catchment are freshwater crayfish (koura), flathead galaxias and longfin eel. The flathead galaxias has a relatively narrow geographical distribution, but is common and arguably abundant in Deepdell catchment, as are koura. Longfin eel are uncommon in the Deepdell Creek catchment and, in my opinion, any protection afforded to them is likely to be met by that provided for other species, as described below in section 4.

4. WATER QUALITY

General water quality

4.1 There has been no regular water quality monitoring of Highlay Creek until recently. Previous spot readings collected during previous surveys in summer found reasonably low water temperatures (for summer), good dissolved oxygen levels (all readings above 9 mg/L) suitable for sensitive fish species, relatively low conductivity levels indicative of low nutrient enrichment, but increasing with distance down the catchment. GHD (2019) report that 17 samples taken from Highlay Creek at site HC01 had a median sulphate concentration below 10 g/m^3 and a maximum recording of 70 g/m^3. The median Nitrate-N value was 0.09 g/m^3 and the maximum reading was 0.49 g/m^3.

4.2 Deepdell Creek typically has a pH above 7 and relatively high conductivity (average of 546 µS/cm). Dissolved inorganic nitrogen levels are elevated (particularly nitrate, average of 0.54 mg/L at DC07) and concentrations in Deepdell Creek at DC08 over the period 2018-2019 peaked at 0.6 mg/L, but generally were much lower. Historically, dissolved (bioavailable) phosphorus has not been monitored in Deepdell Creeks or its tributaries, however, past monitoring of algae and plant growth suggests there is sufficient dissolved phosphorus in Deepdell Creek for significant algae and plant growths. Water clarity is generally very good under average and low flow conditions.

4.3 OceanaGold monitors a site upstream ('Control') and downstream ('Loop Road') of the Deepdell Creek confluence, while the ORC has two SOE monitoring sites in the Shag River further downstream of the Deepdell Creek confluence (Craig Road and Goodwood[3]).

4.4 I compared recent nitrate concentrations between the two OceanaGold Shag River sites and found no obvious pattern, with two out of five occasions where nitrate concentrations were significantly higher at the downstream 'Loop Road' site and three occasions when concentrations were lower at this site (Figure 3). Historically, phosphorus has not been monitored by OceanaGold at its Shag River monitoring sites.

4.5 My colleague Deni Murray undertook trend analysis of nutrient data for the two ORC water quality monitoring sites at Craig Road and Goodwood, which are further down the river. The statistical trend analyses determine the magnitude of any trend in nutrient concentration and the degree of confidence of the trend direction. These analyses are useful for determining whether water quality is improving or degrading.

3 Loop Road site is located approximately 8 km downstream from the Deepdell Creek confluence. Craig Road and is approximately 30 km downstream from the Deedell Creek confluence, and Goodwood Pump is located 10 km downstream of Craig Road.

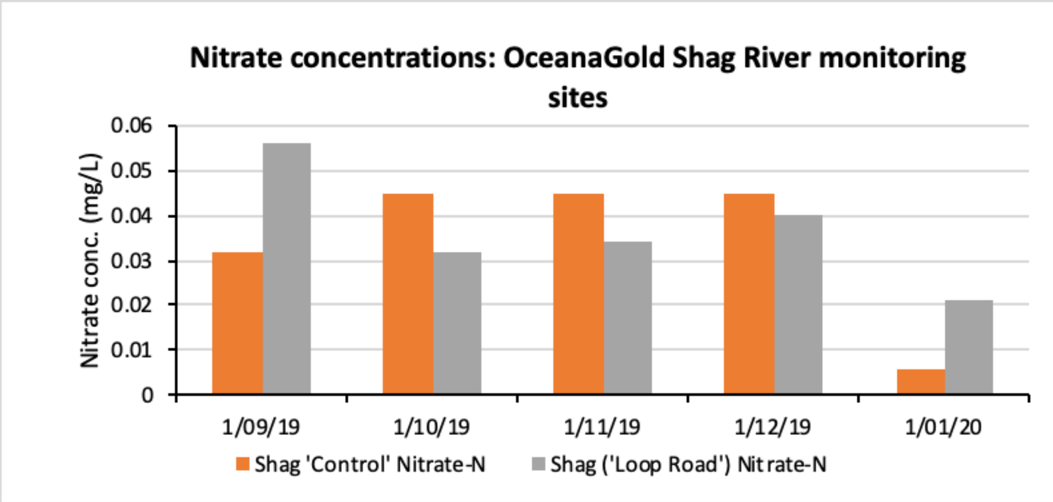

Figure 3: Nitrate-nitrogen concentrations at OceanaGold's two Shag River monitoring sites.

4.6 For the period 2004 – 2020, total oxidised nitrogen (TON: nitrite-nitrogen + nitrate-nitrogen) concentrations are significantly increasing at both sites, however the rate of change is higher at Craig Road (~ 8 %) compared to Goodwood (~ 2 %). Total nitrogen (TN) is also significantly increasing by about 2 % at both sites, but the trend is more probable for Craig Road than Goodwood.

4.7 Total phosphorus (TP) and dissolved reactive phosphorus (DRP) are decreasing over time, however both variables are decreasing at a higher rate at Craig Road compared to Goodwood. This may be due to the higher concentration of agricultural activity occurring between Craig and Goodwood and thus more constant inputs of P into the river.

4.8 Nitrate and sulphate have been identified as two water quality parameters that have increased in downstream receiving water environments due to the effects of the mining operations at Macraes. The DDNth Project will result in these two contaminants reaching Deepdell Creek and Highlay Creek via silt ponds, and consequently some level of treatment can be expected as a result of flow retention and sediment deposition. Potential ecological effects of these contaminants in these two creeks can be expected to be similar given they have similar freshwater communities and drain catchments with similar physical and land use characteristics. Camp Creek will receive clean water only.

Sulphate

4.9 Sulphate concentrations have been monitored in Deepdell Creek for a number of years now, as have fish populations. Both sulphate concentrations and flathead galaxiid fish population estimates are presented in Figure 4 for the period 1990 to 2018 (note regular fish monitoring of Deepdell Creek commenced in 1995). The data for sulphate in Figure 4 show that concentrations have increased from 2006 onwards. Fish population estimates over that period have not altered relative to pre-2006 estimates. While the population varies widely from year to year, the post-2006 median population estimate of 87 fish/10m^2 compares closely to the pre-2006 estimate of 64 fish/10m^2.

4.10 Elevated levels of sulphate in recent years have not resulted in changes to the typical fish population or size classes found in Deepdell in late summer, with the median population estimate in recent years slightly higher than that prior to sulphate levels increasing at DC07.

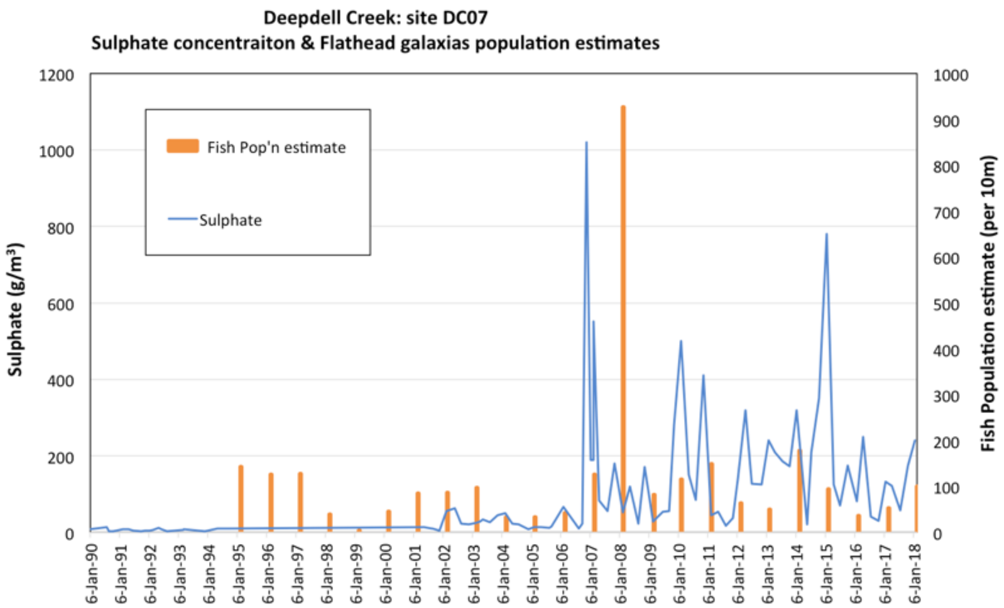

Figure 4: Flathead galaxiid population estimates (per 10 m of creek reach) and sulphate concentrations over time at Deepdell Creek site DC07; 1990 to 2018.

4.11 I was involved in some recent toxicity testing of Macraes mine waste rock seepage leachate using Taieri flathead galaxias (OceanaGold 2018). The most sensitive stages of the flathead galaxias (i.e., eggs and larvae) were exposed to a range mine waste rock seepage concentrations diluted with local (clean) creek water over a 50 day period. The principal chemical constituent of the seepage leachate is sulphate, and the toxicity testing setup used sulphate concentrations ranging from 100 to 3,000 mg/L. No impact was identified on ova and there was no evidence of a toxicity effect during any of the egg development stages. Actual mortally effects did not occur until sulphate concentrations of between 1,640 and 1,920 mg/L were reached. No effects were observed at 1000 mg/L sulphate, which OceanaGold has proposed as a compliance limit for Deepdell Creek.

4.12 I have concluded from the above laboratory testing and receiving water monitoring that, based on existing information, current and proposed consent limits for sulphate concentrations in Deepdell Creek will protect fish populations against potential effects of elevated sulphate levels. Clearly, ongoing monitoring of water quality and fish populations, and regular reporting of that monitoring, is important to confirm the current understanding of the cause and effect relationship between this (and other) species and sulphate. The toxicity study was based on a local native species present at Macraes, local waste rock stack leachate and local stream water. The testing was undertaken independently by the University of Otago. In my opinion, the results are quite clear in their findings.

Nitrate

4.13 This section of my evidence focuses on nitrate (the principal source of nitrogen in most agricultural-dominated catchments in New Zealand). OceanaGold have determined that unburnt ammonium nitrate from explosives and source rock (schist) are sources of nitrate to receiving waters draining the Macraes mine site. Nitrate-nitrogen is a nutrient that is necessary for algae and macrophyte (aquatic plant) growth. In excessive concentrations in freshwater, it can result in nuisance growths of these plant forms, particularly if sufficient phosphorus is also available for growth (along with other factors such as sufficient temperature and water clarity for light penetration). At even higher concentrations, nitrate can be toxic to aquatic life to various degrees.

Nitrate toxicity

4.14 While Taieri flathead galaxiids have not been tested specifically for sensitivity to nitrate, leachate used in sulphate toxicity testing described above indicated that a sulphate limit of 1,000 mg/L, which testing showed to have no effect on flathead galaxias eggs and larvae, is equivalent to a nitrate-N concentration of approximately 7-8 mg/L N. This range is well above current or predicted nitrate levels in the Deepdell catchment or the Shag River.

4.15 I have been able to source only one reference to nitrate toxicity testing using koura. That work was reported on by Hickey (2018). He found that the third most sensitive New Zealand native species to nitrate was juvenile koura, based on testing over a 60 day test on one occasion. The most sensitive thresholds[4] were growth at 2.2 and 2.3 mg/L NO_3-N for length and weight respectively, with a survival threshold of 17.4 mg/L NO_3-N (i.e., approximately 8x above the growth threshold).

4.16 I also note that Hickey (2013) described toxicity testing for the ubiquitous, *Deleatidium* mayfly, which is relatively common in Deepdell Creek and Highlay Creek and its presence regarded as an indicator of good water quality. The chronic mayfly test was for a 20-day exposure and measured survival of the larvae. A no observed effect concentration (NOEC[5]) sensitivity values for *Deleatidium* was 20.3 mg/L NO_3-N in low hardness (soft) water (40 mg/L $CaCO_3$). A geometric mean value of 11.2 mg/L NO_3-N was calculated for inanga from the low and medium hardness water NOEC values and used by Hickey for guideline derivation.

4.17 Given all of the above, for toxicity purposes, applying the NPS-FW Band B would appear to provide ample protection for the aquatic community in the

4 Measuring EC10 and LC10 values (the effect concentration or lethal concentration for a 10% effect).

5 The NOEC is the highest measured continuous concentration of an effluent or a toxicant that causes no observed effect on a test organism. NOEC is determined by a statistical test comparison with control concentrations.

Deepdell Creek catchment. The Attribute Band B values for nitrate (and ammonia) are:

- Nitrate-N g/m^3 (NO3-N) – Annual median [>1.0 and ≤2.4] and Annual 95^3 percentile [>1.5 and ≤3.5]
- Ammoniacal-N g/m^3 (NH4-N) – Annual median [>0.03 and ≤0.24] and Annual 95th percentile [>0.05 and ≤0.40]

4.18 The narrative description for the NPS-FW B Band is "*95% species protection level: Starts impacting occasionally on the 5% most sensitive species*". Hickey (2013) described this level of nitrate management as "very good" and for "*Environments which are subject to a range of disturbances from human activities, but with minor effects*".

Nitrate as a nutrient for algae and plant growth

4.19 The Regional Water Plan for Otago contains water quality schedules that are relevant to nitrate concentrations that are aimed to curb the development of nuisance algae and macrophyte (aquatic plant) growth. The Otago Regional Plan: Water (RPW) Schedule 15 describes the characteristics of good water quality in lakes and rivers along with numerical water quality limits and targets for waterbodies across Otago. The targets and limits specified in this table are to protect against nuisance plant growth as opposed to protection against toxicity.

4.20 Table 2 below sets out the numerical water quality limits/targets for receiving water groups (RWGs) in the Shag River catchment. The limits/targets in Schedule 15 are not limits/targets that apply to any potential discharge, but rather set out the long-term water quality objectives for receiving waters.[6]

[6] These limits/targets apply as 5-year, 80th percentiles when flow is below the median flow at the relevant flow reference site. That is, 80% of values collected when flows are at or below the median flow at the appropriate flow reference site over a 5-year period should be below the Schedule 15 limit.

Table 2: Numerical limits and targets for good water quality in rivers in the Shag River catchment from Schedule 15 of the Otago Regional Plan: Water. RWG = receiving water group, NNN = nitrate-nitrite nitrogen, DRP = dissolved reactive phosphorus.

RWG	NNN (mg/L)	DRP (mg/L)	Ammoniacal nitrogen (mg/L)	*E. coli* (cfu/100 mL)	Turbidity (NTU)	Catchment
2	0.075	0.01	0.1	260	5	Shag

4.21 Currently, the Shag River does not meet the Schedule 15 target concentration (0.075 mg/L) for nitrate-nitrite nitrogen at the two ORC downstream monitoring sites (Craig Road and Goodwood), however monitoring at the OceanaGold downstream monitoring site at Loop Road closer to the Deepdell confluence indicates much lower concentrations, such that the Schedule 15 target may be met at this point along the river. Continued regular monitoring of nitrate-nitrite nitrogen at Loop Road will be necessary to accurately determine whether the Schedule 15 target concentration is being met.

4.22 For the Deepdell catchment, a concentration target of under 0.075 mg/L to achieve this seems overly ambitious in my opinion given current concentrations are almost an order of magnitude higher.

4.23 With respect to the Shag River, long-term ORC monitoring data indicate that TP and DRP are decreasing over time, however both variables are decreasing at a higher rate at Craig Road compared to Goodwood. This may be due to the higher concentration of agricultural activity occurring between Craig Road and Goodwood and thus more constant inputs of P into the river. In contrast, the trend analysis suggests that TON and TN are both significantly increasing in the Shag River at the ORC monitoring sites.

4.24 Both nitrate and dissolved phosphorus are necessary to stimulate algae and plant growth. The pathway for phosphorus to reach surface waters is primarily via overland flow (and direct through stock access to water), whereas nitrate can reach surface waters via subsurface seepage and groundwater. Bioavailable concentrations of nitrogen are trending up in lower Deepdell Creek and the lower Shag River.

4.25 The situation regarding elevated nutrients in Deepdell Creek is not new and occasional nuisance periphyton growths have been a feature of the creek since regular monitoring has commenced. For example, the monitoring report for the 1991 summer monitoring records the lower Deepdell Creek monitoring site (site DC07, but previously known as site L) as having 40% algae cover, which was dominated by the filamentous green algae *Rhizoclonium*, and the benthic invertebrate fauna at this site was dominated by caddisflies, mayflies and snails (i.e., similar to that found today).

4.26 The 1993 summer/autumn report states: "*Examination of available water quality data for Deepdell Creek, while not permitting the derivation of DRP and DIN concentrations, indicates, based on the concentrations of nitrate and total phosphorus, that the concentrations of DRP and DIN likely to cause nuisance algal growths may be exceeded in Deepdell Creek water. Thus, it appears that the periphyton in the creek has an adequate supply of the required nutrients. It is interesting to note that on a number of occasions over the past four years the water right (discharge permit) limits for phosphorus, in particular, have been exceeded throughout the creek, even upstream of the mine. Such exceedances were also recorded prior to the development of the mine.*"

4.27 It is my opinion that setting nutrient limits to manage periphyton growths in the Deepdell Creek catchment using typical guideline values used for periphyton management in New Zealand will not assist the fish population, which is dominated by the flathead galaxias, a species that is clearly adapted to streams with low flows and high benthic algae biomass.

4.28 In my response to ORC's request for further information on aquatic ecology, I compared DIN and DRP concentrations in receiving waters against proposed attribute bands for these parameters contained in the 2019 Draft National Policy Statement for Freshwater Management. These attribute states were included for the management of ecosystem health and not specifically for the management of nuisance periphyton growth. My reason for assessing receiving waters against these proposed attributes was to consider an alternative approach to assessing general ecosystem health rather than focus purely on attributes to manage periphyton. As I stated above, nuisance periphyton growths have been a feature of the Deepdell catchment since monitoring has commenced and streams continue to support abundant galaxiid and koura populations, which I consider should be the primary goal of freshwater ecosystem management in this catchment.

4.29 Notwithstanding the criticisms of the DIN and DRP attributes made by Dr Greer in his evidence for the ORC, some of which I agree with, I still consider that the assessment I made of them provides a useful indicator of where Highlay Creek, Deepdell Creek and the Shag River would potentially sit with respect to their dissolved nutrient status and general ecosystem health. And in that regard, they place in either the A or B band. When I read the narrative descriptions for the A and B bands of these proposed attributes, particularly the B band, in my opinion, they lean towards how I understand the ecological state of these streams. The A band description for these DRP and DIN attributes is as follows:

> *"Ecological communities and ecosystem processes are similar to those of natural reference conditions. No adverse effects attributable to DIN/DRP enrichment are expected."*

4.30 The B band description for these DRP and DIN attributes are as follows:

> *"Ecological communities are slightly impacted by minor DIN/DRP elevation above natural reference conditions. If other conditions also favour eutrophication, sensitive ecosystems may experience additional algal and plant growth, loss of sensitive macroinvertebrate taxa, and higher respiration and decay rates.".*

5. POTENTIAL EFFECTS ON FRESHWATER ECOLOGY

Water quality

5.1 I have discussed receiving water quality effects with respect to nutrients and sulphate in the previous section. A sulphate limit of 1,000 mg/L, as proposed by OceanaGold, does not appear to result in adverse effects on the flathead galaxias. This was confirmed through toxicity testing. While there is no evidence in a decline in the crayfish populations in tributaries that receive runoff and leachate from the Macraes mine, a similar testing programme could easily be implemented for koura.

5.2 Predicted nitrate levels in Deepdell Creek do not appear to be sufficiently high to be toxic to the flathead galaxias or koura. In the previous section I recommended the NPS-FW band B attribute state for nitrate toxicity to provide protection for the aquatic community in the Deepdell Creek catchment. The Attribute Band B values for nitrate (and ammonia) are:

- Nitrate-N g/m^3 (NO3-N) – Annual median [>1.0 and ≤2.4] and Annual 95^3 percentile [>1.5 and ≤3.5]
- Ammoniacal-N g/m^3 (NH4-N) – Annual median [>0.03 and ≤0.24] and Annual 95th percentile [>0.05 and ≤0.40]

5.3 I do not recommend the application of nutrient limits to protect against nuisance periphyton and plant growths. These have always been a feature of streams in the Deepdell catchment, but the key stream ecosystem values (flathead galaxias, koura and occasional longfin eel) have remained. With respect to bioavailable nutrients to maintain ecosystem health, I suggest the following concentration targets:[7]

- Highlay Creek (HC02) and Deepdell Creek (DC07 or DC08)
  - DRP ≤ 0.006 mg/L (median) ≤ 0.021 mg/L (95th percentile)
  - DIN ≤ 0.5 mg/L (median) > 0.56 and ≤01.10 mg/L (95th percentile)
- Shag River (Loop Road)
  - DRP ≤ 0.006 mg/L (median) ≤ 0.021 mg/L (95th percentile)
  - DIN ≤ 0.24 mg/L (median) ≤ 0.56 mg/L (95th percentile)

5.4 While I have not recommended nutrient limits for the management of nuisance periphyton, I am aware that OceanaGold has a consent (Consent No. RM10.351.38) that permits the discharge of water from a reservoir in Camp Creek to Camp Creek downstream of the reservoir for the purpose of operating the (proposed) Camp Creek Reservoir and supplementing flows in the Deepdell Creek catchment.

5.5 It is also proposed that dam flushing flows can also be used to manage algal and macrophyte build up in Deepdell Creek. I have recommended to

7 Based on a rolling median of monthly monitoring over five years.

OceanaGold that the design of the Camp Creek dam include provision to enable an instantaneous flow release greater than the minimum 58 L/s stated in consent conditions. I have also suggested that an appropriate trigger for nuisance algae growth for Deepdell Creek is when filamentous algae >2cm long exceeds 30% of cover of the creek bed at at least two of the existing Deepdell Creek monitoring sites downstream of the Camp Creek confluence. Assessments of periphyton cover can be undertaken quickly and I would suggest that such assessments for flow release purposes are undertaken over the summer months of the year (December to March) when a FRE3 flow (three times the median flow) has not occurred for more than 30 days and repeated every 30 days unless a FRE3 event occurs prior to the next 30 days.

Loss of stream habitat

5.6 The proposed DDNth Project will result in some loss of shallow ephemeral drainage systems and small seepage habitat in the Highlay Creek catchment. Arguably, some of this habitat may be intermittent in character rather than ephemeral, however, based on my (wet) September 2019 observations, it is difficult to distinguish where watercourses change from being ephemeral to intermittent. It is unlikely that they carry surface flow during warmer months of the year.

5.7 Using maps of the proposed project area and GIS tools, I estimated that approximately 350 metres of ephemeral seepage watercourses and 130 metres of possibly intermittent watercourse would be lost in the Highlay Creek catchment. Because they are small, very shallow surface water systems at best, and appear to be largely ephemeral in nature, they do not support fish or typical stream invertebrate habitat and associated communities. Further, given that they lie within farmed land, and historically stock have had direct access to this habitat, they are also likely to be a source of nutrients, sediment and faecal pathogens to watercourses located further downstream.

5.8 My inspections of some of these areas in September 2018 found them to be heavily modified and subject to considerable pugging from stock. Consequently, other than some very minor flow contribution, I consider that these drainage networks provide little to support downstream stream communities of the Highlay Creek tributaries or Highlay Creek itself. It is proposed that 'clean' water will be diverted downstream of the proposed silt pond. The establishment of a silt pond in this part of the catchment may potentially help improve downstream water quality relative to the current situation.

5.9 Populations of Taieri flathead galaxiids are present throughout Highlay Creek catchment, but not in gullies that would be inundated by the proposed Deepdell East Waste Rock Stack. Galaxiid populations are present in the Highlay Creek tributary into which these gullies drain into and in Highlay Creek itself. In my opinion, streams in Highlay Creek catchment that support fish and crayfish populations cannot be regarded as pristine. They are subject to physical disturbance through stock trampling and support nuisance algae growths. However, they obviously have characteristics that are favourable to these species. One of the likely key features responsible for robust crayfish and galaxiid populations in Highlay Creek catchment is the lack of predatory species, in particular brown trout.

5.10 The existing watercourse adjacent to the haul road that drains into the Camp Creek catchment appears devoid of fish, and it is possible the watercourse flows intermittently, which would limit habitat potential even further. Although no fish or crayfish were captured in September 2019 using minnow traps, it is possible that koura may still be present in the system, given the habitat I observed in September 2019. Koura were found in the general vicinity as part of a Fish & Game surveys around 1987-1996. Under the proposed Project, this modified watercourse would not be affected, however approximately 480 metres of an intermittently flowing cut-off drain, located between the confluence with the above watercourse and the man-made pond to east of Horse Flat Road, would be lost to pit infrastructure. Although highly modified and likely to carry little flow even in the cooler months of the year, it potentially may provide some koura habitat if surface water persists throughout all year-round.

5.11 New drains are proposed to divert 'clean' water away from the mine footprint, and sections of these could be constructed in a way that provided habitat for koura.

5.12 An estimated 450 metres of gullies that may support ephemeral watercourses will be lost due to the new pit and associated mine earthworks. These gullies are currently in grazed catchments and are unprotected. They do not support fish habitat.

5.13 The mainstem of Deepdell Creek is also a stronghold for flathead galaxiids and a large population exists in the reach downstream of gullies draining the Deepdell South Pit and the Highlay Creek confluence.

5.14 There will be no physical disturbance to Deepdell Creek as a result of the Project. Provided that the project does not exacerbate low flows, sediment load and general water quality, downstream koura and fish populations should be unaffected by the Project.

5.15 No stream habitats that support fish populations are proposed to be disturbed or lost as a part of the Project. Gullies draining parts of the Highlay Creek catchment that would be lost due to the Deepdell East Waste Rock Stack are very small, heavily impacted, probably ephemeral (potentially intermittent in the lower section) and do not support stream communities (including koura). The estimated length of this habitat that would be lost is approximately 480-500 metres, of which approximately 130 metres of this may have intermittent flow. A proposed silt pond (Deepdell East Silt Pond 1) could potentially be suitable for koura, and riparian planting around the margins would further enhance habitat potential.

5.16 I recommend the loss of approximately 380 metres of a cut-off drain that may potentially support some koura be replaced by constructing an equivalent length of drain to divert 'clean' water around the western side of Project footprint near the haul road and into Camp Creek. To be of net benefit to koura and other aquatic life, the drain, or sections of it, would need to maintain a permanently submerged bed and be of sufficient quality to ensure adequate dissolved oxygen levels. Habitat could be further enhanced by planting tussocks or other overhanging vegetation along the margins and creating shelter through placement of schist slabs and woody debris on the bed.

Spills and sediment management

5.17 Mining disturbs the land, removes vegetation and soil cover, and so increases the risk of fine sediment discharges to watercourses further down the catchment. Fine sediment is already present in tributaries of Highlay Creek, and also present in the mainstem of Highlay Creek and in slow runs and pools in Deepdell Creek. Excessive fine sediment cover is usually detrimental to stream communities, particularly if flow variability is insufficient to regularly flush excess material away. Measures to avoid the introduction and downstream transport of sediment are therefore necessary. Such measures are routinely employed by OceanaGold at the Macraes Mine and are included in proposed consent conditions.

Contaminants and nuisance weed/algae introduction

5.18 To ensure didymo and nuisance weeds are not introduced or spread I recommend that, wherever possible, equipment and other items to be used in or near waterways are first inspected and if necessary cleaned prior to use. Such measures are already in place with existing consent conditions associated with the Macraes Gold Mine and should continue for the Deepdell North Project.

6. MONITORING

6.1 OceanaGold is required to undertake regular monitoring of fish and invertebrate populations in Deepdell Creek, and I recommend this continue, along with similar monitoring in Highlay Creek, as a check against potential effects on freshwater biota due to potential changes in water quality. Regular nitrate and phosphorus monitoring (including bioavailable nutrients) should commence in Highlay Creek and at the existing Deepdell Creek and Shag River monitoring sites. Monitoring for nutrients (N and P) should be undertaken at monthly intervals in order to be consistent with NPS-FM attribute state assessments.

7. COMMENTS ON THE S42A REPORT

7.1 Dr Allibone discusses the cumulative effects of the mine development at Macraes and notes that mitigation for stream loss "*...can take various forms,* *such as enhancement works to improve habitat (riparian planting and fencing), removal of fish passage barriers, or possibly support for Department of Conservation, iwi project or community projects*". I agree with these comments and it is my understanding that OceanaGold has previously undertaken some of the measures listed by Dr Allibone.

7.2 At paragraph 4.17 of his evidence, Dr Greer recommends the inclusion of a consent condition that ensures that fish and koura recovery is undertaken prior to any works in flowing water associated with loss of watercourses in the upper Camp Creek catchment. While I consider it very unlikely that these watercourses contain fish or koura, I acknowledge that other similar work at the Macraes Mine in recent times has required relocation of these species prior to works commencing. It may be prudent to re-survey the affected watercourse as an additional check to confirm the absence of fish and koura.

7.3 Dr Greer also recommends standards for managing nuisance periphyton growths, which, if based on DRP and DIN nutrient limits, would in my opinion be unworkable in the Deepdell catchment for the reasons I set out earlier in my evidence. I have instead recommended a periphyton cover limit that would trigger a flushing flow from the proposed Camp Creek dam, and also nutrient guidelines that should protect existing fish and koura populations.

7.4 At paragraph 5.1(d) of his evidence, Dr Greer recommends that proposed consent conditions stipulate that the culvert on the Highlay Creek tributary is constructed to provide for fish passage. I do not see the need for fish passage at this point in the catchment. Upstream of the proposed culvert location is an ephemeral gully and when I inspected this area in late winter 2019 the surface was barely wet. Figure 5 below is a photo below (taken in August 2019) which look upstream to where the culvert would be located. This gully does not support fish habitat. Further, an existing deer fence looks to sit on a raised bank across the gully, so either surface flow currently impeded under normal flow conditions, else there is some small culvert buried underneath. Regardless, in my opinion, there is no case for the provision of fish passage.

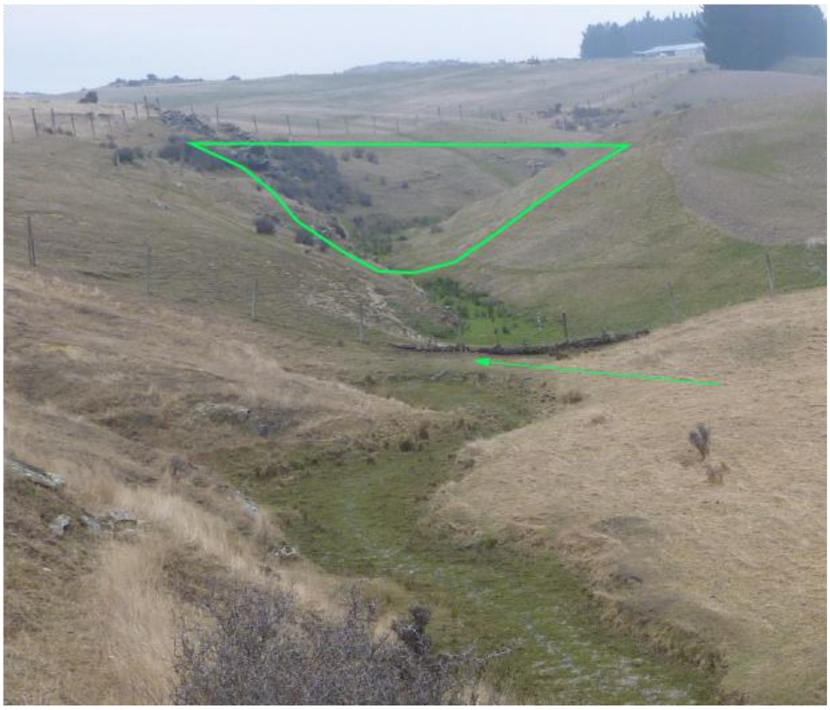

Figure 5: Gully located in a tributary of Highlay Creek, August 2019. Green outline indicates general area where a haul road and culvert are to be located. Arrow shows the raised bank that the deer fence sits on.

7.5 Under section 7.4 of the s42A report, it states: "*Dr Allibone states that further work and monitoring will be required to determine if flushing flows work as desired under the existing consent condition. Dr Allibone states that from experience, flushing flows from some dams are unable to achieve the management objective as there are limitations on the size of the flushing flow that can be released due to the dam design.*". I can find no reference to this statement in Dr Allibone's evidence, however, I agree that flushing flows are very much 'horses for courses' and I recommended in my report to OceanaGold that the potential to provide effective flushing flows from the Camp Creek dam is investigated.

7.6 The s42A report recommends 'periphyton standards' for Highlay Creek, Deepdell Creek and Shag River. For the reasons I have already stated above and in sections 4 and 5 of my evidence, I do not recommend periphyton standards for the Deepdell catchment based on dissolved nutrient concentrations, but suggested a periphyton cover trigger (30% filamentous algae >2cm long at two or more of the existing Deepdell Creek monitoring sites downstream of the Camp Creek confluence.) for the release of flushing flows from the proposed Camp Creek dam, and alternative dissolved nutrient concentration guidelines for stream ecosystem health.

7.7 Proposed numerical compliance criteria put forward in the ORC's s42A report include provision for DIN and DRP concentrations for Deepdell Creek (DC08) and the Shag River (Loop Road), but did not recommend what these concentrations should be. I suggested some target concentrations in section 5 of my evidence, as follows:

- Deepdell Creek (DC07 or DC08)
    - DRP ≤ 0.006 mg/L (median) ≤ 0.021 mg/L (95^{th} percentile)
    - DIN ≤ 0.5 mg/L (median) > 0.56 and ≤01.10 mg/L (95^{th} percentile)
- Shag River (Loop Road)
    - DRP ≤ 0.006 mg/L (median) ≤ 0.021 mg/L (95^{th} percentile)
    - DIN ≤ 0.24 mg/L (median) ≤ 0.56 mg/L (95^{th} percentile)

8. COMMENTS ON SUBMISSIONS

8.1 DOC's submissions cites concerns about the loss of habitat and the effects of hydrology on freshwater species, particularly koura and the Taieri flathead galaxias. I have addressed the loss of habitat in my evidence. I would also note here that both species appear to be particularly resilient to low flows and, based on my observations at Macraes over many years, can thrive in very small creeks.

Greg Ryder
4 August 2020

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APPENDIX A: SURFACE WATER DEFINITIONS

When describing surface water features in this evidence, the Auckland Unitary Plan definitions for surface waters have been adopted for convenience. The relevant definitions are:

Ephemeral stream

- Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent or intermittent.

Intermittent stream

- Stream reaches that cease to flow for some periods of the year because the bed can be above the water table at some times.
- This category is defined by those stream reaches that do not meet the definition of permanent and meet at least three of the following criteria;
- It has natural pools
- It has a well-defined channel, such that the bed and banks can be distinguished
- It contains surface water more than 48 hours after a rain event which results in stream flow
- Rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel
- Organic debris resulting from flood can be seen on the floodplain
- There is evidence of substrate sorting process, including scour and deposition.

River (or stream or creek)

- Means a continually or intermittently flowing body of fresh water; and includes a stream and modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal).

Note that the definition of river is that found in the Resource Management Act and is also contained in the Regional Plan: Water for Otago glossary.