Fiordland link experience – wetland assessment

NIWA Client Report: CHC2004-065
June 2004

NIWA Project: RHL04502

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Prepared for

Riverstone Holdings Ltd

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Executive Summary

In March 2004 NIWA was contracted by Riverstone Holdings Ltd (RHL) to carry out an assessment of the Dunton Swamp on the route of the monorail part of the proposed tourism experience from Queenstown to Lake Te Anau. NIWA's role was to assess the characteristics of the natural environment in the Dunton Swamp, particularly in relation to its natural character, the potential impacts of the monorail development, and mitigation measures. NIWA's assessment of the environmental effects of the monorail on the wetland will be included as a section in the final EIA document.

The assessment was carried out using information from previous environmental studies carried out by the Department of Conservation and Landcare Research Ltd, and from information gathered during a site visit between 5th – 7th April 2004. We have also used information provided by RHL regarding the monorail route, proposed construction methods and operations.

The Dunton Swamp is a palustrine fen wetland (see Ward & Lambie 1999 for explanation of wetland classification) of high natural character and in highly unmodified condition. It scored highly using the Ministry for the Environment condition assessment protocol (21.5 out of a possible score of 25) due to its large size, high diversity of habitats and of native plant species, and low impact of factors that reduce natural character in wetlands (e.g. hydrological disturbance, nutrient enrichment, burning, weed invasion). Some impact of pastoral grazing on vegetation composition was evident at the margins, with moderate impact of exotic weed species in some communities, especially an area of *Carex coriacea*-dominated sedgeland at the northeastern margins. There is currently very low pressure from environmental threats that could cause any future loss of wetland condition at the site.

This report includes an assessment of effects of the Fiordland Link proposal on:

- Habitat for species-rich communities
- Hydrological modification
- Soil disturbance and peat oxidation
- Nutrient enrichment
- Weed and pest invasion
- Fire

The effect of the monorail on the native communities will depend on the route and the location of piers in the wetland. A number of species-rich communities dominated by *Sphagnum* and wire rushes were

identified. These are mostly avoided by the current proposed route, with some exceptions at the 25 km mark. The dominant community along the selected route is a *Carex coriacea* sedgeland which already has lost some natural character due to grazing, and has high cover of weeds associated with grazing such as Yorkshire fog and creeping bent.

Hydrological disturbance and disturbance of peat and vegetation are the two most significant issues associated with construction of the monorail. Changes in topography, including diversions of watercourses, and changes in drainage, would have prolonged effects on community composition, such as invasion on non-wetland species, and loss of wetland species. Also associated with changes to hydrological regime and topography are possible nutrient enrichment due to modified hydrology and soil oxidation.

Weed invasion could occur during construction due to contamination of construction machinery, and after construction due to movement of the monorail through the wetland, and from the piers and sites of earthworks acting as sites for weed recruitment. The opportunity for the route to provide increased access for mammalian predators of birdlife in the wetland is difficult to quantify, but remains a possibility.

Fire is a major hazard during the construction period, and may remain a hazard post-construction from the risk of electrical sparking. Increased awareness of the wetland may also increase the risk of fire from vandalism.

Mitigation options suggested in the report include:

- Consideration of how to minimise the impingement of the monorail into the wetland area or its margins.

- Construction methodology that minimises overturning and exposure of peat and peat-based vegetation, and that minimises disturbance by tracking of machinery and equipment through the wetland.

- Protocols to avoid fires and discharges of pollutants at site during construction and by operation of the monorail after construction.

- Avoiding changes to the existing water tables, water courses and drainage in and out of the wetland.

- Weed and pest survey and eradication proposals, including post-construction monitoring.

1. Introduction

1.1. Background

On 26 February 2004, NIWA provided a scoping of issues associated with the Riverstone Holdings Limited (RHL) Fiordland Link project, a proposed tourism experience from Queenstown to Lake Te Anau, one sector of which is a monorail between Kiwi Burn to the edge of Lake Te Anau at Te Anau Downs. This included a desk-top study of the environmental characteristics and values of wetland environments on the route, and potential issues affecting wetlands. The assessment was based predominantly on two previous reports on wetland communities on the route (Rance 1995; Lee and Elliot 1995). In particular, the route traverses one highly significant wetland, the Dunton Swamp, ranked by the Department of Conservation (DoC) in the top 5 of 50 wetlands in the area for conservation significance.

For the purposes of carrying out a complete assessment of environmental effects, NIWA was then contracted to further evaluate characteristics of the Dunton Swamp, and the potential impacts of the proposed monorail on those values. This report covers that evaluation and raises issues that should be addressed as part of an assessment of environmental effects (EIA). Although this report is not a comprehensive EIA, it is a technical memorandum intended to be incorporated, along with other memoranda being prepared by Boffa Miskell Ltd and other specialist consultants, into the full EIA being prepared by John Edmonds and Associates Ltd on Riverstone Holdings' behalf.

1.2. Scope

The environmental characterisation (Section 2) addresses wetland values that are potentially affected by construction activities and operation of the monorail, in particular community composition, natural character and nutrient status. As proposed in the scoping study, we have applied the standard wetland condition assessment methodology of Clarkson et al. (2003) to assess the current status of the wetland. We also provide quantitative data on the community composition that can be used as a baseline to monitor any changes during or after monorail construction. Assessment of potential impacts (Section 3) relates to the proposed monorail plan as at 31 March 2004, on the basis of the potential issues identified in the scoping study. Briefly, these issues were hydrological disturbance, disturbance of peat and vegetation, weed and pest invasion, fire, and nutrient enrichment. Section 4 describes possible measures to mitigate the effects.

The wetland assessment concentrates on the Dunton Swamp, which DoC has identified as the major ecological feature of the Upukerora section of the monorail

route (Rance 1995). Some wetland vegetation also occurs on the route at 28 (26)[1] km, and this area was also surveyed (see Figure 1 for location of surveyed sites). Other wetland systems occur on the proposed route, which could not be visited and assessed during this study. The river valley between 13 (15) km and 15 (17) km on the proposed route, which is part of Glen Echo station, was not visited due to weather conditions at the time of field work, but aerial photographs suggest some wetland vegetation exists on the river flats in this area. Outside the conservation estate, the route passes through wetland areas on private farmland at 33 (35) km. We were not granted permission by the landowner to make a detailed assessment of this area, although a brief visual examination was possible. It appeared that this wetland had been modified considerably by grazing and drainage, with exotic pasture species invading the native community. The revised preferred route also passes across a wetland community at 37 (35) km, which again could not be visited without landowner permission. According to local information, this wetland is dominated by *Sphagnum* moss. Further assessment of these wetlands may be necessary in the future.

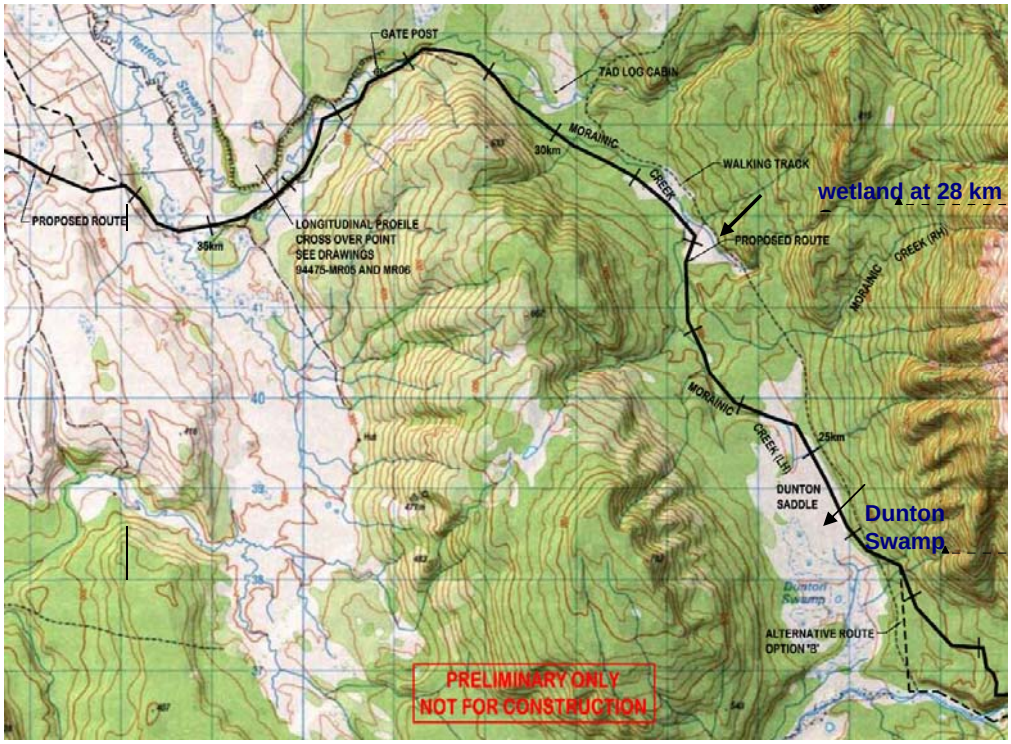

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Figure 1: Location of the wetlands assessed in this report.

[1] The bracketed number is the distance on the route map during the survey. Since then the route was revised and the new distances are now given.

1.3. Site description

The Dunton Swamp is a ca. 100 ha wetland in a valley floor within the Dunton range, between the Upukeroa River and the Retford stream. According to the Ministry for the Environment's wetland classification system for New Zealand, it is a palustrine fen, i.e. an inland freshwater wetland with a peaty substrate and significant water input from both rainfall and surface and/or groundwater inflow (Ward and Lambie 1999). The distinctive ecological features of fens are specialised plant communities supported by high rainfall and low to moderate fertility. These are generally the most species-rich of freshwater wetlands, and hence have very high conservation value. Surface water inflows are from the beech forest on the eastern margin of the wetland, and there is a strong gradient of increasing wetness from west to east. Outflow is both northwards and southwards – flow to the south is to a creek that is a tributary of the Upukerora River, and flow to the north begins as a groundwater flow that acts the source of the left-hand branch of Morainic Creek. The highest elevation in the system is the Dunton Saddle; even here the vegetation is dominated by wetland species, and wetland vegetation continues into the headwaters of Morainic Creek (LH branch).

Rance (1995) emphasised the high floristic diversity of the site, with a total of 11 distinct plant communities that fell in three major categories – oligotrophic (low-nutrient) wetland communities, eutrophic (high-nutrient) wetland communities, and edge communities. Associations between red tussock (*Chionocloa rubra*) and other species were identified as particularly unusual, with the greatest significance being given to the edge communities located on the forest margins to the east. These act as an ecotone (ecological transition) between forest and wetland. These communities had high species diversity, and have been lost from most New Zealand wetlands. Lee and Elliot (1995) identified the site as the major ecological feature of the Upukerora section of the proposed monorail, and also stressed the conservation significance of the forest-wetland ecotones. They recommended that the monorail route should avoid communities on the south side of the catchment. The current route does so by emerging from the bush into the wetland further north in the *Carex coriacea* sedgeland.

2. Wetland assessment

2.1. Methods

We carried out a wetland assessment of the Dunton Swamp from 5th – 7th April 2004. The methodology used for assessing the wetland condition is described in Clarkson et al. (2003). The assessment considers the status of the site as a whole, and is supported by quantitative sampling concentrated in the area of the proposed monorail route. The assessment scores and summarises the site for a range of parameters important for

natural character in wetlands. The scores are based on existing information from reports and project documentation for the wetland, with further information from the site visit. Scores are given for (i) current wetland condition, and (ii) existing pressures to wetland condition. The assessment methodology also provides a basis for monitoring change in condition as a result of the construction and operation of the monorail.

We identified three major vegetation communities along the eastern margin. Within each community we defined a permanent 2 m x 2 m plot marked by G.P.S. and surveyed its vegetation composition (Appendix I). Any subsequent changes in composition can be used to monitor effects of the monorail on the Dunton Swamp. In addition, soil and vegetation samples were taken from each plot, and assayed for a range of nutrient (nitrogen and phosphorus) parameters that allow the current nutrient status of the site to be determined, and any nutrient enrichment to be identified in future monitoring. Further details of how sampling is carried out and scores are assessed are described in Clarkson et al. (2003).

At the wetland at the 28 (26) km mark, a 2 m x 2 m plot was also marked by GPS and surveyed for vegetation composition (Appendix 1).

2.2. Results and discussion

2.2.1. Wetland condition

The record sheet used to characterise wetland condition is shown in Appendix I. The wetland scored highly on all aspects of hydrological intactness, nutrient enrichment and extent of human impact, with a score of 21.5 out of a possible 25. This reflects a high degree of natural character and low human impact, in comparison with many wetlands in New Zealand that have greater impact by drainage and nutrient enrichment associated with urban development and agriculture. Each of the condition indicators specified in the record sheet, which identify loss of condition due to human activity, is discussed below:

- *Changes in hydrological integrity:* There was little, if any, evidence of the hydrological damage associated with human modification seen in many other wetlands. There was no evidence of any artificial drainage networks in the wetland. The soil was saturated to the surface over much of the wetland area, as would be expected in a hydrologically intact fen wetland. Although long-term monitoring of water levels would be necessary to characterise the natural water regime in detail, it was possible during the site visit to identify features indicative of undisturbed hydrology such as *Sphagnum* moss that was fully saturated and not

desiccated. In addition, soil in the plots was water-saturated with water tables near the surface, and the soil had the characteristic dark brown-black colour of waterlogged wetland soil that has not been subject to unnatural drainage. Finally, there was no sign of the encroachment of terrestrial, non-wetland plants, whether native or exotic, into the wetland, although some such species were present at the margins. Invasion of wetland vegetation by dryland species is a highly specific indicator of drying soil.

- *Change in physico-chemical parameters:* After hydrological disturbance, physical and chemical disturbance such as burning, sedimentation and nutrient enrichment (eutrophication) are the next most common factors affecting wetland condition. There was no evidence visible during the site visit of any major effect of these factors. Fire is a frequent threat to wetlands in developed areas, but no major signs of fire damage were present, and there were no charcoal or soot particles in the surface horizons sampled in any of the plots. Hence, any fires at this site have not been recent enough to have any major impact on the ecosystem. Many components of the vegetation are fire-sensitive species that would not be present if there had been recent fires. Characteristic signs of sedimentation and erosion damage such as scouring and silt deposits were also absent. The concentrations of nitrogen and phosphorus in soil and plant material from the plots were consistent with unmodified fen habitats elsewhere. The lowest nutrient concentrations were in the species-rich wire rush/*Sphagnum* communities, which have the highest species diversity. The area showing evidence of grazing, i.e. that dominated by *Carex coriacea* and with a high cover of exotic species, had much higher nitrogen and phosphorus levels than the other sites, and was also drier than the other sites.

- *Change in ecosystem intactness:* This refers to any loss in area or change in plant or animal communities of the original wetland due to human modification. There has been very little such change at the Dunton Swamp. However, there is evidence of grazing activity that has had an impact on vegetation stature and composition, predominantly at the southernmost and northernmost areas of the site. The mosaic of *Sphagnum* bogs, string bogs and flood channels on the western and central areas of the site are intact. There are highly diverse communities in the wetland to forest ecotone at the southeast that are also intact. Drier areas of the wetland, such as the *Carex coriacea*-dominated sedgelands at the northeast, have the highest contribution by introduced pasture species and the lowest diversity of native species.

- *Change in browsing, predation and harvesting:* There was evidence of browsing activity in the wetland by feral animals such as hares and deer. The impact of these animals was relatively low and there was little, if any, sign of extensive

mortality or change in plant composition due to grazing or trampling. Signs of grazing by domestic stock were restricted predominantly to margins at the south-west and *Carex coriacea* communities to the north-east. Impacts of predators at this site have not been assessed, but mustelids, rats and cats are likely to be present. There is no impact of human harvesting (e.g. *Sphagnum* and flax removal) at present.

- *Change in dominance of native plants:* Invasion of wetlands by non-native plant species can be extensive and have large effects on community structure and on vegetation structure and habitat values. Many weed species create dense artificial monocultures or cause excessive sedimentation and nutrient enrichment, as well as displacing native species. In the Dunton Swamp, however, there was little evidence of non-native species having such impacts, either in the canopy of the vegetation or in the ground cover. Non-native species were mainly restricted to the margins, especially in association with grazing impacts. The absence of non-native plants spreading into the wetland is also likely to be related to the low nutrient status of the site, as most weed species are encouraged by nutrient enrichment.

The quantitative condition assessment confirms that this site has very high, intact natural character, as suggested in the earlier assessments in the 1990s. The site is unusual for its large size, low impact of human activity, low invasion of weed species, and high native diversity. No formal survey of native fauna was carried out, but 7 – 8 native bird species were noted in the area during the field visit, suggesting that this wetland has high bird value. This is not surprising in light of the high habitat diversity of the site, which would allow a high number of species to co-exist.

2.2.2. Wetland pressures

The record sheet (Appendix I) also provides a score for the current pressures (threats) that could affect wetland condition in the future. Low pressure scores indicate that a site is well-protected from pressures and unlikely to deteriorate in the near future. The Dunton Swamp is currently facing minimal pressures, as none of the factors that generally reduce condition are significant. The site is contained within a catchment with largely natural hydrology, with little modification of streams in the vicinity of the site, and minimal development of drainage networks in the catchment. The only possible hydrological pressure is some change in drainage due to stock access at the margins. The absence of extensive agricultural or urban development in the catchment also ensures that there is currently little if any threat of nutrient enrichment at the site. No change in condition is likely from the minor animal access present at the site. There are also no invasive plant species that drive significant loss of wetland character within or in the vicinity of the wetland.

The low pressure scores indicate that the high natural character of this wetland is unlikely to change at present. Consideration of possible impacts of the monorail must therefore be made in relation to a wetland of extremely high natural character with little current pressure on its condition.

2.2.3. Vegetation types

Six vegetation types were identified in the wetland, as specified on the wetland record sheet in Appendix I. Details of the composition of the three plant communities at the eastern margin are provided on plotsheets for each vegetation type in Appendix I. All plots had high native diversity and low invasion by exotic species. The only community having a high contribution of exotic species was the *Carex coriacea* sedgeland at the northeast margin, which had high cover of the pasture weeds Yorkshire fog (*Holcus lanatus*) and creeping bent (*Agrostis stolonifera*). Location of these communities at the eastern margins of the wetland is shown in Figure 2.

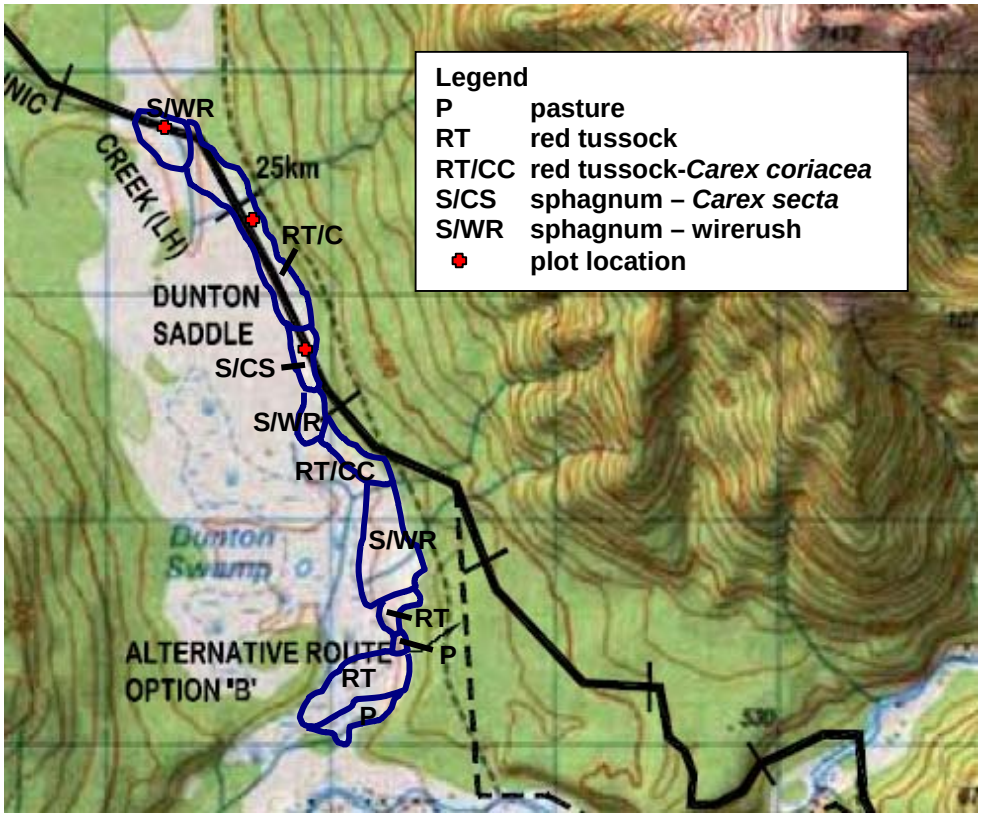

Figure 2: Map of the Dunton Swamp showing location of major plant communities at the eastern margins of the swamp in the area of the proposed Fiordland Link Experience route.

The plot at the wetland at the 28 (26) km mark was dominated by *Carex coriacea* but had a greater proportion of exotic species than the Dunton Swamp plots. This is probably due to more frequent stock grazing.

3. Assessment of potential impacts of the proposed monorail

Potential impacts of the proposed monorail include issues that (i) relate to the positioning of the monorail route and the communities identified in the field survey, (ii) short-term disturbances during construction, and (iii) longer-term issues that arise due to the on-going presence and operation of the monorail.

3.1. Monorail route

The current proposed monorail route has the route emerging from beech forest into the valley floor occupied by the Dunton Swamp at the 24 (22) km mark. The route then traverses the north-eastern corner of the wetland, and then turning westwards where the wetland system begins draining into Morainic Creek (LH branch) The route continues down Morainic Creek and traverses the western edge of a small wetland at the 28 km mark. This route is predominantly traversing drier, *Carex coriacea*-, red tussock- and *Carex secta*-dominated communities. The *Carex coriacea*- and *Carex secta*- dominated communities are less floristically diverse and probably the more eutrophic of the vegetation types. However the red tussock communities have been identified by Rance (1995) as having the greatest significance of all vegetation types present at Dunton Swamp due to their unusual species composition and the rarity in the Te Anau basin of red tussock being found in association with wetlands. The route therefore needs to be located through this section to minimise it's occurrence within the red tussock communities.

A number of areas of species-rich *Sphagnum* and wire rush-dominated communities occur at the northern end of the wetland at approximately 25 (23) – 25.5 (23.5) km on the current route and could potentially be impacted (Figure 3). Effects on the *Carex*-dominated and red tussock communities and their values would depend on the degree of disturbance during construction and operation (see below).

3.2. Construction issues

The proposed tourism experience from Queenstown to Lake Te Anau specifies that construction of the rail in the Dunton Swamp will be based on transport of construction material on the existing rail. This would avoid the need for vehicle tracks

Figure 3: Vegetation of high natural character dominated by *Sphagnum* moss and wire rush (*Empodisma minus*)

and other ground disturbances. Damage of the site and invasions of weeds and pests due to such tracks can therefore be avoided. Other impacts that may still be an issue using this construction method are as follows.

Hydrological disturbance and disturbance of peat and vegetation are the two major issues associated with construction of the monorail. Wetlands can only exist in the landscape due to specific hydrological conditions that allow water saturation of the soil close to or at the surface for most of the growing season of plants, and that allow the small seasonal fluctuations in water table that encourage wetland plant growth. Even small alterations in water regime can result in relatively large changes in wetland character as terrestrial and weed species invade the habitat of native wetland plants. Construction activities can disturb soil and drainage networks so that rates of drainage out of wetlands increase, leading to loss of wetland flora and fauna. Drainage can be sudden with rapid effects, if deep channels and ditches are created in the landscape, and can also be gradual in response to more subtle changes. High water tables in wetlands are also often sustained by deeper layers of impermeable soils such as iron pans, and prolonged drainage can occur if these are pierced and the substrate below is not saturated.

Peat soils form from plant growth over periods of tens to thousands of years, but oxidise and break down rapidly when drained or exposed to the atmosphere. Peat oxidation increases nutrient availability, encouraging weed invasion, and causes soil subsidence, changing floristic composition. Any disturbance of peat during construction can take many years to repair, as plants in low-nutrient wetlands are slow-growing and require long periods of recovery. Soil disturbance can also increase nutrient inputs into infertile sites such as the Dunton Swamp, as increases in groundwater and surface water flow at the margins can increase nutrient input.

The construction phase is also a period of possible weed and pest invasion. During construction, construction material and equipment moved into the site are likely to be a source of weed propagules. Any overburden left on the surface from excavating holes for piers can provide desirable sites for weed invasion and therefore should be removed from the site.

Fire is also a potential impact during the construction phase. Standing plant litter in wetlands is prone to fire damage, and the red tussock, *Carex coriacea* and *C. secta* species vegetation in the planned route burn readily. *C. secta* is fire-sensitive and its tussocks can require several years to recover from burning. Fire risks include petrol-driven machinery, sparking from electric machinery and welding equipment, and construction activities such as rubbish fires.

3.3. Post-construction issues

Weed invasion would remain a risk after construction. Structures such as piers offer localised disturbances and sites of nutrient enrichment that encourage weed invasion. Movement of the monorail through the wetland could also carry weed propagules from outside the site.

There would be an on-going risk of fire. Being electrically driven, the monorail avoids the high fire risk associated with petrol and diesel engines, but electrical sparking is a possible fire hazard. Increased awareness of the wetland from the operation of the monorail also increases the risk of fire because of deliberate vandalism. Many wetland fires are the result of vandalism. There could also be a risk of discharge of pollutants e.g. lubricants from the operation.

4. Mitigation

Minimising the impingement of the proposed tourism experience from Queenstown to Lake Te Anau, on the wetland communities with highest natural character can be

achieved by careful planning of the route and position of the piers. The current route plan avoids most of the species-rich native communities at the western and south-eastern ends of the Dunton Swamp. However it may traverse the highly valued red tussock communities on the north-eastern margin of the swamp. The red tussock occurs in a mosaic with the less intact *Carex coriacea*- and *Carex secta*-dominated communities and it may be possible to locate the route so the track mostly traverses these less intact plant communities. Particular care should be taken to avoid the *Sphagnum*-wire rush associations on the route at approx. 25 (23) km. There should be careful positioning of piers to avoid the more peaty communities of high natural character. This could be achieved by involving DoC staff and wetland experts on the ground at the detailed design stage and during the construction process.

Construction methodology should seek to minimise the overturning of peat and peat-based vegetation wherever possible, and avoid disturbing these communities. All overburden should be removed from the site. Before construction, there should be a formal description of soil stratigraphy in the area where the piers are to be placed, to determine any effect on hydrological patterns, especially drainage. This can be achieved by consultation with professionally qualified geologists and/or geo-technical engineers who can identify mitigation options if necessary. Mitigation options are likely to involve construction techniques for driving and 'fixing' piers into the substrate.

To allow hydrological modifications to be avoided and documented, there should be installation of automated equipment for monitoring of water level in the soil, such as capacitance probe depth recorders. Water regime should be established prior to construction from a seasonal depth record. Changes after construction can be detected. If changes were detected, and could not be explained from nearby climate data (e.g. at Te Anau), then the cause would need to be identified and addressed. The water recorders required for this monitoring are inexpensive and easily constructed and operated. This monitoring can be incorporated as part of the development of the project by consultation with wetland scientists with suitable hydrological expertise.

There should be protocols in place for avoiding fires during construction in particular, and for minimising the risk of fire from the operation of the monorail after construction. Fire risk avoidance plans should recognise the possibility of vandalism. Protocols should also address any potential risk of pollutant discharges.

A particularly thorough methodology for minimisation, detection and eradication of weed invasions is essential. This would include methods for avoiding contamination of construction equipment during the construction phase, and of the monorail train after construction. In addition all overburden should be removed from the site to

prevent the creation of sites for weed invasion. A monitoring programme should be in place to identify any weed invasions in relation to the location of the route, and with protocols for weed eradication and management. This should include a list of alarm weeds – those that are currently absent but known to be particularly destructive in wetlands – that would have highest priority for eradication if detected. Increases in browsing, grazing or predation activities should also be monitored. The monitoring programme should also be used to detect any other environmental change, particularly changes in species composition and loss of native species, in relation to the operation. One possible remediation option that could be investigated is fencing to reduce deer browsing effects.

5. Conclusion

Minimising the impact of the proposed tourism experience from Queenstown to Lake Te Anau, on wetland values should be possible by careful planning of the route and positioning of the piers provided appropriate construction techniques are used to prevent drainage occurring adjacent to the route and at the pier sites and that the proposed mitigation methods during the construction period are followed. Provided the final line of the route is identified on the ground with a team of ecologists, landscape architects and DoC staff working alongside Fiordland Experience staff, it should be possible to agree on a line that maintains ecological values while providing for landscape and experiential values. It should therefore be possible to establish the proposed project whilst maintaining wetland values in the area.

6. References

Clarkson, B.R.; Sorrell, B.K.; Reeves, P.N.; Champion, P.D.; Partridge, T.R.; Clarkson, B.D. 2003. Handbook for Monitoring Wetland Condition. Coordinated monitoring of New Zealand Wetlands. A Ministry for the Environment SMF funded project. Ministry for the Environment, Wellington.

Lee, W.G.; Elliot, G.P. 1995. Snowdon Forest – proposed monorail route: biological assessment. *Landcare Research Contract Report LC9495/117*.

Rance, B.D. 1995: Wetlands of the Te Anau Basin – an ecological investigation. Department of Conservation, Southland Conservancy, May 1995.

Ward, J.C.; Lambie, J.S. (Eds) 1999. Monitoring changes in wetland extent: an environmental performance indicator for wetlands. A Ministry for the Environment

SMF funded project. Final Report - Project Phase One. Lincoln Environmental. Lincoln University. Canterbury

Appendix I

Wetland condition assessment record sheet for the Dunton Swamp and plotsheets for vegetation assessments in three communities

WETLAND RECORD SHEET

Wetland name: Dunton Swamp **Date:** 5/04/04
Region: Southland **Grid Ref.:**
Altitude: 450m **No. of plots sampled:** 3

Classification: I System	**IA Subsystem**	**II Wetland Class**	**IIA Wetland Form**
Palustrine	Permanent	Fen	Valley bottom

Field team: Brian Sorrell, Paula Reeves

Indicator	**Indicator components**	**Specify and Comment**	**Score 0– 5[1]**	**Mean score**
Change in hydrological integrity	Impact of manmade structures	No evidence of drains in wetland	5	4.7
	Water table depth	None evident	5	
	Dryland plant invasion	Confined to margins	4	
Change in physico-chemical parameters	Fire damage	No recent fire evidence	5	4.5
	Degree of sedimentation/erosion	None visible	5	
	Nutrient levels	Measured levels moderate with no evidence of enrichment	4.5	
	Von Post index	Some decomposition in surveyed plots.	3.5	
Change in ecosystem intactness	Loss in area of original wetland	Wetland mostly intact, some edges have been modified by grazing.	4	4
	Connectivity barriers	Mostly intact	4	
Change in browsing, predation and harvesting regimes	Damage by domestic or feral animals	Stock damage confined to margins. Feral animal access evident on bogs (mostly deer, hares).	4	4.5
	Introduced predator impacts on wildlife	Not known		
	Harvesting levels	None	5	
Change in dominance of native plants	Introduced plant canopy cover	Mainly confined to margins	4	4
	Introduced plant understorey cover	Mainly confined to margins	4	
Total /25				21.7

[1] Assign degree of modification as follows: 5=v. low/ none, 4=low, 3=medium, 2=high, 1=v. high, 0=extreme

Main vegetation types:

- *Sphagnum –Carex* mossland
- *Sphagnum – Empodisma* mossland
- *Sphagnum – Empodisma- red tussock* mossland
- Sphagnum - Bog pine – celery pine – *Empodisma* shrubland
- *Carex coriacea* sedgeland
- *Carex sinclairii* sedgeland

Native fauna: NZ Robin, fantails, tomtits, kakariki, waxeye, brown creeper, hawk

Other comments:

Pressure	Score[2]	Specify and Comment
Modifications to catchment hydrology	1	Very minor from infrequent grazing along the margins.
Water quality within the catchment	1	Runoff is mostly from surrounding beech forest.
Animal access	1	Stock can access margins.
Key undesirable species	1	Tall fescue, Yorkshire fog, deer.
% catchment in introduced vegetation	1	Only a small amount of the catchment (to the north and south of the swamp) is in pasture grasses.
Other pressures		

[2]Assign pressure scores as follows: 5=very high pressure, 4=high, 3=medium, 2=low, 1=very low, 0=none

WETLAND PLOT SHEET

Wetland name: Dunton Swamp **Date:** 5.4.04 **Plot no:** 1
Plot size (2m x 2m default): 4 m^2 **Altitude:** 450m **GPS:** E 21 15 233, N 55 39 751
Field leader: B. Sorrell **Structure:** mossland **Composition:** *Sphagnum cristatum* – *Empodisma minus*

Canopy			**Subcanopy**			**Groundcover**		
Species[1]	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**
Carex sinclairii	10	0.2				*Sphagnum cristatum*	35	0.05
Sphagnum cristatum	60	0.05				*Drosera spathulata*	+	0.23
Empodisma minus	20	0.18						
Lachnagrostis semiglabra	+	0.35						
Chionochloa rubra	6	0.8						
Schoenus pauciflorus	1	0.27						
Open water	3							

1 % = % cover within relevant vegetation layer; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type: *Carex coriacea*

. **Indicator** (use plot data only)	**%**	**Score 0–5**[2]	**Specify and Comment**
. Canopy: % cover introduced species	0	5	
Understorey: % cover introduced spp[3]	0	5	
. Total species: % number introduced spp	0	5	
Total species: overall stress/dieback	NA	5	
Total /20	NA	20	

[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high
[3]Add subcanopy and groundcover % cover for introduced species

Field measurements:

Water table cm	3-5 cm	Water conductivity uS (optional)	**5.3. 20-30**
Water pH (optional)	3.7	Von Post peat decomposition index	5

Soil core laboratory analysis (3 soil core subsamples)**:**

Water content % dry weight	2459	Total C %	47.7
Bulk Density T/m^3	0.04	Total N %	1.48
pH	4.05	Total P mg/kg	1288

Foliage laboratory analysis (leaf/culm sample of dominant species)**:**

Species	*Empodisma minus*	%N	1.16	%P	0.118

WETLAND PLOT SHEET

Wetland name: Dunton Swamp **Date:** 5.4.04 **Plot no:** 2
Plot size (2m x 2m default): 4 m^2 **Altitude:** 450m **GPS:** E 21 15 724, N 55 39 197
Field leader: B. Sorrell **Structure:** sedgeland **Composition:** *Carex coriacea*

Canopy			Subcanopy			Groundcover		
Species[1]	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**
Carex coriacea	70	0.6				*Blechnum penna-marina*	5	0.1
**Holcus lanatus*	18	0.7				*Viola cunnighamii*	2	0.1
**Agrostis stolonifera*	10	0.5				*Oreomyrrhis ramosa*	2	0.2
Carex sp.	2	0.55				**Trifolium repens*	2	0.15
						**Cerastium fontanum*	+	0.4
						Ranunculus membranifolius	+	0.1

1 % = % cover within relevant vegetation layer; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type: *Chionochloa rubra, Coprosma propinqua, Hypocheris radicata, Eleocharis acuta.*

. **Indicator** (use plot data only)	**%**	**Score 0–5**[2]	**Specify and Comment**
. Canopy: % cover introduced species	28	3	*Holcus lanatus* and *Agrostis stolonifera*
Understorey: % cover introduced spp[3]	2	4	*Trifolium repens* and *Cerastium fontanum*
. Total species: % number introduced spp	20	4	
Total species: overall stress/dieback	NA	5	
Total /20	NA	16	

[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high
[3]Add subcanopy and groundcover % cover for introduced species

Field measurements:

Water table cm	below surface	Water conductivity uS (optional)	18.3. 70
Water pH (optional)	6.1	Von Post peat decomposition index	6-7

Soil core laboratory analysis (3 soil core subsamples)**:**

Water content % dry weight	1039	Total C %	45.4
Bulk Density T/m^3	0.09	Total N %	2.45
PH	5.62	Total P mg/kg	2807

Foliage laboratory analysis (leaf/culm sample of dominant species)**:**

Species	*Carex coriacea*	%N	1.17	%P	0.104

WETLAND PLOT SHEET

Wetland name: Dunton Swamp **Date:** 5.4.04 **Plot no:** 3
Plot size (2m x 2m default): 4 m^2 **Altitude:** 450m **GPS:** E 21 15 896, N 55 38 723
Field leader: B. Sorrell **Structure:** sedgeland **Composition:** *Carex secta/Sphagnum cristatum*

Canopy			**Subcanopy**			**Groundcover**		
Species[1]	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**
Carex secta	60	0.8	*Hierochloe redolens*	15	0.85	*Sphagnum cristatum*	10	0.05
Sphagnum cristatum	20	0.05	**Holcus lanatus*	5	0.5	*Coprosma propinqua*	1	0.02
**Holcus lanatus*	5	0.5				*Hierochloe redolens*	10	0.5
**Epilobium ciliatum*	+	0.05				*Lachnagrostis semiglabra*	1	0.4
Coprosma acerosa ssp. brunnea	1	0.02						
Lachnagrostis semiglabra	2	0.3						

1 % = % cover within relevant vegetation layer; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type: *Leptospermum scoparium, Carex coriacea, Blechnum penna-marina, Coprosma intertexta, Hebe odora, Myrsine divaticata, Phyllocladus alpinus, Halocarpus bidwillii.*

. **Indicator** (use plot data only)	**%**	**Score 0–5**[2]	**Specify and Comment**
. Canopy: % cover introduced species	5	4	*Holcus lanatus* and *Epilobium ciliatum*
Understorey: % cover introduced spp[3]	12	4	*Holcus lanatus* in the subcanopy
. Total species: % number introduced spp	25	3	Two introduced species only
Total species: overall stress/dieback	NA	5	
Total /20	NA	16	

[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high
[3]Add subcanopy and groundcover % cover for introduced species

Field measurements:

Water table cm	below surface	Water conductivity uS (optional)	21.3. 60
Water pH (optional)	5.3	Von Post peat decomposition index	2

Soil core laboratory analysis (3 soil core subsamples)**:**

Water content % dry weight	1840	Total C %	44.9
Bulk Density T/m^3	0.05	Total N %	1.35
pH	5.34	Total P mg/kg	1883

Foliage laboratory analysis (leaf/culm sample of dominant species)**:**

Species	*Carex secta*	%N	1.38	%P	0.144

WETLAND PLOT SHEET

Wetland name: Wetland at 28 km **Date:** 5.4.04 **Plot no:** 1
Plot size (2m x 2m default): 4 m^2 **Altitude:** 300m **GPS:** E 21 14 249, N 55 41 672
Field leader: B. Sorrell **Structure:** sedgeland **Composition:** *Carex coriacea*

Canopy			**Subcanopy**			**Groundcover**		
Species[1]	**%**	**H**	**Species**	**%**	**H**	**Species**	**%**	**H**
Carex coriacea	40		*Epilobium ciliatum*	1		*Epilobium ciliatum*	1	
Carex gaudichaudiana	10		*Eleocharis acuta*	1		*Eleocharis acuta*	1	
Schoenus pauciflorus	10		*Stellaria graminae*	1				
**Agrostis capillaris*	10		**Prunella vulgaris*	+				

**Holcus lanatus*	5	1m						
**Juncus acutiflorus*	5							
**Lotus pedunculatus*	5							
Ranunculus cheesemanii	5							
***Trifolium repens*	3							
Viola cunnighamii	2							
**Juncus effusus*	3							
**Parentucellia viscosa*	1							
Bryophytes	1							
**Plantago lanceolata*	+							
**Hypocheris radicata*	+							
**Cirsium palustre*	+							

1 % = % cover within relevant vegetation layer; H = maximum height in m; indicate introduced species by *

Additional species in vicinity in same vegetation type: *Lepidosperma australe, Carex diandra, *Ranunculus repens, *Trifolium pratense, Wahlenbergia albomarginata.*

. **Indicator** (use plot data only)	**%**	**Score 0–5**[2]	**Specify and Comment**
. Canopy: % cover introduced species	32	3	*Agrostis capillaris, Holcus lanatus, Juncus acutiflorus* and *Lotus pedunculatus* are the main introduced canopy species.
Understorey: % cover introduced spp[3]	+	5	*Prunella vulgaris* (+)
. Total species: % number introduced spp	52	2	
Total species: overall stress/dieback	0	5	
Total /20		15	

[2]5=0%: none, 4=1– 24%: very low, 3=25–49%; low, 2=50–75%: medium, 1=76–99%: high, 0=100%; v. high
[3]Add subcanopy and groundcover % cover for introduced species