Milford Opportunities

CRITICAL STRUCTURES FOR WALKING AND CYCLING

CONSTRUCTION FEASIBILITY

03 APRIL 2024

Around the Mountain Cycle Trail – Fairlight Suspension Bridge – Southland District Council – Frame Group Limited

CRITICAL STRUCTURES FOR WALKING AND CYCLING – CONSTRUCTION FEASIBILTY

Milford Opportunities

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REV	DATE	DETAILS
A	19/02/2024	Draft for client comment
1	26/02/2024	Final
2	11/03/2024	Final – change to person approving
3	03/04/2024	Final – Hine-te-awa Bowen Falls lower access viewing platforms

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EXECUTIVE SUMMARY

Milford Opportunities (MOP) and Southern Land have identified critical structures included in the walking and cycling routes proposed by the Milford Opportunities (MOP) Masterplan Stage 2 and the Southern Land document titled *Milford Opportunities Project Walking and Cycling Experiences Report December 2023 – Draft*.

WSP has been requested to provide a high-level construction feasibility assessment of the critical structures. Natural hazards and environmental impact are considered separately.

Table 1 provides a summary of findings.

Table 1 – Critical Structures – Construction Feasibility – Summary of Findings

Item	Site Name	Structure Type	Comments/considerations
1	Lower Upokororo Eglinton River	Bridge – suspension - 125m span	Very large span but construction is feasible with consideration required on the extent of vegetation clearance, high site wind loads (and funnelling) on large and lightweight structure. Potential boulders within moraine foundation material. River course is stable with some localised areas of scouring. Span to be confirmed so that it generously allows for riverbank scour. Good construction access to true left. Limited construction access to true right.
2	East Upokororo Eglinton confluence	Riverbank scour protection - 75m Rock armouring/rockfall protection	Construction is feasible but consideration required regarding the maintenance cost and disturbance to users from ongoing regular minor maintenance (clearing of debris/minor rockfall) and more significant maintenance after flood events (reinstatement/repositioning of rock armouring). River course is stable. The site is accessible by construction machinery if the necessary approvals are gained.
3	Upokororo Eglinton River just above east branch	Bridge – suspension – 45m	Construction is feasible with consideration required on extent of vegetation clearance, wind loads, and detailing to accommodate rock foundation material on true right. River course is stable. Span to be confirmed so that it generously allows for scouring of the true left bank. The site is accessible by construction machinery if the necessary approvals are gained.
4	Countess Range Hut	Hut – alpine - 18mx10m	Construction is feasible with consideration of alpine site and extreme weather conditions. Rockfall and avalanche hazard are important considerations that are part of natural hazard assessment being reported separately. Piled foundation will need to consider bearing capacities and hold down requirements. Specific

			site geotechnical study required during detailed design stage. No construction access. Helicopter lifting required. Alpine site.
5	Kiosk Creek bridges	Bridge – Land span Two bridges of 16m span.	Construction is feasible. Stream bed is mobile and is aggrading. Stream course is stable with some localised scouring. Allow for future lifting/packing of bridge beams as bed aggrades. Span to be confirmed so that it generously allows for scouring. Pile abutment foundations. Provide wingwalls and scour protection. Limited construction access. Helicopter aerial lifts will be required.
6	Mistake Creek	Bridge – suspension – 24m span.	Existing walkway and bridge site (3 wire). Construction is feasible with consideration of extent of vegetation clearance and detailing to accommodate mix of gravel, rock, and small boulder foundations. Limited construction access. Helicopter aerial lifts will be required.
7	Upokororo Eglinton River at Ōtāpara Lake Gunn	Bridge – suspension – 20m span.	Construction is feasible with consideration of extent of vegetation clearance and detailing to accommodate gravel, rock, and small boulder foundations. Limited construction access. Helicopter aerial lifts will be required.
8	Melita Bluff gantry(s) at Ōtāpara Lake Gunn	Bluff bridge – Gantry Propped and braced off rock with rock anchors/bolts. 1400m	Construction is technically feasible but maintaining the required grade for a cycling trail through historic debris slides, overhangs, and bush clad rock faces will require vegetation and rock removal. The rock anchor installation and any vegetation removal will disturb the thin organic root layers on the steep rock face creating the risk of initiating debris slide(s). The construction of a 1400m long bluff bridge gantry comes with high risk. The natural hazard assessment will confirm the risks but with current knowledge this structure is considered likely not viable.
9 & 10	Hinepipiwai Marian Creek Bridges	Bridge - Suspension – 35m and 55m span.	The sites for the Hinepipiwai Marian Creek Suspension bridges are located in an area of large boulders generated by rockfall overlain by mature beech forest. The specific sites are not known and require confirmation to confirm the suitability of the foundation and confirm appropriate clearance from the bridge soffit to high flow events. The size and stability of the large boulders is unknown.

			The foundation design will be challenging as the size and stability of the boulders to resist the required lateral loading is not known. Further investigations will be necessary to confirm a suitable foundation for a suspension bridge(s). With current knowledge the construction of suspension bridges are not likely viable for the proposed true left Hinepipiwai Marian Creek bridge sites unless a suitable site(s) is confirmed by detailed geotechnical investigations and survey .
11	Whakatipu-ka-tuku Hollyford River bridge at Homer Hut	Bridge – multi span – 16m.	Construction is feasible. The site is easily accessible and standard short span (4-6m) timber multi span bridges with timber piles. The stream bed is mobile and subject to overland flow during rainfall. Allow for future lifting/packing of bridge beams as bed may aggrade. The site is accessible by construction machinery if the necessary approvals are gained.
12	Sheerdown Peak gantry	Bluff bridge – Gantry propped and braced off rock with rock anchors/bolts – 175m.	Technically feasible and is similar to the item 8 Melita Bluff gantry. However, construction has a reduced risk due to the face being clear of vegetation. Any new debris slides will come from above the debris slide or at new locations where there is currently no slide where the new gantry is not present. There is no construction access to the site however the Milford Road is nearby. Refer to Natural Hazards Assessment to assess risks to this proposed structure. Construction of a gantry at this site may have acceptable risk when compared to Melita Bluffs but with current knowledge this structure is considered likely not viable.
13	Horse Bridge	Bridge – suspension - 35m span.	There is an existing historic suspension bridge at this site. Construction is feasible. The historic bridge introduces resource consent and heritage aspects that affect the construction. Any bridge at the site must consider the existing bridge and gain all necessary approvals. Options include the removal and full replacement of the existing bridge, upgrading of the existing bridge retaining the existing fabric where possible, or retaining the existing bridge with some upgrading works to preserve it, but not be in service along with a new suspension bridge. The existing fabric of the bridge is in a poor state and is not considered reusable. A new bridge is necessary.

			Retaining the current bridge alongside a new bridge is not considered a safe option due to the potential for visitors to use an unsafe bridge. There is no construction access to the site however the Milford Road is nearby. Helicopter aerial lifts will be required.
14	Barren Peak spur and Lower Hine-te-awa Bowen Falls stairs and viewing platform.	Viewing platform and stairs	Construction is feasible. Rock anchors with extent of vegetation clearance to be confirmed. Works must be undertaken to ensure that weaknesses are not created in the thin vegetation root layers. There is no construction access – helicopter aerial lifts will be required.
15	Lower Hine-te-awa Bowen Falls access.	Pontoon/Bluff Bridge Gantry – 95m	Bluff Bridge Gantry Refer to Natural Hazards Assessment to assess risks to this proposed gantry structure. Construction of a gantry at this site may have acceptable risk when compared to Melita Bluffs but with current knowledge this structure is considered likely not viable. Pontoon Construction is feasible. Consideration to be given to vessel movement and distance/clearance from cliff face for rockfall. Also consideration to rockfall protection gallery. Construction access would be from a boat or barge.

1 INTRODUCTION

1.1 CRITICAL STRUCTURES

The Southern Land Draft document titled *Milford Opportunities Project Walking and Cycling Experiences Report December 2023 – Draft* provides a technical feasibility report for a range of walking and cycling experiences identified from the Milford Opportunities (MOP) Masterplan Stage 2. The Southern Land Report is comprehensive and provides relevant high-level details of the requirements for the proposed walking track and cycle ways. The walking tracks and cycleways will require numerous structures including culverts, boardwalks, bridges, shelters, and huts. Southern Land has selected preferred options for the types of structure required at various locations along the walking tracks and cycleway.

MOP and Southern Land have identified 15 structures along the route as “critical structures” which due to their scale or site, require additional consideration to confirm their feasibility. These are summarised in Table 2. Note that the Chasm Bridge(s) replacement is being considered and investigated separately by the Department of Conservation (DOC) and is not included within this report.

WSP has been requested to provide a high-level construction feasibility assessment of the critical structures. WSP has only considered the structure types confirmed by Southern Land and has not considered other possible structure options at the “critical structure” sites.

This construction feasibility assessment briefly discusses natural hazard risks at some of the proposed sites but does not consider this in detail. Natural hazard risks are assessed separately.

The consenting requirements for the proposed works have not been considered. These are also assessed separately.

WSP has not visited all the sites for the structures but has used the information gathered by Southern Land along with desktop studies and institutional knowledge from many years of providing professional engineering services for works along the Milford Road corridor to formulate a high-level opinion on the feasibility of construction for these structures.

Table 2 - MOP - Walking and Cycling Experiences - Critical Structures

Item	Site Name	Structure Type	Length
1	Lower Upokororo Eglinton River	Bridge - suspension	125m
2	East Upokororo Eglinton confluence	Riverbank scour protection Rock armouring/rockfall protection	75m
3	Upokororo Eglinton River just above east branch	Bridge - suspension	45m
4	Countess Range Hut	Alpine Hut	18mx10m
5	Kiosk Creek bridges	Bridge - land span	2x16m
6	Mistake Creek	Bridge - suspension	24m

7	Upokororo Eglinton River at Ōtāpara Lake Gunn	Bridge - suspension	20m
8	Melita Bluff gantry(s) at Ōtāpara Lake Gunn	Bluff bridge/gantry – propped and braced off rock with rock anchors/bolts.	1400m
9	Hinepipiwai Marian Creek Bridge	Bridge – suspension	35m
10	Hinepipiwai Marian Creek Bridge	Bridge - suspension	55m
11	Whakatipu-ka-tuku Hollyford River bridge at Homer Hut	Bridge – multi span – walkway/boardwalk bridge	16m
12	Sheerdown Peak gantry	Bluff bridge/gantry - propped and braced off rock with rock anchors/bolts	175m
13	Horse Bridge	Bridge - suspension	35m
14	Barren Peak spur stairs and viewing platform.	Viewing platform and stairs	50m
15	Lower Hine-te-awa Bowen Falls access.	Pontoon	95m

1.2 FACTORS INFLUENCING DESIGN

1.2.1 DESIGN STANDARDS

It is expected that the design criteria for the walkway and cycle way access structures will be in accordance with the design loadings and requirements of the Track and Outdoor Structures New Zealand Handbook in SNZ HB 8630:2004.

1.2.2 DESIGN CONSIDERATIONS

With reference to SNZ HB 8630:2004, the following structural design criteria should be considered for the walking and cycling infrastructure:

- User Group – Day visitors User Group 3 or Short Stop Travelers User Group 2
- Loading for viewing platforms – Table 8 "Basic live loads" of SNZ HB 8630:2004 requires 5kPa Uniformly distributed Live Load for easily accessible structures. This aligns well with the requirements of ASNZS 1170.01 for assembly areas without out fixed seating susceptible to overcrowding.
- Restricted load structures – Table 9 "Basic live loads for restricted load structures" of SNZ HB 8630:2004 – can limit structures to a single person, two persons, five persons or ten persons. A limit to the number of people permitted on a structure at a time is common in back country areas. A limit of ten people permitted on a bridge structure at a time is considered reasonable for the expected traffic volume. Limits of less than ten people per structure should not be considered due to concerns around compliance.
- Barrier loadings – Table 10 "Basic live loads for barriers" of SNZ HB 8630:2004 clearly specifies the live load requirements for barriers on viewing and access structures.
- Access widths can be 0.75m for Day visitors or 1.2m for Short Stop travelers.
- Cycleway width 1.5m.
- Design redundancy – the Department of Conservation has a policy of providing a level of redundancy for its new suspension bridge structures i.e. the bridge must continue to be stable after the loss of a suspension cable. It is expected that the proposed suspension bridges on the walking and cycle trail will also be designed to include a similar level of redundancy.
- Durability – the design of structures shall consider durability and specify materials and detailing appropriate for the Te Rua-o-Te-Moko Fiordland National Park environment.
- Design life – the NZ Building Code requires a minimum design life of 50 years. This is considered appropriate for the structures. To achieve a 50-year design life, regular and ongoing maintenance of the structures will be necessary and a detailed asset management plan for each structure is recommended. The design details will require due consideration to allow the easy replacement of componentry as individual items reach end of life e.g. bolts.
- Importance level – an Importance Level 1 (in accordance with ASNZS 1170.0-2002 Table 3.1 and the NZ Bridge Manual Table 2.1) will be appropriate.
- Lateral loading – wind and seismic. It is expected that wind loading will govern the design of the suspension bridges for lateral loading however seismic loadings will need to be considered for the foundations where liquefaction may occur. Liquefaction risk is only likely to be a risk for the structures located on the Waipāteke Cleddau River delta or any reclaimed land at Milford Sound Piopiotahi, this will need to be confirmed during detailed design.
- Freeboard – clearance from the lowest part of the bridge structures to the river level. Of particular concern during a flood event. The NZ Bridge Manual requires a clearance 1.2m during a Serviceability Limit State flood where there is a possibility that large trees may be carried down the waterway. The amount of clearance will need further consideration during the detailed design stage to confirm if this level of clearance is deemed sufficient.

2 CRITICAL STRUCTURES DISCUSSION

2.1 LOWER UPOKORORO EGLINTON RIVER SUSPENSION BRIDGE

Southern Land has identified a site on the Cycle Trail, Option 1 for a suspension bridge to cross the Lower Upokororo Eglinton River. As shown in Figure 1. The site is approximately 2.4 to 2.5km from the mouth of the Upokororo Eglinton River where it flows into Te Ana-au Lake Te Anau.

Figure 1 – Aerial view of proposed site for the Lower Upokororo Eglinton Suspension Bridge (source Southern Land Report)

There are numerous examples of back country suspension bridges that have been constructed within New Zealand and Te Rua-o-Te-Moko Fiordland National Park for walking tracks and increasingly so for cycling tracks. It is considered that a walking and cycleway suspension bridge can be successfully constructed at the proposed Lower Upokororo Eglinton River site.

The span of the bridge identified by Southern land is 125m. This is a significant span but is achievable. The Timber Trail in the Pureora Forest Park has a cycleway suspension bridge spanning 140m (Maramataha Bridge). See Figure 2. A suspension bridge is well suited to this span and the site.

Figure 2 – Timber Trail – Maramataha Bridge – 140m (source: Timber Trail website)

2.1.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The foundation of the suspension bridge can be piles, ground bearing pads (or combination) or rock anchored concrete bearing pads depending on the site conditions. The suspension cables can be anchored with ground bearing concrete deadmen, rock anchors or rock anchored concrete pads. The site conditions will determine the most suitable foundations.

The proposed site for the Lower Upokororo Eglinton River Suspension Bridge is within an area of glacial moraine, and large boulders could be encountered during the construction of the bridge towers and deadman anchors. The requirement to adjust the site locally to account for this should be considered in detailed design. Over excavation and reinstatement of the excavated material may be necessary if large boulders are encountered. It is considered that the site will have suitable ground conditions for the bridge foundations and deadman anchors.

The foundation type will be confirmed during the detailed design, but the tower foundations are likely to be a ground bearing concrete pads with short piles to resist lateral loading. The deadman anchors will be ground bearing.

The river course is stable at the proposed location however, there is riverbank scour approximately 300m upstream at a knee in the river on the true right bank which could translate downstream over time. Providing adequate scour protection to the riverbanks would be difficult and costly. The span length should be generous to allow for degradation of the riverbanks over the design life of the bridge. A scour assessment will be required during the detailed design phase.

WIND LOADING

The significant span and towers supporting the suspension cables will attract significant wind loading. The towers for a suspension bridge spanning 125m are expected to be in the order of 15m tall. The high wind loads in the area, and localised funnelling of wind along the river course, will make the design of the suspension bridge for wind loading a critical consideration in the design. This can be accounted for in the design with appropriate wind stays.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The 125m span will require backstays that extend approximately 30m behind the abutments, and wind stays both upstream and downstream. The cycleway may require hardfill ramps to provide the appropriate grade of access to the bridge. The native vegetation and trees in the area will require removal to allow the installation of these items.

The removal and disturbance of trees and vegetation should be carefully considered as it could result in the destabilisation of the surrounding trees, which can affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered during detailed design.

RIVER HIGH FLOW EVENTS/FREEBOARD

The freeboard from the deck level, and cable wind stays, to the high river flow events requires confirmation from further investigation. The chosen site has elevated embankments and this along with the positive curvature, or precamber, of the suspended bridge deck should allow appropriate clearances between high flow events and the deck to be achieved. The wind stays will have catenary sag and the clearances to high flow events will be less as a result, but it is still considered that there will be sufficient clearance at this site.

CONSTRUCTION ACCESS

Access to the true left abutment can be obtained from an existing vehicle track although upgrades may be necessary. The true right abutment currently has no access. The design of the suspension bridge will need to allow for this limited access in the design of the componentry. Numerous suspension bridges have been successfully constructed in remote back country locations with the use of helicopters.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

2.2 EAST UPOKORORO EGLINTON CONFLUENCE – SCOUR PROTECTION

Southern Land has identified a route for the Option 1 cycle trail that traverses a slip at the confluence of the west and east branches of the Upokororo Eglinton River. See Figure 3, Figure 4, Figure 5, and Figure 6.

The slip has been activated by the scouring at the toe due to the East Upokororo Eglinton River flowing normal to the main branch of the Upokororo Eglinton River and to the slip face. There is also overland flow over the face of the slip from a water source from the eastern slopes of the Earl Mountains.

It is suggested in the Southern Land Report that the cycleway can either traverse above the slip with a more challenging grade than other sections of the trail, or traverse over the base of the slip near the river. The lower alignment course is preferred to provide a consistent grade for the pathway. To create the route across the face of the slip, benching will be necessary with significant rock armouring to protect the path from scour from the west and east branches of the Upokororo Eglinton River. Works will also be necessary to protect the slip face from overland flow of stormwater from the water course originating in the Earl Mountains.

Rock armouring and stormwater management systems have been successfully constructed alongside the Upokororo Eglinton and Whakatipu-ka-tuku Hollyford River to protect the Milford Road - SH94. The path at the confluence site can also be successfully protected. Regular maintenance will be required.

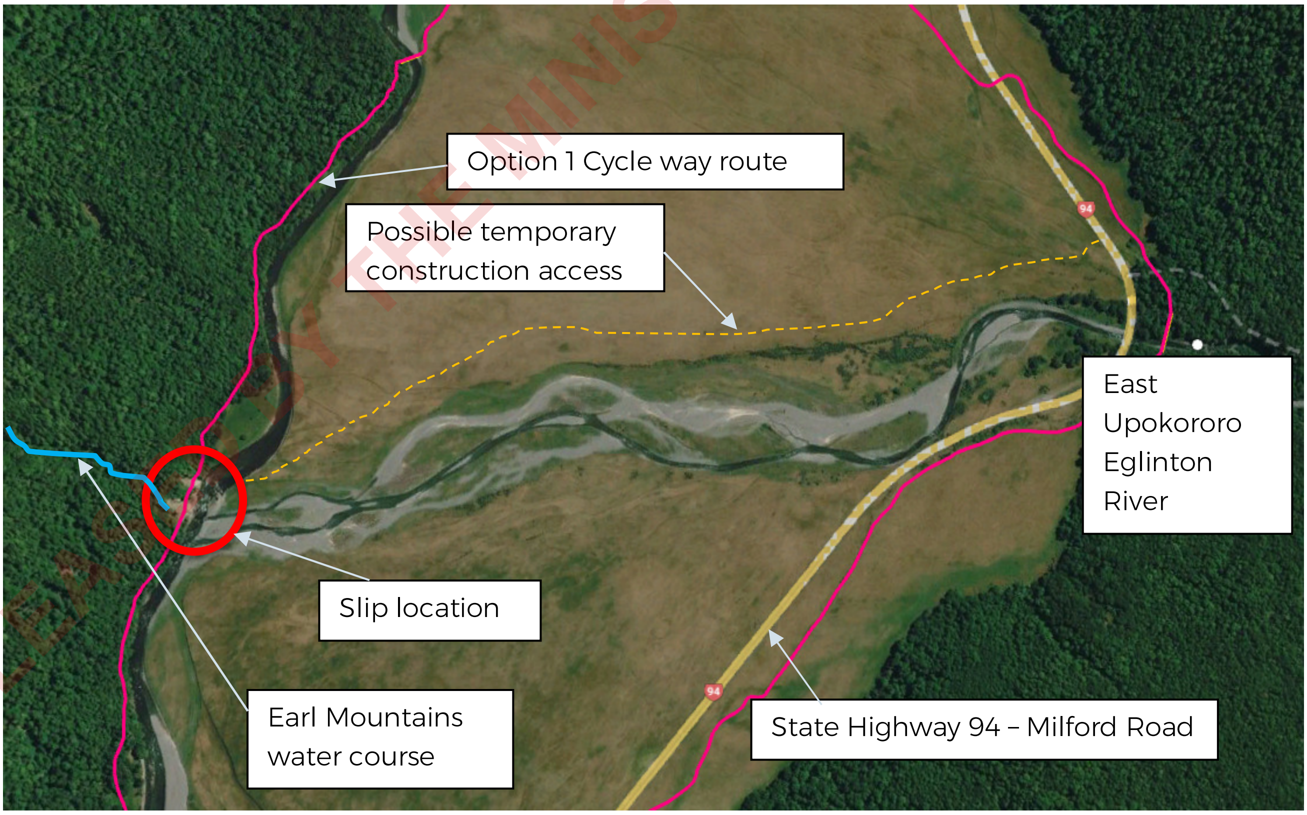

Figure 3 – Aerial view and location of East Upokororo Eglinton Confluence Slip (Source: Southern Land Report with additional annotation by WSP).

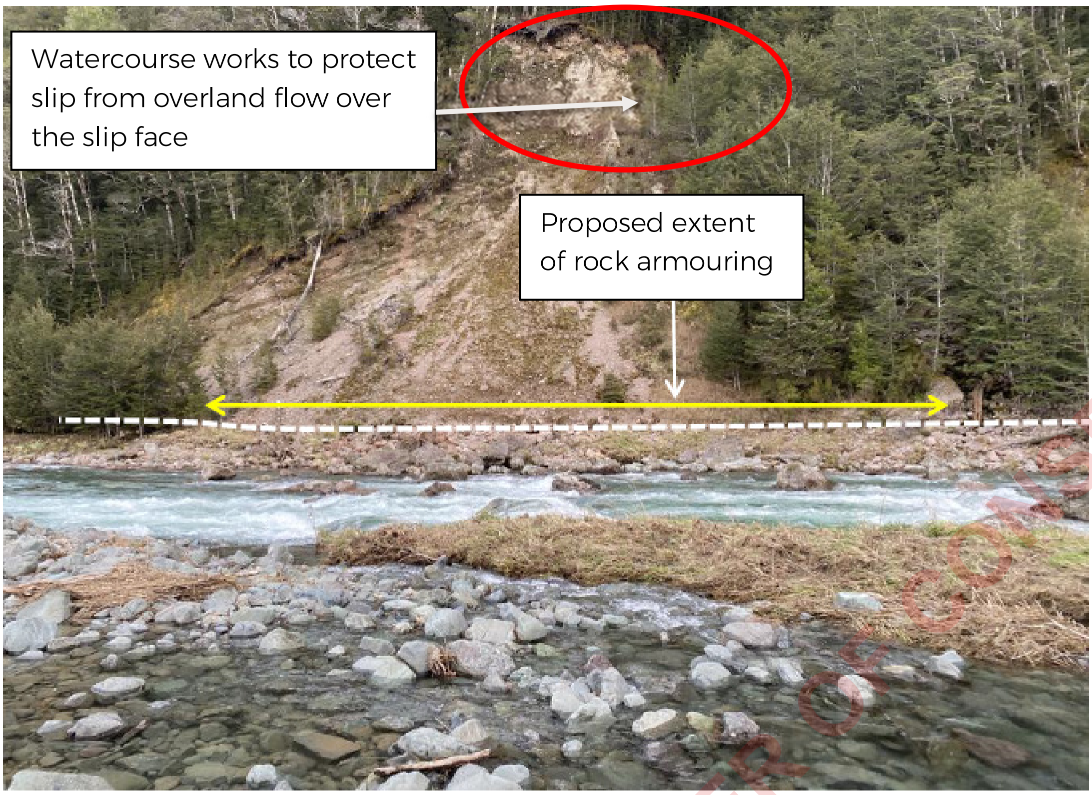

Figure 4 – View of slip from East Upokororo Eglinton River (Source: Southern Land Report with additional annotation by WSP).

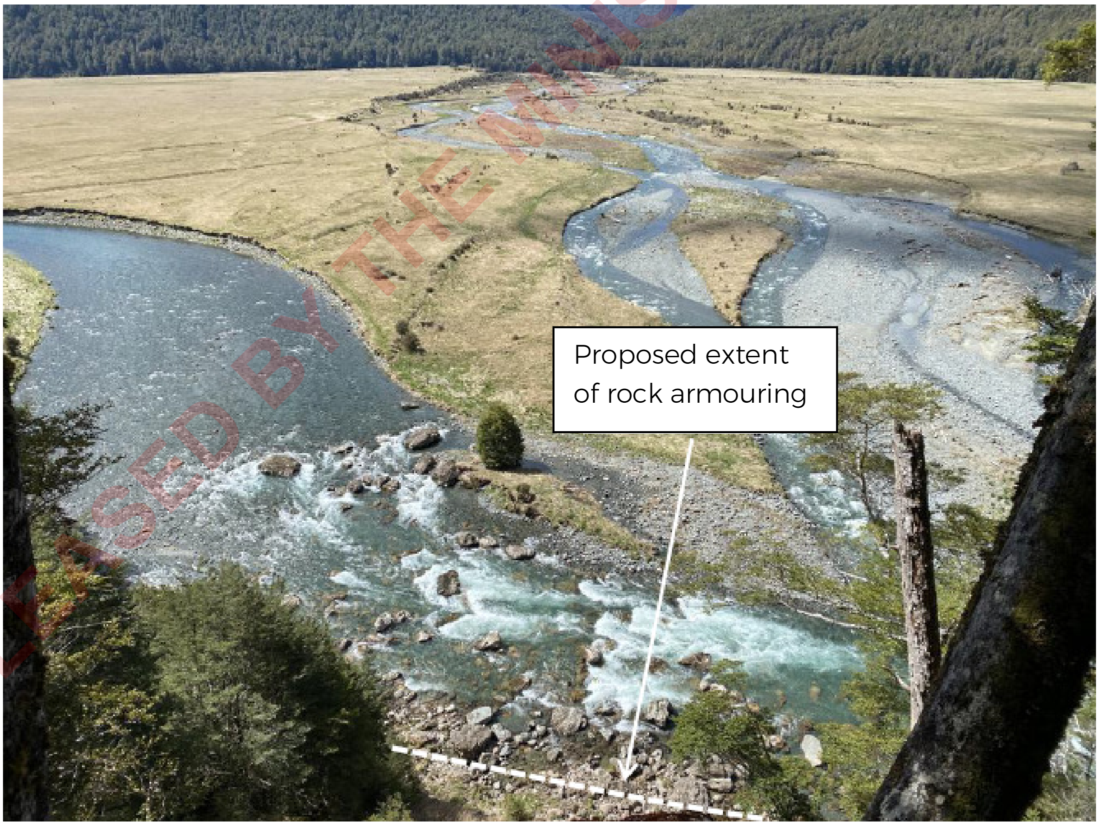

Figure 5 – View from top of East Upokororo Eglinton Confluence Slip (Source: Southern Land Report)

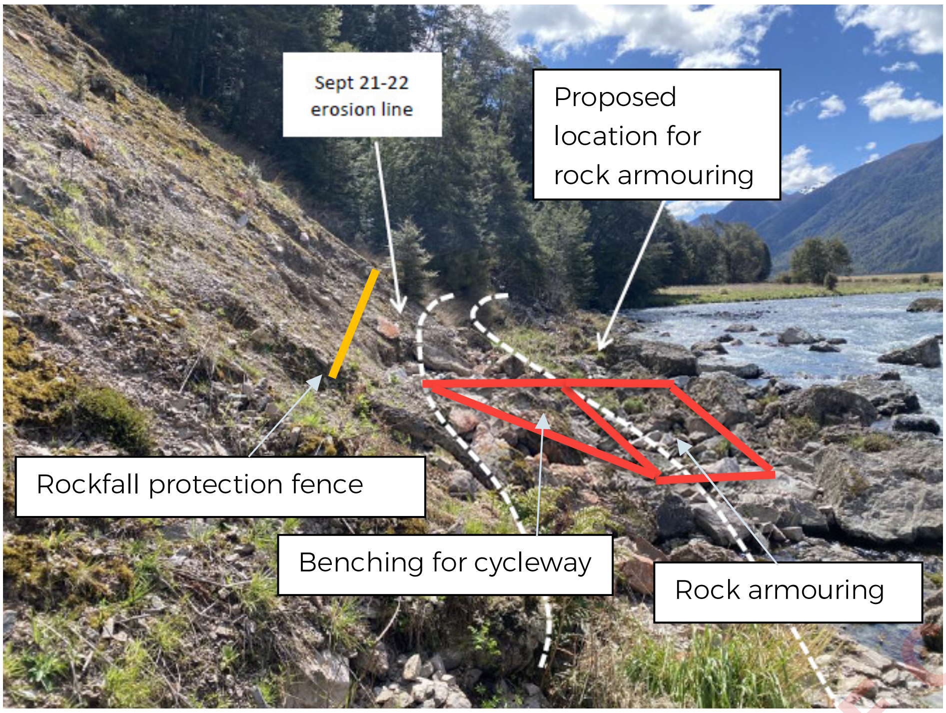

Figure 6 – Schematic section/possible route at East Upokororo Eglinton River confluence (Photo Source: Southern Land Report with additional annotation by WSP)

2.2.1 CONSIDERATIONS

Rock armouring and revetment has been placed at numerous locations along State Highway 94-Milford Road to protect the road from scour with successful outcomes. See Figure 7.

Figure 7 – Red Slip rock armouring (Source: WSP)

CONSTRUCTION ACCESS

Access to the site for the heavy machinery required to construct the rock armouring can be gained from the nearby State Highway 94-Milford Road via a temporary accessway. See Figure 3. The construction route could be successfully reinstated to its original state upon completion; however, consideration should be given to retain the accessway to allow easy access for the maintenance of the armouring.

ROCK ARMOURING MATERIAL

Suitable rock for the armouring can be sourced from within the National Park from the Whakatipu-ka-tuku Hollyford River Valley. The necessary approvals would need to be granted.

DRAINAGE AND STORMWATER MANAGEMENT

Works will be necessary to direct the flow of stormwater away from the face of the slip. The works could include culverts and riprap within a formed channel from above the slip to the river.

ROCKFALL PROTECTION

Providing protection to the cyclists from potential rockfall should be considered. The installation of a rockfall fence, like that shown in Figure 8, is considered necessary.

Figure 8 – An example of suitable rockfall fence protection (Source: MBIE website).

MAINTENANCE

Routine inspection and maintenance, including the upkeep of rock armouring, maintaining stormwater management systems above and beside the slip, and debris removal from behind any installed rockfall protection, will be essential. Following major flood events, more substantial maintenance tasks, such as repositioning rocks or adding extra rock materials, are anticipated to be necessary.

2.2.2 ALTERNATIVE ROUTE OPTION

An alternative option for the cycleway route is to bypass the slip area by utilising the nearby SH94 Milford Roading infrastructure. See Figure 9. This option requires further investigations to confirm it as a favourable option. It has some advantages and disadvantages over the currently proposed route.

ADVANTAGES

- Greater resilience to flooding/natural hazards.
- Lower maintenance costs by removing the need to maintain the riprap and rockfall protection at the slip face.
- Provides an additional location for access (hop on /hop off point) to the cycleway.

DISADVANTAGES

- Potential for diminished experience with potential road crossings and interaction with road traffic.
- One additional river crossing.
- Provides an additional vehicle stopping location with associated additional risks of increased vehicle interactions.

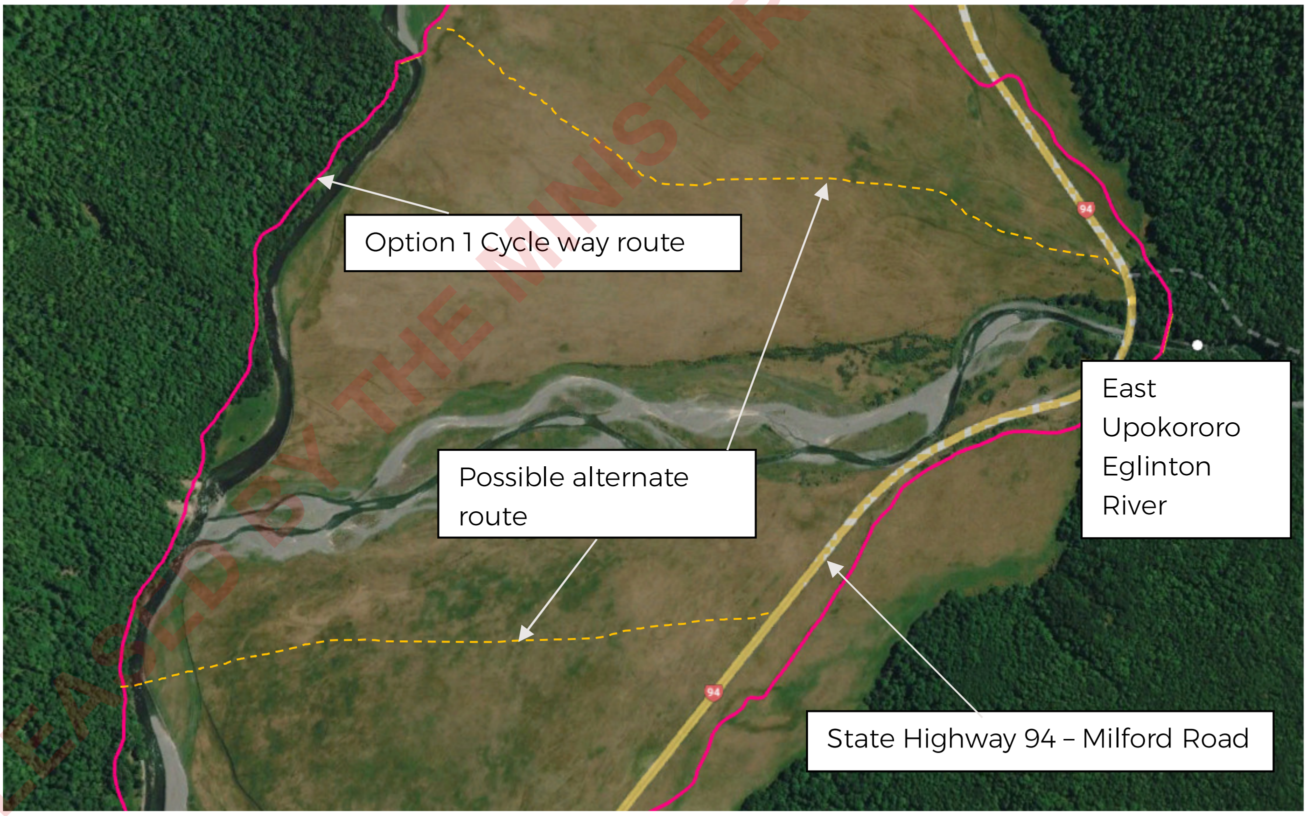

Figure 9 – Alternate route option to bypass East Upokororo Eglinton Confluence slip. (Source: Southern Land Report with additional annotation by WSP).

2.3 UPPER UPOKORORO EGLINTON RIVER SUSPENSION BRIDGE

Southern Land has identified a site on the Cycle Trail, Option 1 for a suspension bridge to cross the Upper Upokororo Eglinton River, as shown in Figure 10. The site is approximately 1km upstream from the confluence of the east branch.

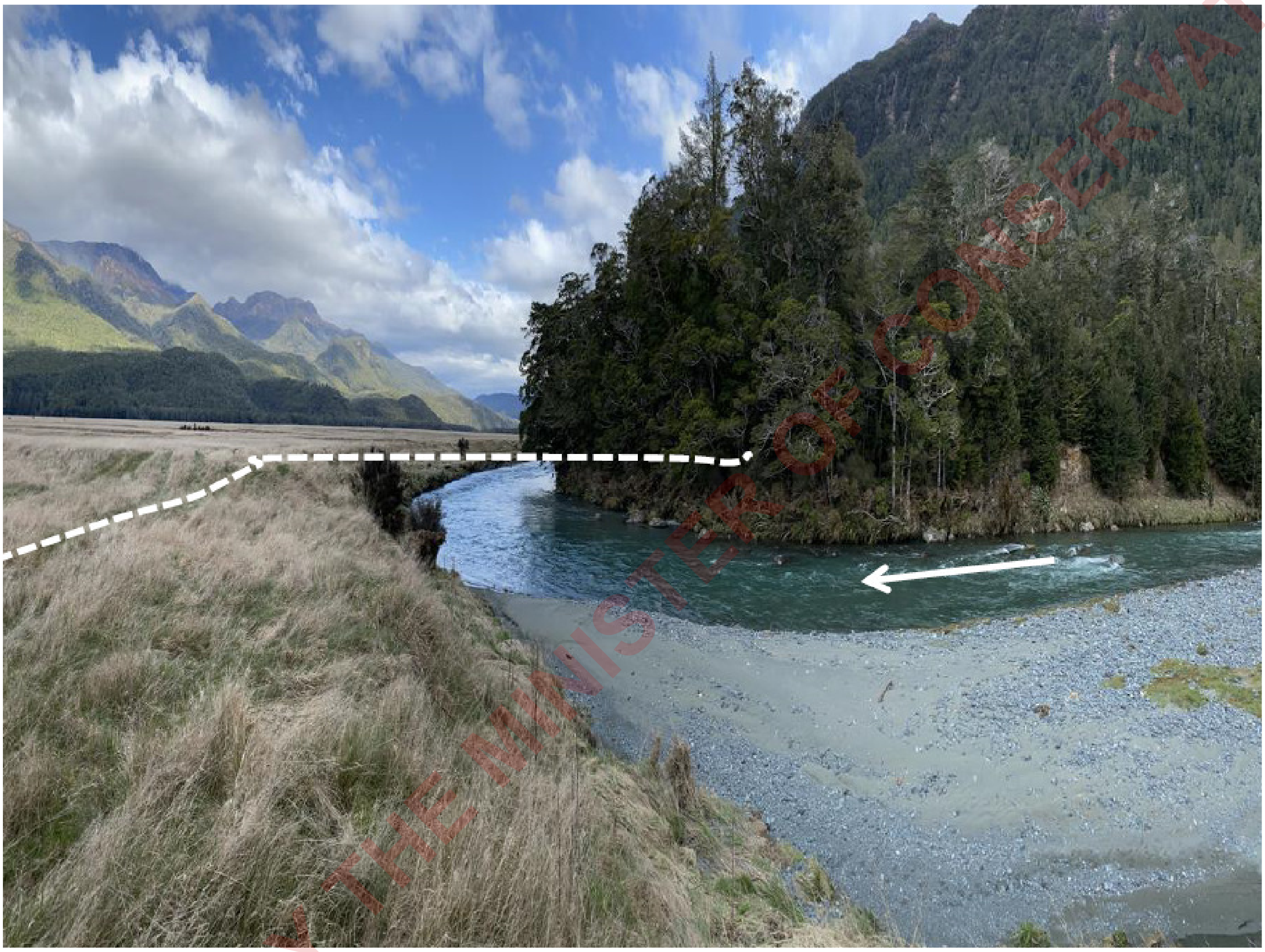

Figure 10 – Proposed site for the Upper Upokororo Eglinton Suspension Bridge (Source: Southern Land Report)

There are numerous examples of back country suspension bridges that have been constructed within New Zealand and Te Rua-o-Te-Moko Fiordland National Park for walking tracks and increasingly so for cycling tracks. It is considered that a walking and cycleway suspension bridge can be successfully constructed at the proposed Upper Upokororo Eglinton River site.

The span of the bridge identified by Southern land is 45m and a suspension bridge is well suited to this span and the site.

2.3.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The foundation of the suspension bridge can be piles, ground bearing pads (or combination) or rock anchored concrete bearing pads depending on the site conditions. The suspension cables can be anchored with ground bearing concrete deadmen, rock anchors or rock anchored concrete pads. The site conditions will determine the most suitable foundations.

The proposed site for the Upper Upokororo Eglinton River Suspension Bridge has different ground conditions at each abutment. The Upokororo Eglinton River at this location runs a course along the western side of the valley. The course of the river is forced alongside the underlying rock of the Earl Mountains by the alluvial fan created by the East branch of Upokororo Eglinton River. The course of the river is stable.

The true left bank consists of alluvium with grassland vegetation and is stable but does have some risk of scour during flood events. The true left abutment/suspension tower should be located well back from the river embankment edge to account for this and may result in a longer span than recommended by Southern Land (+10%?). The true left foundation for the suspension bridge will accommodate ground bearing foundation pads with short piles and a buried ground bearing reinforced concrete deadman anchors.

The true right riverbank is rock and rock boulders covered with typical bush vegetation of the area and has numerous large trees. The design of the true right foundation will need to carefully consider the appropriate location for rock anchored foundations to ensure that the suspension cables are successfully anchored. The stability of the rock/boulders will need to be determined and some pinning of the rock mass together may be required. The requirement to adjust the site locally to account for this will need to be considered during the detailed design.

WIND LOADING

The area's high wind loads, coupled with localised wind funnelling along the river course, highlight the importance of incorporating wind load considerations into the suspension bridge's design. However, it is believed that these factors can be effectively addressed and integrated into the design process.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The 45m bridge span will require a backstay that extends approximately 15m from the abutment on the gently sloping true left approach. Any vegetation disturbance will be easily reinstated in this grassland area.

The length of the backstay on the true right abutment will be determined by the ground profile at this location and is likely to be shorter than the true left due to the rising footslope.

Wind stays will also be required both upstream and downstream to mitigate the effects of wind which will require vegetation clearance.

It is expected that the cycleway may require hardfill ramps to allow easy access to a raised bridge deck. The size of the ramps will need to be large enough to provide an easy grade for the cyclists and will require a larger clearance area of native vegetation and trees when compared to other sites with no ramps.

The removal and disturbance of trees and vegetation on the true right approach should be carefully considered as it could results in destabilisation of the surrounding trees, which can affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered.

RIVER HIGH FLOW EVENTS/FREEBOARD

The clearance from the deck level, and cable wind stays, to the high river flow events requires confirmation from further investigation and hydrological studies. The chosen site is likely to require hardfill ramps to allow easy access to a raised bridge deck. Ramp access to the bridge will allow the deck and wind stays to be sufficiently clear of the river during high flow events.

CONSTRUCTION ACCESS

Access to the true left abutment can be achieved from the Milford Road – SH94 using a similar route as the access to the East Upokororo Eglinton Confluence slip. See Figure 11

The true right abutment currently has no access. The design of the suspension bridge will need to allow for this limited access in the design of the componentry. Numerous suspension bridges have been successfully constructed in remote back country locations with the use of helicopters.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

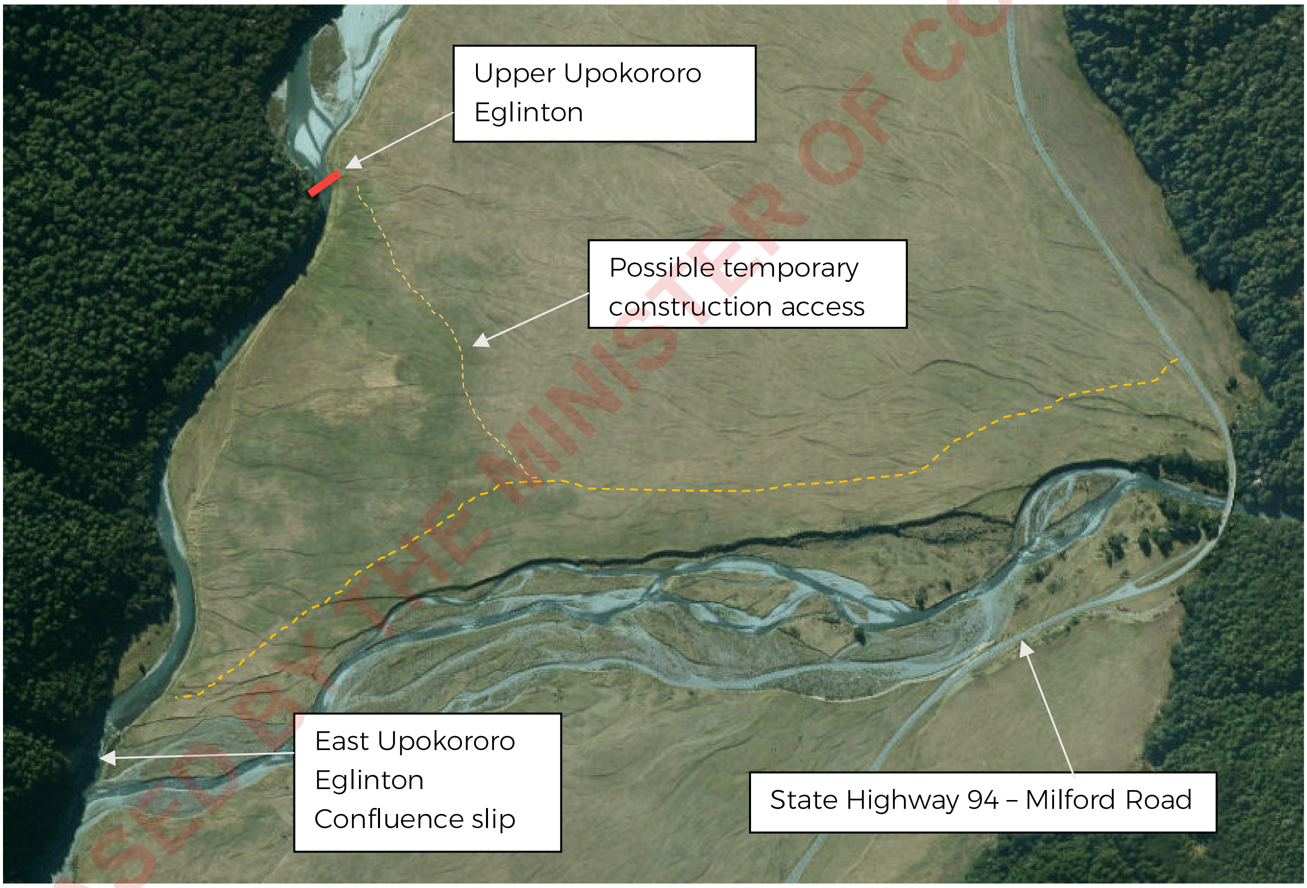

Figure 11 – Upper Upokororo Eglinton River Suspension Bridge – location and construction access (Source: SDC Maps/ESRI)

2.4 COUNTESS RANGE HUT

The Southern Land Report includes options for the construction of an alpine hut on the Countess Range offering an overnight tramping experience. The elevation of the proposed site is at approximately 1200m and is above the bush line. Figure 12 shows three possible hut sites that all have similar challenges. At the detailed design stage only one site will be chosen.

The remote site is challenging; however, there are numerous examples, as shown in Figure 13 and Figure 14, of Alpine/back country huts constructed successfully in areas with similar challenges.

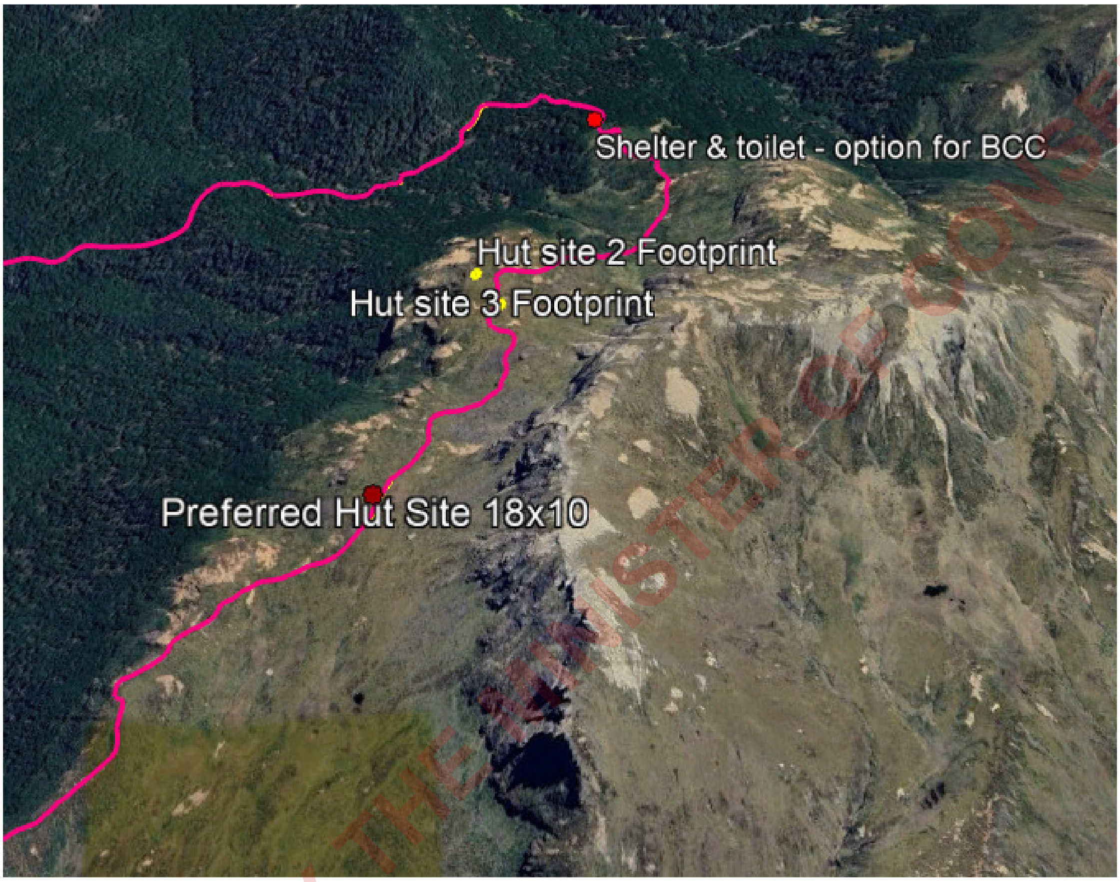

Figure 12 – Countess Range proposed hut locations (Source: Southern Land Report)

Figure 13 – Moonlight Tops Hut – 1,000m - Paparoa National Park (Source: Hutbagger website)

Figure 14 – Mueller Hut – 1800m – Aoraki Mt Cook National Park (Source: DOC website)

2.4.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The ground conditions at the site are unknown but could be rock, boulders, gravels or soft organic materials or a combination. Geotechnical investigations will be required when the preferred site is confirmed. The chosen site must consider appropriate foundations to provide adequate bearing capacity but also take consideration of lateral loads and uplift forces from extreme wind loads. The building must be adequately held down. From the site information we have the likely foundation type is embedded piles. The design of the hut should be carried out so that there is an ability to adjust the pile locations and/or site locally to account for any large boulders encountered.

DESIGN LOADS

Gravity loading from snow and lateral loading from wind are likely to govern the structural design of the hut. The huts must be designed to withstand extreme weather conditions.

The site must also ensure that there is no rockfall or avalanche hazard risk. These risks are considered in a separate natural hazards assessment.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The proposed sites are in areas of low-lying alpine scrub that will not provide any challenges to clear or reinstate around the construction area.

CONSTRUCTION ACCESS

There is no access to the site, but numerous huts have been constructed in similarly remote areas with the use of helicopters.

MAINTENANCE

The construction materials for the huts require careful selection and detailing to ensure they are durable and suited to the site. DOC should be consulted to ensure that any “lessons learned” from the detailing of their Alpine huts are incorporated into the design.

2.5 KIOSK CREEK BRIDGES

Southern Land has completed the initial scoping of a short walk at Te Huakaue Knobs Flat that will require two bridges that will span approximately 16m over Kiosk Creek, as shown in Figure 15. Landspan bridges are suggested for the sites.

Pedestrian bridges with a single span of approximately 16 metres are widely used, offering numerous design alternatives. Among these, aluminium truss bridges are increasingly popular for such applications, favoured for their durable materials and lightweight construction. The advantage of a lightweight bridge is that it can be prefabricated offsite and then airlifted to its destination by helicopter, where it can be easily installed on straightforward timber pile and timber capping beam abutments. If heavy decking planks are chosen, they can be installed when the main span is in place. See Figure 16 and Figure 17 for examples.

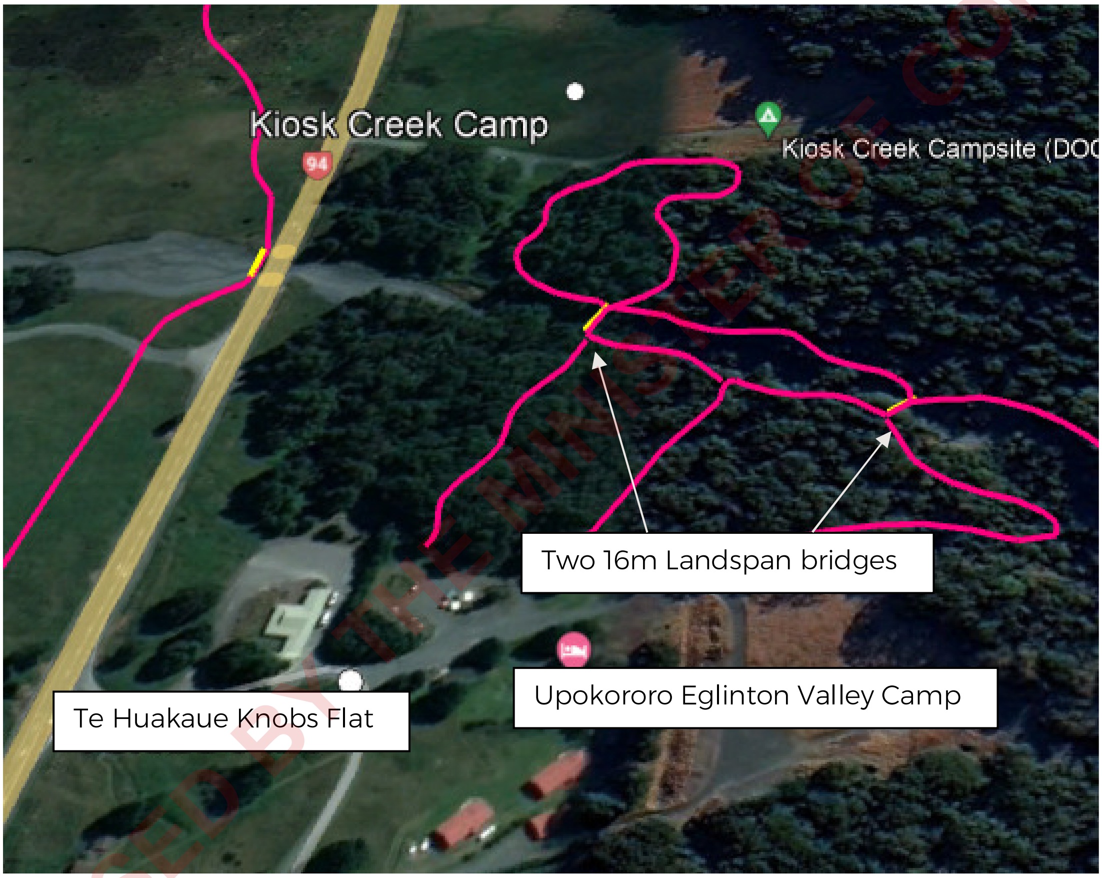

Figure 15 - Kiosk Creek Bridge location (Source: Southern Land Report with additional annotation by WSP)

Figure 16 – Aluminium pedestrian bridge. (Source: Monkeytoe website).

Figure 17 – Aluminium pedestrian bridge with timber railing to improve the aesthetic. (Source: Monkeytoe website).

2.5.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The Kiosk Creek Bridge sites are located on alluvium soil and can be supported on piled foundations. The stream bed is mobile with the course of the stream meandering through a channel bordered by large vegetation. The vegetation is assisting with holding the course to a fixed corridor but there are localised areas of scour. Aggradation of the stream bed is occurring. See Figure 18.

Consideration should be given to localised scouring when selecting the bridge alignment and choosing the length of span. A larger bridge span is likely to provide a longer design life. Scour protection in the form of rock rip rap may be necessary to protect the abutments and ramps.

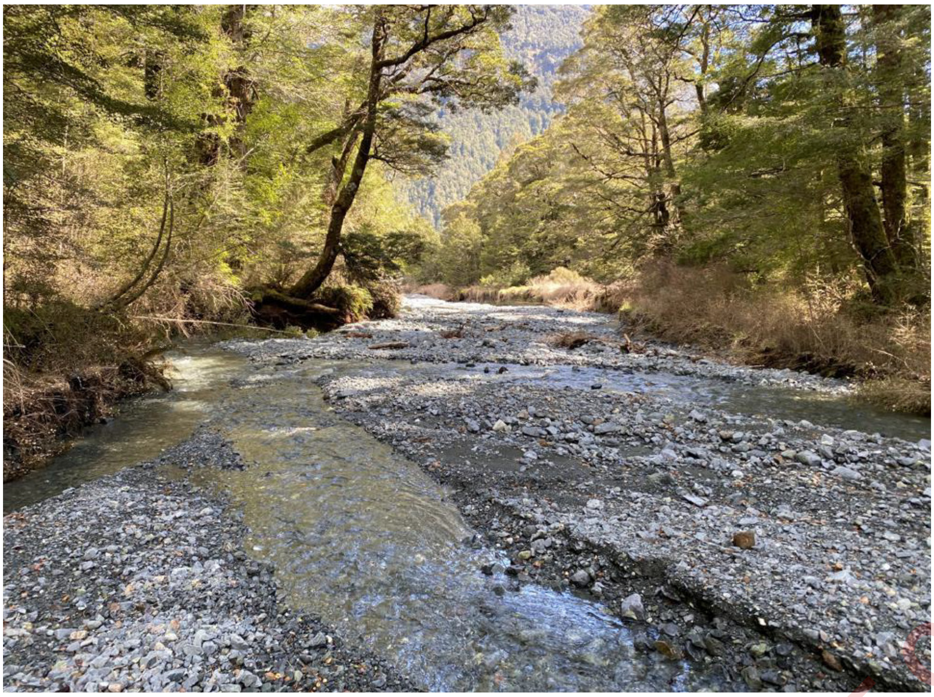

Figure 18 – Kiosk Creek – aggrading stream bed (Source: Southern Land Report)

FOOTPRINT AND DISTURBANCE OF VEGETATION

The footprint required for these bridges is small and only a small area of vegetation will be affected by the construction. Care should be taken to avoid affecting any large trees that assist in retaining the stream bank.

RIVER HIGH FLOW EVENTS/FREEBOARD

The clearance required from the deck level to the high river flow events requires confirmation from further investigation and hydrological studies. The chosen sites are likely to require hardfill ramps to allow easy access to a raised bridge deck. The abutment foundation should include wingwalls/headwalls for retaining the ramped access to the bridge.

The design of the abutments should also accommodate future raising of the bridge superstructure should the aggradation of the stream bed start to affect the bridges' soffit freeboard. Allowance for lifting and packing of the bridge superstructures at the bearings should be considered during detailed design.

CONSTRUCTION ACCESS

A lightweight bridge superstructure can be lifted onto simple timber piles and timber capping beam abutments with the aid of a helicopter. It may also be possible to gain access to the site with machinery via the stream bed from the nearby Milford Road however the appropriate approvals will be necessary.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required. Scour protection at the abutments may need to be reinstated after significant flood events.

2.6 MISTAKE CREEK SUSPENSION BRIDGE

Southern Land has identified a site on the Cycle Trail for a suspension bridge to replace the existing walk wire over the Upper Upokororo Eglinton River at Mistake Creek, as shown in Figure 19 and Figure 20.

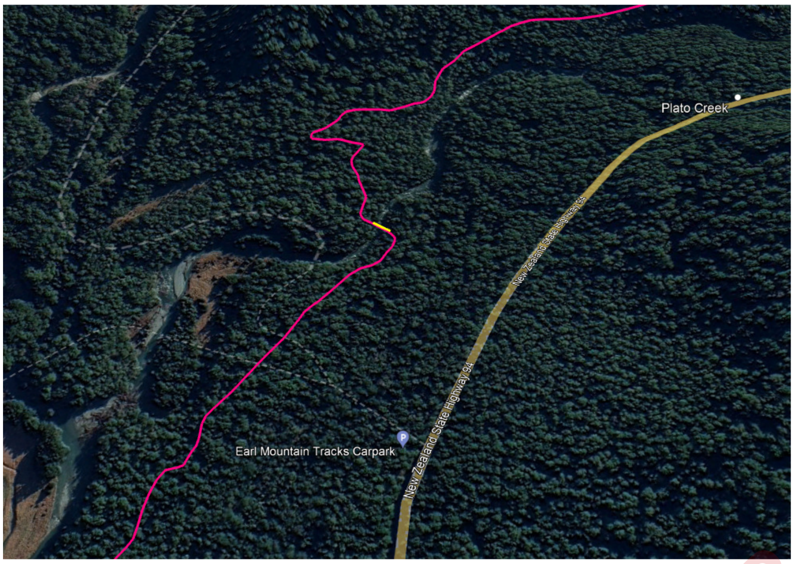

Figure 19 – Mistake Creek Suspension Bridge location – Source (Southern Land Google Earth record)

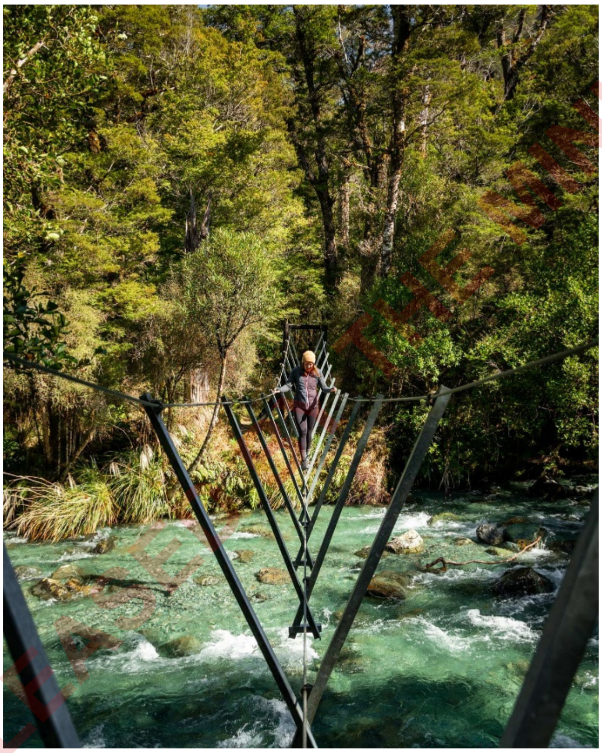

Figure 20 – Existing walk wire at Mistake Creek (Source: Tracks less travelled website)

There are numerous examples of back country suspension bridges that have been constructed within New Zealand and Te Rua-o-Te-Moko Fiordland National Park for walking tracks and increasingly so for cycling tracks. It is considered that a walking and cycleway suspension bridge can be successfully constructed at the proposed Mistake Creek walk wire site. The span of the bridge identified by Southern land is 24m.

2.6.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The foundation of the suspension bridge can be piles, ground bearing pads (or combination) or rock anchored concrete bearing pads depending on the site conditions. The suspension cables can be anchored with ground bearing concrete deadmen, rock anchors or rock anchored concrete pads. The site conditions will determine the most suitable foundations.

The proposed site for the Mistake Creek Suspension Bridge is located within dense bush and with a mix of gravels and boulders.

A mix of ground bearing pads and rock anchored pads are expected for the foundations. Large boulders could be encountered during the construction of the bridge towers and deadman anchors. The stability of any rock/boulders encountered will need to be determined and some pinning of the rock mass together may be required. The requirement to adjust the site locally to account for a complicated mix of boulders and gravels will need to be considered during the detailed design.

The river course is stable at the proposed location; however, the embankments should allow for degradation of the riverbanks over time. The span should be generous to allow for degradation of the riverbanks over the design life of the bridge.

WIND LOADING

The wind loading will be reduced in this sheltered location within the bush, but the suspension bridge should still be designed to withstand the same wind loading as the other bridges. The vegetation cover could change over time and there will still be funnelling effects along the course of the river.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The 24m bridge span will require a backstay approximately 8m back from the abutments. Wind wires will also be required both upstream and downstream. The cycleway may require hardfill ramps to provide the appropriate grade of access to the bridge. The native vegetation and trees in the area will require removal to allow for the construction of the bridge.

The removal and disturbance of trees and vegetation on the approaches should be carefully considered as it could result in destabilisation of the surrounding trees, which can affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered.

RIVER HIGH FLOW EVENTS/FREEBOARD

The clearance from the deck level, and cable wind stays, to the high river flow events requires confirmation from further investigation and hydrological studies. The chosen site is however likely to require hardfill ramps so the bridge deck and wind stays can be constructed sufficiently clear of the river during high flow events.

CONSTRUCTION ACCESS

Milford Road – SH94 is approximately 200m from the proposed bridge site; however, the site is located within dense bush. The materials and construction methodology adopted for the suspension bridge will need to consider the limited access. Numerous suspension bridges have been successfully constructed in similar remote back country locations with the use of helicopters.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

2.7 UPOKORORO EGLINTON RIVER SUSPENSION BRIDGE AT ŌTĀPARA LAKE GUNN

Southern Land has identified a site on the Cycle Trail for a suspension bridge near the location of a previous bridge over the Upper Upokororo Eglinton River at Ōtāpara Lake Gunn, as shown in Figure 21 and Figure 22.

There are numerous examples of back country suspension bridges that have been constructed within New Zealand and Te Rua-o-Te-Moko Fiordland National Park for walking tracks and increasingly so for cycling tracks. It is considered that a walking and cycleway suspension bridge can be successfully constructed over the Upokororo Eglinton River at the proposed Ōtāpara Lake Gunn site. The span of the bridge identified by Southern land is 20m.

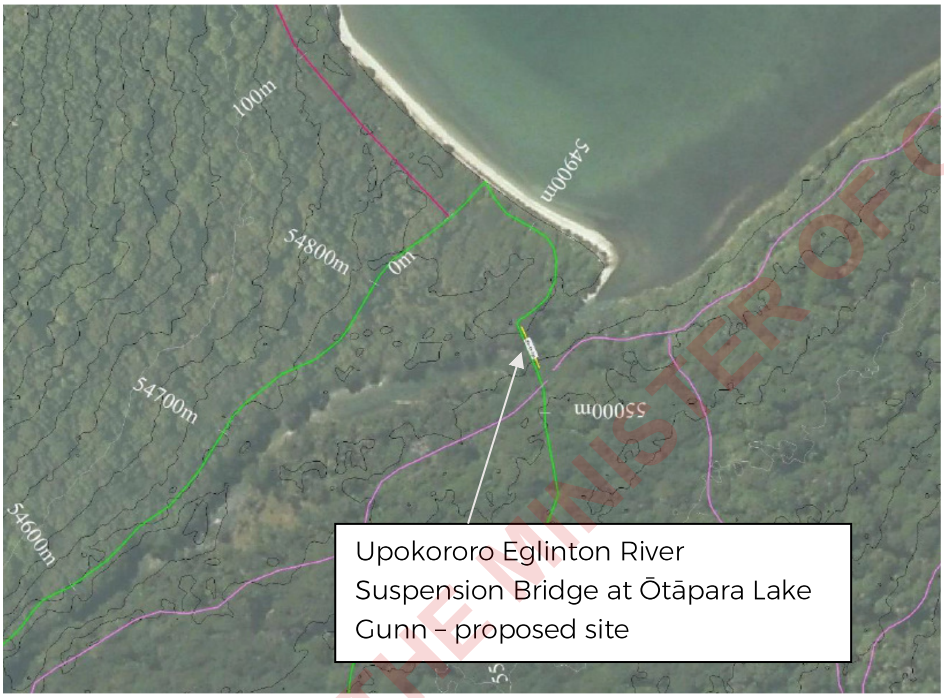

Figure 21 – Upokororo Eglinton River Suspension Bridge at Ōtāpara Lake Gunn – proposed site (Source: Southern Land)

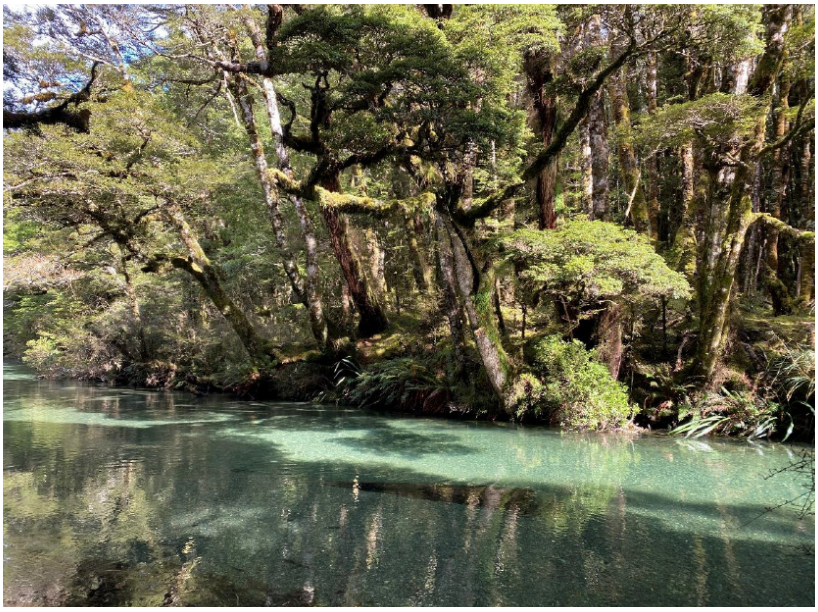

Figure 22 – Upokororo Eglinton River flowing out of Ōtāpara Lake Gunn (Source: Southern Land)

2.7.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The foundation of the suspension bridge can be piles, ground bearing pads (or combination) or rock anchored concrete bearing pads depending on the site conditions. The suspension cables can be anchored with ground bearing concrete deadmen, rock anchors or rock anchored concrete pads. The site conditions will determine the most suitable foundations.

The proposed site for the Upokororo Eglinton River Suspension Bridge at Ōtāpara Lake Gunn is located within dense bush and is likely founded on historic landslide deposits potentially overlain with a mix of gravels and boulders. Large boulders could be encountered during the construction of the bridge towers and deadman anchors. The requirement to adjust the site locally to account for this should be considered in any detailed design. Over excavation and reinstatement of the excavated material may be necessary if large boulders are encountered. The foundation type will be confirmed during the detailed design but the tower foundations are likely to be a ground bearing concrete pads with short piles to resist lateral loading. The deadman anchors will be ground bearing.

The river course is stable at the proposed location; however, the embankments should allow for degradation of the riverbanks over time. The span should be generous to allow for degradation of the riverbanks over the design life of the bridge.

WIND LOADING

The wind loading will be reduced in this sheltered location within the bush but the suspension bridge should still be designed to withstand the same wind loading as the other bridges. The vegetation cover could change over time and there will still be funnelling effects along the course of the river.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The 20m bridge span will require a backstay approximately 6-8m back from the abutments. Wind wires will also be required both upstream and downstream. The cycleway may require hardfill ramps to provide the appropriate grade of access to the bridge. The native vegetation and trees in the area will require removal to allow for construction of the bridge.

The removal and disturbance of trees and vegetation on the true right approach should be carefully considered as it could result in destabilisation of surrounding trees, which affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered.

RIVER HIGH FLOW EVENTS /FREEBOARD

The clearance from the deck level, and cable wind stays, to the high river flow events requires confirmation from further investigation and hydrological studies. The chosen site is in close proximity to Ōtāpara Lake Gunn, and the river level is closely linked to the lake level and is not fast flowing.

However, the site is still likely to require hardfill ramps so the bridge deck and wind stays can be constructed sufficiently clear of the river during high flow events.

CONSTRUCTION ACCESS

The Milford Road – SH94 is approximately 500m from the proposed bridge site; however, the site is located within dense bush. The materials and construction methodology adopted for the suspension bridge will need to consider the limited access. Numerous suspension bridges have been successfully constructed in similar remote back country locations with the use of helicopters.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

2.8 MELITA BLUFF GANTRY

Southern Land has identified a route for the Cycle Trail to traverse the western shore of Ōtāpara Lake Gunn to allow the proposed cycle and walking trail to terminate at the Divide instead of Ōtāpara Cascade Creek.
The route features near-vertical cliffs, necessitating the construction of a continuous propped cantilever structure, or gantry, anchored to the rock faces to support the path. Southern Land estimates that the gantry will be 1400m in length. Refer to Figure 23.

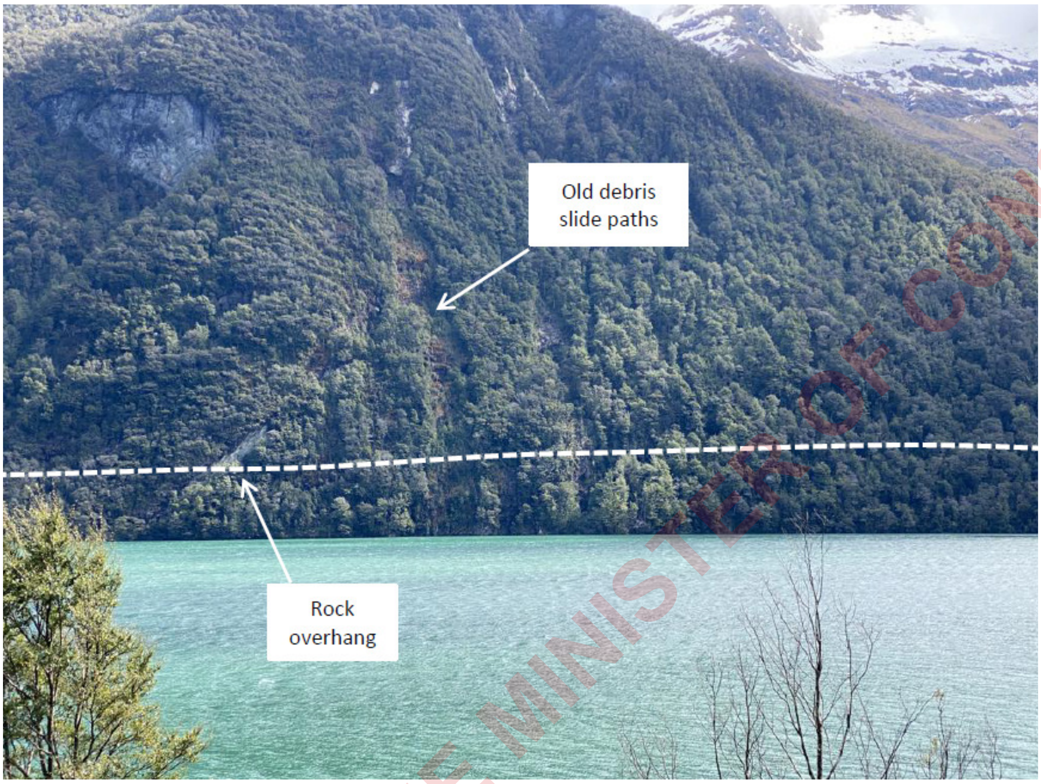

Figure 23 – Bluffs on western shore of Ōtāpara Lake Gunn – Melita Creek at RHS (Source: Southern Land).

2.8.1 CONSIDERATIONS

OTHER INSTALLATIONS

Gantries have been installed at other sites including at Milford Sound Piopiotahi. The Milford Sound Piopiotahi gantry provided walkway access to the base of the Hine-te-awa Bowen Falls but has been removed due to rockfall risk to pedestrians and rockfall damage to the gantry.

More recently, the Dunstan Trail, which was constructed in 2021, has gantries that provide cycling access around bluffs alongside Lake Dunstan, as shown in Figure 24 and Figure 25.

The design and construction of these gantries is technically difficult but is achievable as is evidenced by the Dunstan Trail installation. The site at the Melita Bluffs site has additional challenges due to the presence of vegetation and a much greater rainfall. The Lake Dunstan Trail averages less than 400mm of rainfall per annum while the Melita Bluffs site averages more than 6,000mm per annum (source:NIWA). The presence of the vegetation and high rainfall provide greater risks to the proposed gantry structure. A brief discussion regarding the Natural Hazards to the site is included here however separate Natural Hazards Assessment covers this aspect in more detail.

It is also important to note that there are alternative points of view in the engineering community about whether the gantries on the Dunstan Trail are appropriate with respect to the risk of rockfall.

Figure 24 – Gantry on Dunstan Trail (source: Dunstan Trail website).

Figure 25 - Gantry on Dunstan Trail (source: Dunstan Trail website).

CONSTRUCTION ACCESS

Access for the construction of the gantry will be created as the gantry is constructed and so it will need to be designed for construction loads. Boats could be utilised during the construction; however, access to the gantry from a boat may impose challenges due to the gantry's height above the water. The use of helicopters will also be necessary however any overhanging areas of the bluff will complicate the construction markedly.

ROCKFALL AND DEBRIS SLIDES AND VEGETATION DISTURBANCE – NATURAL HAZARDS

Numerous debris slides have been documented along the western slope of Ōtāpara Lake Gunn, primarily triggered by extreme weather conditions or when the mass of vegetation grows to a point where the underlying rock and supportive vegetation network can no longer bear the increasing weight. Given these conditions, debris slides are expected to persist in this area, posing a significant risk to any structures in their path.

Constructing the gantries will require significant disturbance of the vegetation and tree removal to allow a consistent grade for the pathway. It is thought that this disturbance will likely create a weakness in the thin vegetation/rock interaction layer which will likely create new debris slides.

The gantry and its users are vulnerable to damage and injury from rockfalls and debris slides, with the risk amplified by the gantry's considerable length of approximately 1400 metres. To enhance safety, the design of such an extensive gantry should incorporate refuge points at regular intervals. These points will require rockfall protection measures, including covered areas (rockfall protection galleries) and reinforced pathway support. However, it is improbable that the gantry can be engineered to withstand a significant debris slide.

2.9 HINEPIPIWAI MARIAN CREEK SUSPENSION BRIDGES

Southern Land has completed the initial scoping for a new route for a second leg to the Hinepipiwai Lake Marian walkway to create a loop track. The track does not accommodate cycling and therefore the choice of route can be more flexible. The proposed loop track includes two suspension bridges that span 35m and 55m. The exact location of the proposed bridges is unknown but is generally as shown in Figure 26.

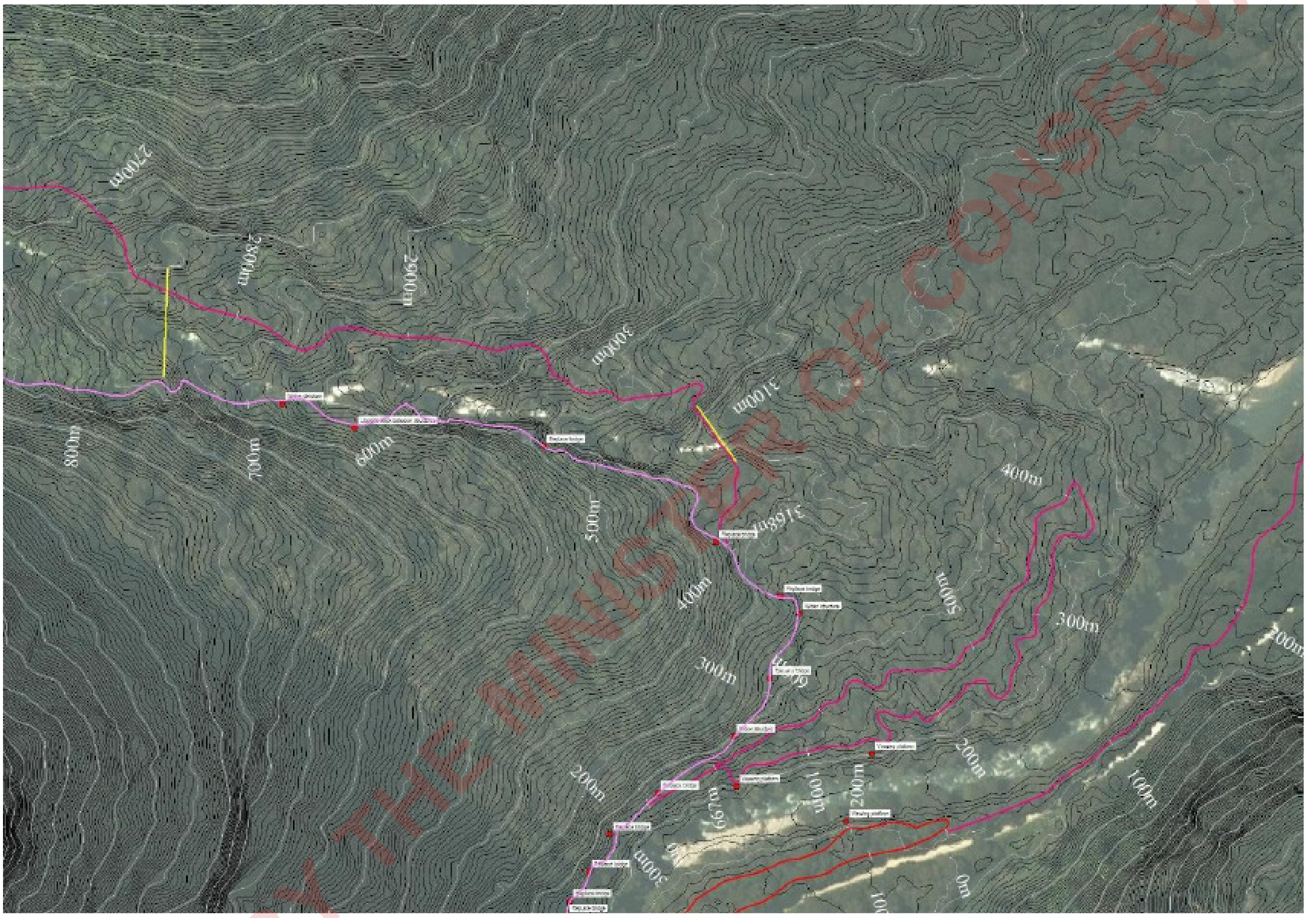

Figure 26 – Upper and lower Hinepipiwai Marian Creek Suspension Bridge sites (Source- Southern Land)

2.9.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The locations for the two Hinepipiwai Marian Creek suspension bridges are not confirmed but is characterised by terrain covered with large boulders resulting from historic rockfalls overlain by mature beech forest. The exact sites for these bridges have yet to be determined, necessitating further investigations to assess foundation suitability.

Constructing suspension bridges in such environments poses challenges, particularly as anchoring directly into bedrock may be impractical due to the depth of the boulder layer.

Instead, the bridge foundations, including towers and backstays, will require anchoring into the large boulders using rock anchors. It is important that any boulders that are used for anchoring have a solid foundation and are not prone to movement. If the bridge is anchored into one or multiple boulders, the boulders will need to have sufficient mass to resist tension loads from the rock anchored suspension cables without any movement. It may be necessary to tie several large boulders together with rock anchors.

It is essential that the selected sites feature boulders with a stable foundation, immune to movement. Should the bridge foundations rely on one or several boulders, these must possess enough mass to counteract the tension forces exerted by the suspension cables without shifting.

The risks associated with using boulders for anchorage include the challenge of accurately determining the size and mass of each boulder. Additionally, drilling anchors into the rocks or boulders may compromise their integrity, leading to cracks or splits.

WIND LOADING

The area's high wind loads, coupled with localised wind funnelling along the river course, highlight the importance of incorporating wind load considerations into the suspension bridge's design. If appropriate anchorage of the wind stays can be confirmed it is believed that these factors can be effectively addressed and integrated into the design process.

FOOTPRINT AND DISTURBANCE OF VEGETATION

It is difficult to determine the extent of backstay lengths without survey confirmation of the proposed bridge site. Wind wires will be required both upstream and downstream. The native vegetation and trees in the area will require removal to allow the construction of the bridge.

The removal and disturbance of trees and vegetation should be carefully considered as it could result in destabilisation of the surrounding trees, which can affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered but will be less than at the cycleway sites as there is no requirement for any ramp construction.

RIVER HIGH FLOW EVENTS/FREEBOARD

The exact sites for these bridges have yet to be determined, necessitating further investigations to ensure adequate clearance between the bridge's soffit and the river level during high-flow events is obtained.

CONSTRUCTION ACCESS

There is no direct access to the proposed bridge sites. The materials and construction methodology of the suspension bridges will need to consider the limited access. Numerous suspension bridges have been successfully constructed in similar remote back country locations with the use of helicopters.

MAINTENANCE

Durable materials can be specified for the construction of the bridges; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

2.10 WHAKATIPU-KA-TUKU HOLLYFORD RIVER BRIDGE AT HOMER HUT

Southern Land has completed the initial scoping of a short walk at the Homer Hut in the Gertrude Valley. A bridge that is approximately 16-18m in length is proposed to cross an area of alluvium that is subject to overland flow during rainfall. The bridge will have several short spans (4-6m) and multiple piers. The walking route to access the walkway path beyond the alluvium is currently unclear to users and a bridge(s) and adjacent boardwalk will provide a clear and designated route across the shingle. See Figure 27 and Figure 28.

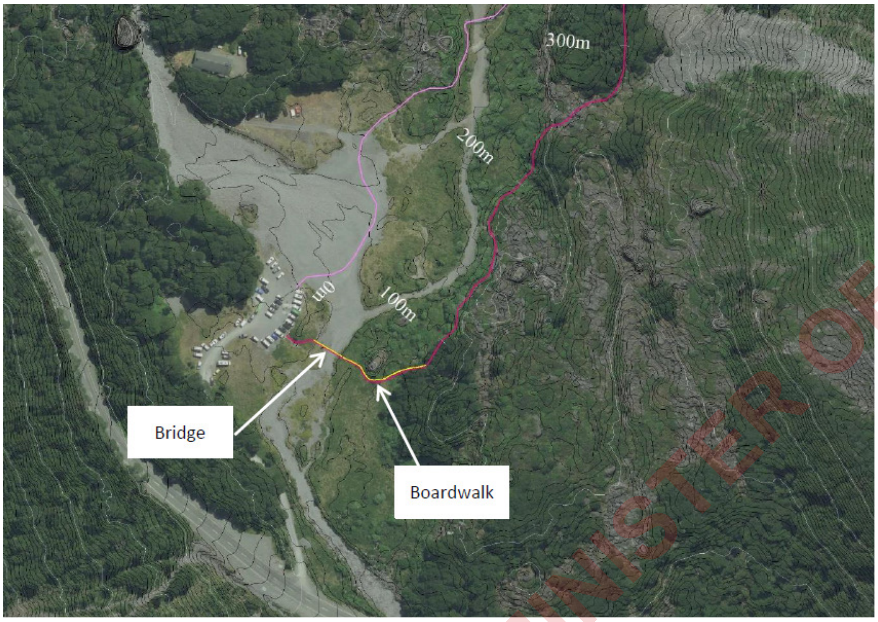

Figure 27 – Whakatipu-ka-tuku Hollyford River Bridge at Homer Hut (Source: Southern Land)

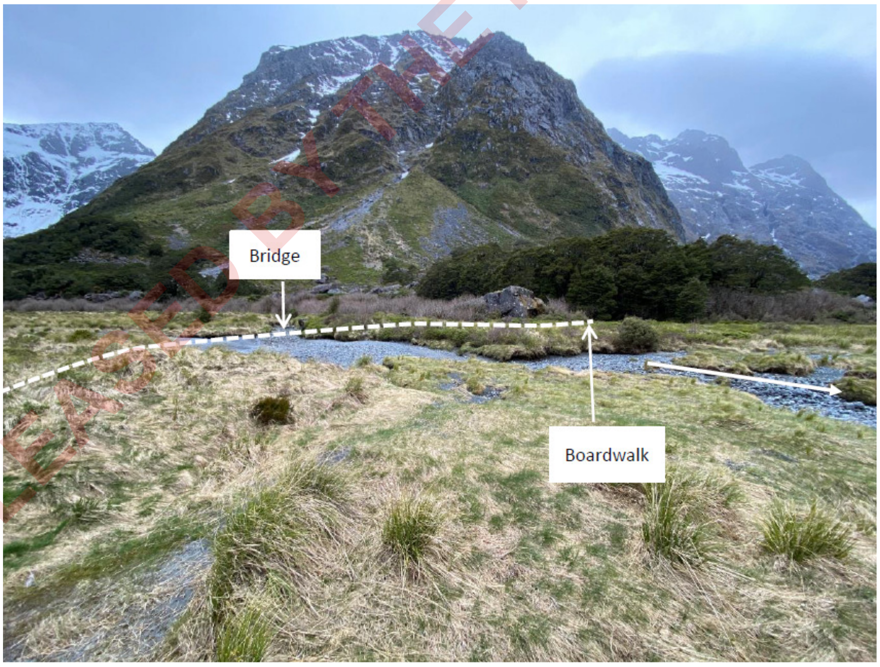

Figure 28 – Whakatipu-ka-tuku Hollyford River Bridge at Homer Hut (Source: Southern Land)

2.10.1 SITE CONSIDERATIONS

GROUND CONDITIONS FOUNDATIONS

The proposed Whakatipu-ka-tuku Hollyford River Bridge at Homer Hut is founded on alluvium and can be supported on piled foundations. The stream is only flowing during rainfall events, causing the bed to be mobile. Additionally, there is ongoing aggradation of the stream bed.

The design of the abutments should also accommodate future raising of the bridge superstructure should the aggradation of the stream bed start to affect the bridges' freeboard beneath the soffit. Allowance for lifting and packing of the bridge superstructures at the bearings should be considered during detailed design.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The footprint required for these bridges is small and only a small area of vegetation will be affected by the construction. Any affected vegetation can be easily restored.

RIVER HIGH FLOW EVENTS/FREEBOARD

During high flow events the steam at this location becomes overland flow spreading over wide area with no opportunity for debris or large logs to be included within the flow.

The design of the abutments should accommodate future raising of the bridge superstructure should the aggradation of the stream bed start to affect the bridges' soffit freeboard. Allowance for lifting and packing of the bridge superstructures at the bearings should be considered during detailed design.

CONSTRUCTION ACCESS

The site is easily accessible from the adjacent Homer Hut carpark.

SCOUR

The extent of any scour is likely to be minor but to ensure the long-term resilience of the structures rock riprap protection should be provided at the abutments.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required. The embankments may need to be reinstated at the abutments after a flood event.

2.11 SHEERDOWN PEAK GANTRY

The Southern Land Report proposes a new walking track from the Chasm to the Horse Bridge. The route traverses a historic debris slide which now has steeply faced rock with minimal vegetation cover necessitating the construction of a continuous propped cantilever structure or gantry anchored to the rock face supporting the path. The Sheerdown Peak gantry has similar construction difficulties issues as the Ōtāpara Lake Gunn Melita Bluffs gantry but at a significantly reduced length of 175m. See Figure 29 and Figure 30.

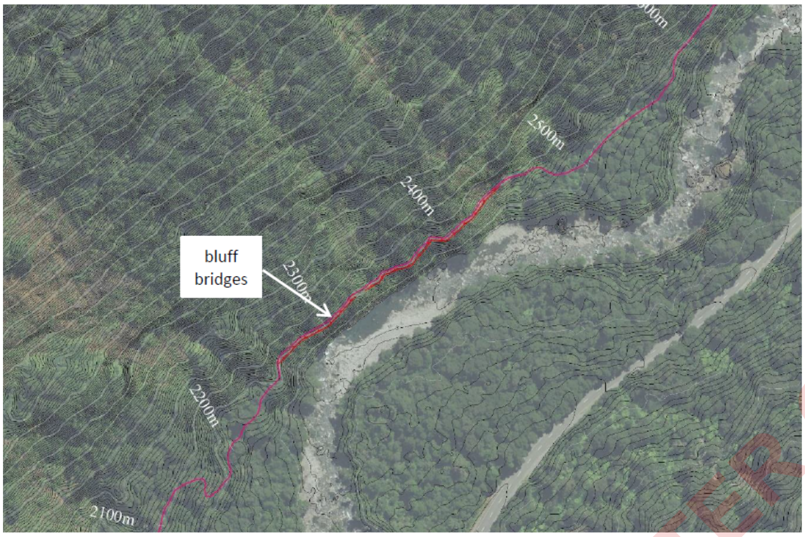

Figure 29 – Sheerdown Peak Gantry location (Source: Southern Land Report)

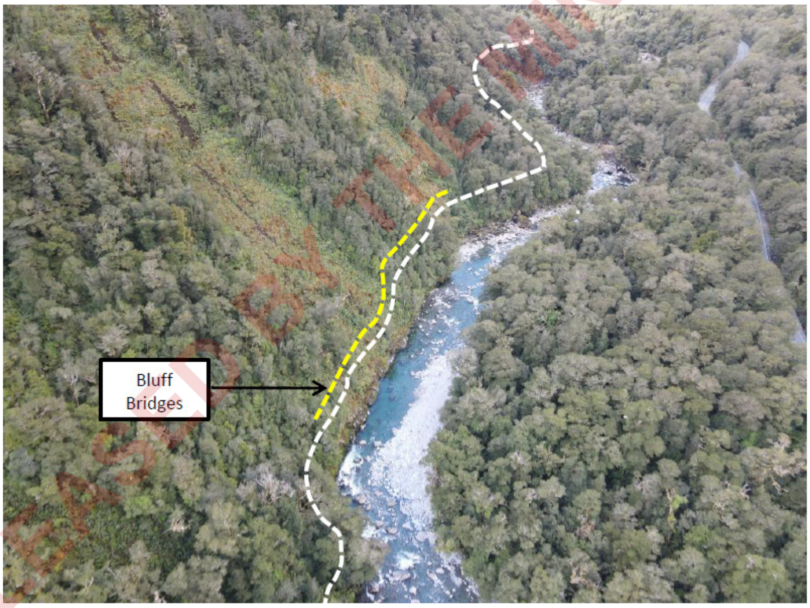

Figure 30 – Sheerdown Peak Gantry location (Source: Southern Land Report)

2.11.1 CONSIDERATIONS

OTHER INSTALLATIONS

As noted in Section 2.8 gantry installations have been installed at other sites, previously at Milford Sound Piopiotahi and more recently on the Lake Dunstan Cycle Trail. The design and construction of these gantries is technically difficult but is achievable. Notably the Milford Sound Piopiotahi gantry has been removed due to rock fall risk and damage.

A brief discussion regarding the Natural Hazards to the site is included here however a separate Natural Hazard Assessment covers this aspect in more detail.

CONSTRUCTION ACCESS

There is no direct access to the proposed site and the material and construction methodology will need to consider the limited access. The use of helicopters as part of the construction methodology will be necessary. The Milford Road is nearby.

As the gantry is constructed the completed section will be used for construction access and the storage of construction materials; therefore, the gantry will need to be designed for construction loads.

ROCKFALL AND DEBRIS SLIDES

The site is on a historic debris slide and is clear of large vegetation. Any new significant debris slides will form above the existing debris slides or at the fringes. Any debris slides from the current slip face are likely to be small and are likely to occur only as vegetation growth increases.

The gantry and its users are vulnerable to damage and injury from rockfalls and debris slides. To enhance safety, the design of such an extensive gantry should incorporate refuge points at regular intervals. These points will require rockfall protection measures, including covered areas (rockfall protection galleries) and reinforced pathway support. However, it is improbable that the gantry can be engineered to withstand a significant debris slide.

2.12 HORSE BRIDGE

A day walk from the Chasm to the Horse Bridge is proposed. Southern Land Report proposes a 35m suspension bridge at the current Horse Bridge Site.

The current Horse Bridge was constructed in 1932 and is currently closed due to damage and poor condition. To complete the proposed Chasm to Horse Bridge Day walk a bridge is required at the site.

The Department of Conservation (DOC) is carrying out further investigations to confirm a course of action, which could include a range of actions from the permanent closure and removal of the bridge to the upgrading and reopening of the bridge. Options include the removal and full replacement of the existing bridge, upgrading of the existing bridge retaining the existing fabric where possible, or retaining the existing bridge with upgrading works to preserve it, but not bring it back into service, along with a new suspension bridge.

Stantec has provided DOC a Condition Assessment for the bridge titled *"Cleddau Horse Bridge Condition Assessment - July 2022"*. The assessment confirms that the bridge is in a significant state of disrepair and that damage has occurred at the true right side due to the presence of a large standing wave coming into contact with the bridge during flood events. The standing wave was caused by the presence of a large boulder located in the riverbed, and it is our understanding that this boulder has subsequently been removed. Other condition issues are due to the significant deterioration of the bridge elements over time. See Figure 31 and Figure 32.

Figure 31 – Horse Bridge site (Source: Southern Land)

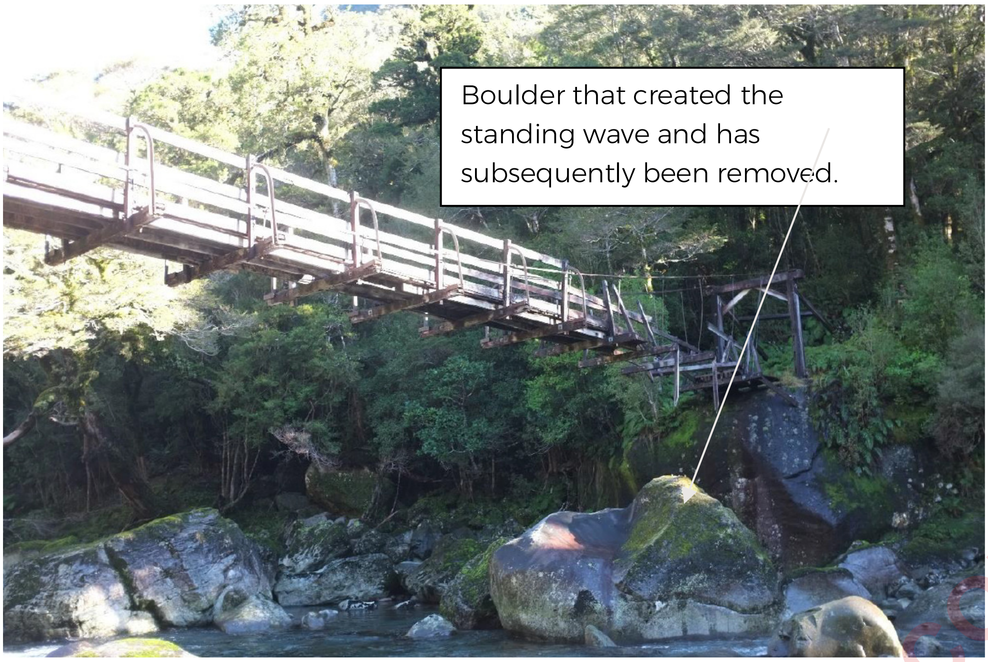

Figure 32 – Horse Bridge (Source: Stantec "*Cleddau Horse Bridge Condition Assessment - July 2022*")

2.12.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

The foundation of the suspension bridge can be piles, ground bearing pads (or combination) or rock anchored concrete bearing pads depending on the site conditions. The suspension cables can be anchored with ground bearing concrete deadmen, rock anchors or rock anchored concrete pads. The site conditions will determine the most suitable foundations.

The suspension cable of the current bridge has concrete pads/blocks which are expected to be anchored into rock. Similar detailing for the suspension cables and wind stays anchors is expected for any new or upgraded bridge, but to current standards.

WIND LOADING

The area's high wind loads, coupled with localised wind funnelling along the river valley, highlight the importance of incorporating wind load considerations into the suspension bridge's design. However, it is believed that these factors can be effectively addressed and integrated into the design process.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The 35m bridge span will require a backstay that extends approximately 12m, likely less as the ground contour rises up from the river. Wind stays are also required. The native vegetation and trees in the area will require removal to allow the installation of these items.

The removal and disturbance of trees and vegetation should be carefully considered as it could result in the destabilisation of the surrounding trees, which can affect the bridge. The required area of vegetation and tree clearance needs to be carefully considered during detailed design.

CONSTRUCTION ACCESS

There is no direct construction access to the site and the design of the suspension bridge will need to allow for this limited access in the design of the componentry. Numerous suspension bridges have been successfully constructed in remote back country locations with the use of helicopters for heavy lifting. The Milford Road is nearby which could be of assistance to shorten the flight time of heavy lifts.

MAINTENANCE

Durable materials can be specified for the construction of the bridge; however, regular inspections and maintenance will be required during the life of the bridge to clear vegetation and replace componentry as required.

The reuse of any material from the current bridge will require careful consideration to ensure it meets the necessary material strength specifications and is fit for purpose.

EXISTING HORSE BRIDGE – CONDITION AND HERITAGE

The existing Horse Bridge is in a poor state as confirmed by the Stantec Report Condition Assessment. It is considered that no items from the current bridge are suitable for use in a new, upgraded or strengthened bridge. A new bridge is necessary. A new bridge could be located at the current bridge site or nearby.

It is considered that leaving the current bridge in place, closed to use, comes with the risk of visitors using the bridge when it is unsafe to do so.

Heritage aspects of the current bridge will need to be considered when confirming the details of a new bridge and the new bridge site. The heritage value of the current Horse Bridge is not considered within this report.

2.13 BARREN PEAK SPUR STAIRS AND VIEWING PLATFORM

The Southern Land report provides details of the proposed short walk to a new Barren Peak Spur viewing platform. The walkway will be located within dense vegetation and will require steps and stairs. Southern Land has identified a section of the walkway that will require stairs at an exposed rock face. Refer to Figure 33.

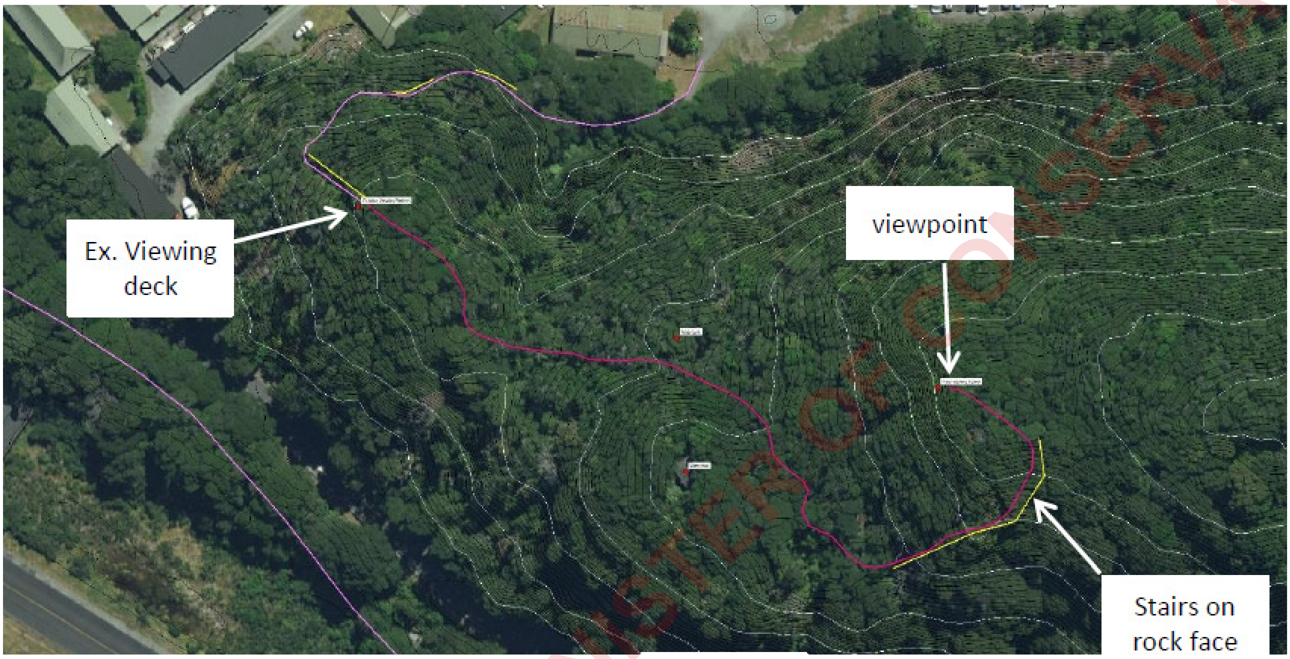

Figure 33 – Barren Peak Spur Stairs and Viewing Platform location (Source: Southern Land)

2.13.1 SPECIFIC CONSIDERATIONS

GROUND CONDITIONS/FOUNDATIONS

There are numerous examples of viewing platforms and stairs on back country walks, as shown in Figure 34 and Figure 35. The site has shallow topsoils and vegetation root mass over bedrock and the structure's foundations will require rock anchors. The preferred foundations are rock anchors embedded in reinforced concrete plinths to provide long term durability.

Figure 34 – Observation Rock, Stewart Island (Source: Otago Daily Times)

Figure 35 – Millenium Track, Bluff (Source: NZ Frenzy South Island website)

LIVE LOADING

The design of the viewing platform shall include protection from falling and a minimum live load of 5kPa as required by SNZ HB 8630:2004. Any reduction in the live loading by limiting numbers of people on the platform is not an acceptable design parameter as this is an area where people may congregate. The design of the platform shall also consider redundancy in the foundations and structure. Bolted shear connections shall be avoided so that there is always a vertical/bearing load path.

EVACUATION POINT

The Barren Peak Spur walkway has been identified as a possible evacuation point in the event of a tsunami. Further investigation will be required to confirm the requirements of an evacuation point which may include greater live loads, increased path widths, additional congregation areas/view points and possibly a shelter.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The construction of a walkway differs to that of the cycleway as it permits changes of alignment in the path both horizontally and vertically that will allow the path to avoid disturbing significant vegetation and therefore avoid creating weakness in the vegetation root layers.

The viewing point will require the clearance of a larger area of vegetation and care must be taken to avoid creating any weakness in the vegetation root mass layer that could promote a debris slide.

CONSTRUCTION ACCESS

Construction access is limited with materials likely required to be air lifted by means of a helicopter. Accessible laydown areas are nearby in the Milford Sound Piopiotahi township.

MAINTENANCE

Durable materials can be specified for the construction of the stair and viewing platform; however, regular inspections and maintenance will be required during the life of the structures to clear vegetation and replace componentry as required.

2.14 LOWER HINE-TE-AWA BOWEN FALLS - SHORT WALK

2.14.1 GANTRY OR FLOATING PONTOON ACCESS

Access to the Lower Hine-te-awa Bowen Falls walking track currently requires visitors to be transported by boat across a short distance from the Freshwater Basin vessel berthing area. The previous timber gantry walkway access across the face of the bluff has been removed due to rockfall damage to the gantry and the unacceptable risk to the users. See the route of the former gantry in Figure 36.

Southern Land Report options for a new access walkway include a replacement gantry or a floating pontoon. Both options have risks of damage to the structure or injury to users from rockfall.

The floating pontoon option has merit as it can be placed further away from the bluff face to avoid impacts from rockfall, but what this separation distance should be will require further investigation. A large separation distance, with no risk from rockfall, may not be acceptable due to the effect this may have on vessel movements at the nearby passenger vessel berths. The risk of rock fall impact will reduce as the separation distance increases and the size of the rock will also reduce. There may be a separation distance where there is an acceptable risk from smaller rock fall. In this high traffic area, if there is any risk of rock fall, a rock fall protection gallery should be installed. See Figure 37.

A floating pontoon will need to be suitably anchored and detailed to accommodate tidal variation with sliding ramps and possibly a causeway at the western end.

Both a gantry or pontoon option could include a rock fall protection gallery option to protect the structure and users from rockfall. Other walkways at Milford Sound Piopiotahi are covered to provide shelter from the rain. A gallery on the gantry pontoon could be a continuation of this weather protection for walkers.

The design of any pontoon or gantry at this location shall include protection from falling and a minimum live load of 5kPa. Any reduction in the live loading by limiting numbers of people on the platform is not an acceptable design parameter as this is an area where people may congregate.

CONSTRUCTION ACCESS

Access for construction will need to be provided from a boat/barge.

MAINTENANCE

Durable materials can be specified for the construction of the ponton or gantry; however, regular inspections and maintenance will be required during the life of the structures to clear vegetation and replace componentry as required.

FEASIBILITY

Construction of a gantry or pontoon accessway is feasible; however, the location of a pontoon will need to be carefully considered due to vessel movements and berth locations. It is considered that both the gantry and pontoon would require a roof to provide protection to the users and the structure from rockfall.

The tethering and anchoring of either structure will require rock anchors.

It is improbable that the gantry can be engineered to withstand a significant debris slide.

A pontoon with appropriate separation distance from the bluff along with a roof is the preferred option. Pontoons are common in a marina setting and the design could be altered for the Milford Sound Piopiotahi location with wider boardwalks and handrails, as shown in Figure 38 and Figure 39. Landspan ramps would be necessary at each to accommodate tidal variation.

Figure 36 – Location of previous gantry – now removed.

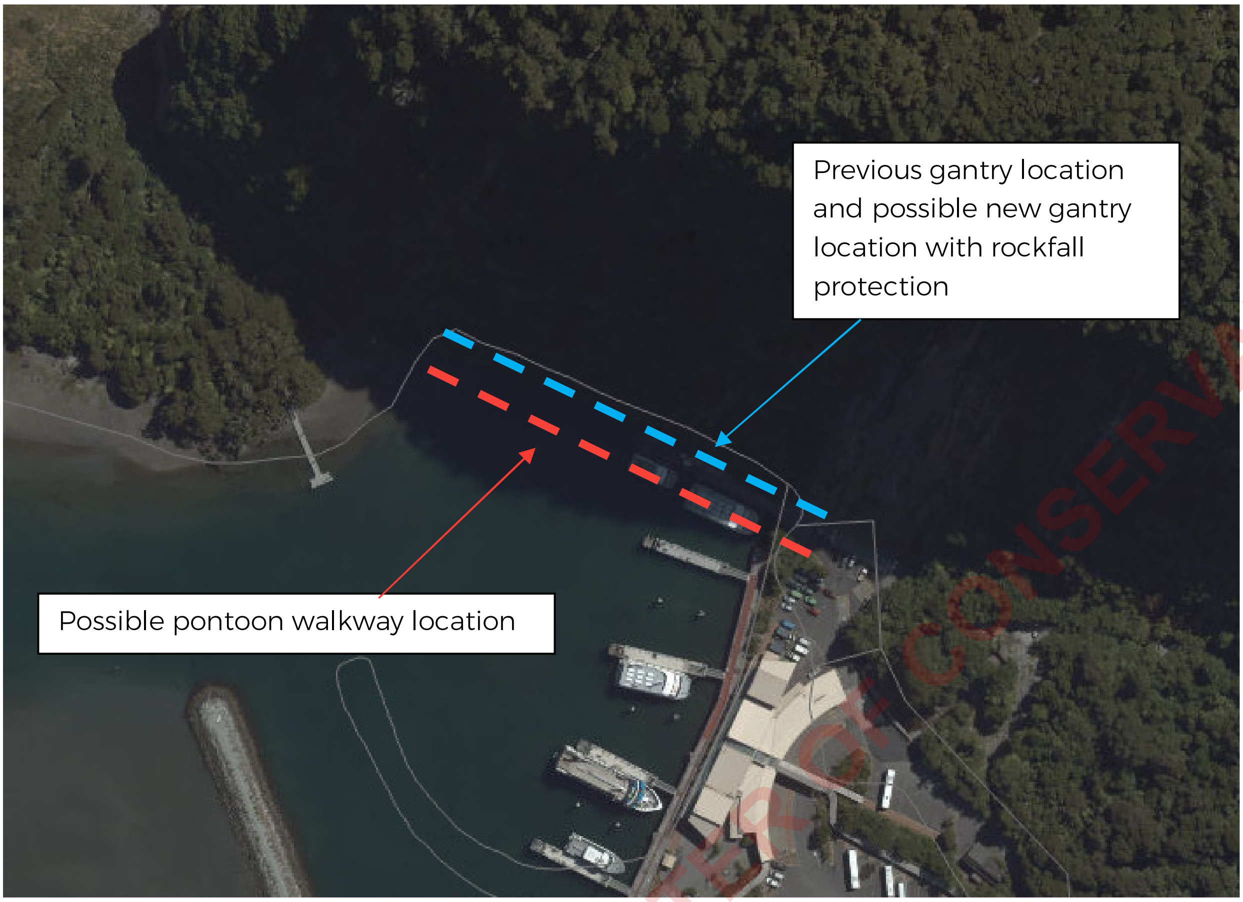

Figure 37 – Lower Hine-te-awa Bowen Falls Access

Figure 38 – Westhaven Marina Auckland – pontoon walkway without handrailing

Figure 39 - Pontoon with Landspan ramp (Source: Marine Services Ltd)

2.14.2 LOWER SHORT WALK – STAIRS AND VIEWING PLATFORM

The Southern Land report provides details of a proposed improved and extended short walks to view the Lower Hine-te-awa Bowen Falls from two vantage points. The walkways will be located on the fall's delta, requiring boardwalks, and on the steep rock face within dense vegetation and will require steps, and stairs. Southern Land has identified a section of the walkway that will require stairs at an exposed rock face. Refer to Figure 40. A viewing platform will be located at each vantage point.

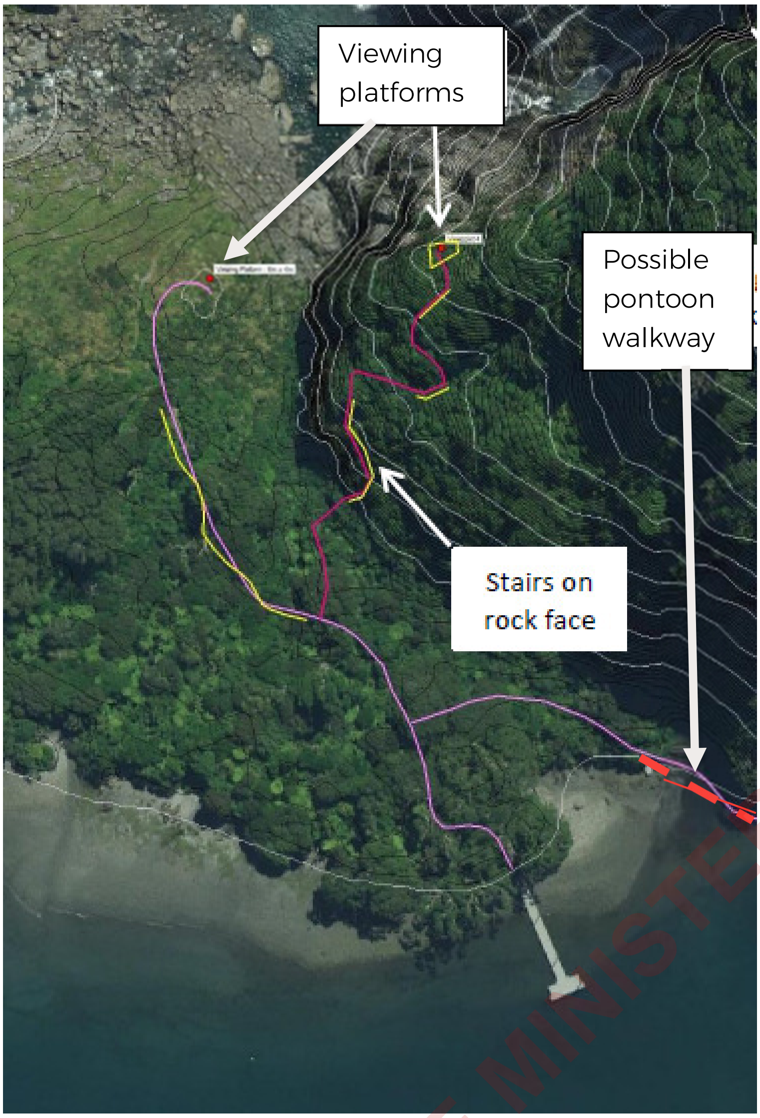

Figure 40 – Lower Hine-te-awa Bowen Falls walkway, stairs and viewing platform.

2.14.1 SPECIFIC CONSIDERATIONS

The Lower Hin-te-awa Bowen falls walkway, stairs and viewing platform will have the same design requirements as the Barren Peak Spur walkway although on a slightly larger scale.

GROUND CONDITIONS/FOUNDATIONS

There are numerous examples of viewing platforms and stairs on back country walks, as shown in Figure 34 and Figure 35 of Section 2.13.1. The sites have river delta material, shallow topsoils and vegetation root mass over bedrock. The structure's foundations will include shallow piles on the delta and likely require rock anchors on the rock faces. The preferred foundations for the rock anchors will include embedded anchors within reinforced concrete plinths to provide long term durability.

LIVE LOADING

The design of the viewing platform shall include protection from falling and a minimum live load of 5kPa as required by SNZ HB 8630:2004. Any reduction in the live loading by limiting numbers of people on the platform is not an acceptable design parameter as this is an area where people may congregate. The design of the platform shall also consider redundancy in the foundations and structure. Bolted shear connections shall be avoided so that there is always a vertical/bearing load path.

FOOTPRINT AND DISTURBANCE OF VEGETATION

The construction of a walkway differs to that of the cycleway as it permits changes of alignment in the path both horizontally and vertically that will allow the path to avoid disturbing significant vegetation and therefore avoid creating weakness in the vegetation root layers.

The viewing point will require the clearance of a larger area of vegetation and care must be taken to avoid creating any weakness in the vegetation root mass layer over rock that could promote a debris slide.

CONSTRUCTION ACCESS

Construction access is limited with materials likely required to be air lifted by means of a helicopter. Accessible laydown areas are nearby in the Milford Sound Piopiotahi township.

MAINTENANCE

Durable materials can be specified for the construction of the stair and viewing platform; however, regular inspections and maintenance will be required during the life of the structures to clear vegetation and replace componentry as required.

3 CONCLUSIONS

The construction feasibility of the Critical Structures is discussed below and summarised in Table 3.

SUSPENSION BRIDGES

Suspension bridges similar to those proposed in the Southern Land Report have been constructed in numerous locations around the back country of New Zealand and are being constructed for cycleways in increasing numbers. These structures have proven to be resilient and durable.

The proposed Hinepipiwai Marian Creek Bridges face challenges due to undetermined locations and ground conditions characterised by large boulders from historic rock falls. Identifying a suitable site for anchorage in stable rock and ensuring clearance for high river flows is difficult. Without additional detailed geotechnical and survey investigations on potential sites, the project is considered high risk and likely unfeasible with the current information.

All other suspension bridge sites are deemed potentially feasible to construct, pending verification of their spans and necessary clearance above high river levels. During the detailed design phase, the placement of abutments must be carefully chosen to prevent erosion from riverbank scour.

The Horse Bridge site requires additional inputs with respect to the heritage values of the current bridge but can be resolved by completing meaningful consultation with the affected parties.

LAND SPAN BRIDGES

The Land span bridges are deemed potentially feasible to construct, pending verification of any scour implications and confirmation of required freeboard clearance during detailed design.

EAST UPOKORORO EGLINTON CONFLUENCE – SCOUR PROTECTION

The proposed cycleway embankment and scour protection, along with rockfall protection at the East Upokororo Eglinton confluence are deemed feasible to construct. Similar works have been carried out at various locations along the Milford Road. Regular maintenance will be required, particularly after high flow events.

COUNTESS RANGE ALPINE HUT

There are many examples of alpine huts successfully constructed and operating within New Zealand. It is considered that if the natural hazard risk of avalanche and rockfall are acceptable, then an Alpine Hut can be constructed at or near the proposed site(s). Specific geotechnical studies are necessary to confirm the final location.

GANTRIES – MELITA BLUFFS, SHEERDOWN PEAK AND LOWER HINE-TE-AWA BOWEN FALLS ACCESS

Rock anchored and propped cantilever gantries are deemed feasible to design and construct. Construction methodologies could be developed; however, the natural hazards are significant, and the gantry structure could not be designed to withstand the impact from a significant debris slide.

The Natural Hazards Assessment will provide further insights into the risk of debris slide and rockfall affecting these structures and its users. Without this further input, and based on current information on the potential hazard, the construction of the gantries may not be viable.

BARREN PEAK SPUR AND HINE-TE-AWA LOWER BOWEN FALLS STAIRS AND VEIWING PLATFORM

There are numerous examples of successfully constructed stairs and viewing platforms that are safe and durable within New Zealand. It is considered that with the appropriate detailing during the detailed design phase, the Barren Peak Spur and Hine-te-awa Lower Bowen Falls Stairs and Viewing Platform are deemed feasible to construct. Appropriate and durable rock anchorage will require detailing during the design phase. On site engineering supervision during construction will be essential.

LOWER HINE-TE-AWA BOWEN FALLS ACCESS PONTOON

Using floating pontoons for access in marine environments is a common solution, and it is believed that such a pontoon walkway can be designed for access to Lower Hine-te-awa Bowen Falls. During the detailed design phase, considerations will need to include the walkway's distance from the rock face to prevent damage from rock falls, possibly incorporating a rock fall protection barrier. Additionally, the design will need to assess and mitigate any impact on boat traffic in the area.

Table 3 – MOP – Walking and Cycling Experiences – Critical Structures – Feasibility Summary

Item	Site Name	Structure Type	Structural Feasibility
1	Lower Upokororo Eglinton River	Bridge – suspension	Yes – specific consideration to span and river clearance required.
2	East Upokororo Eglinton confluence	Riverbank scour protection Rock armouring/rockfall protection	Yes – consider maintenance requirements.
3	Upokororo Eglinton River just above east branch	Bridge – suspension	Yes – specific consideration to span and river clearance required.
4	Countess Range Hut	Alpine Hut	Yes – specific site Geotechnical studies required at final site
5	Kiosk Creek bridges	Bridge – land span	Yes – specific consideration to span and river clearance required.
6	Mistake Creek	Bridge – suspension	Yes – specific consideration to span and river clearance required.
7	Upokororo Eglinton River at Ōtāpara Lake Gunn	Bridge – suspension	Yes – specific consideration to span and river clearance required.
8	Melita Bluff gantry(s) at Ōtāpara Lake Gunn	Bluff bridge/gantry – propped and braced off rock with rock anchors/bolts.	Natural Hazards Assessment Required – likely not viable.
9	Hinepipiwai Marian Creek Bridge	Bridge – suspension	Survey and geotechnical investigations required – likely not viable.
10	Hinepipiwai Marian Creek Bridge	Bridge – suspension	Survey and geotechnical investigation required – likely not viable.

11	Whakatipu-ka-tuku Hollyford River bridge at Homer Hut	Bridge – Landspan – multi span – walkway/boardwalk bridge	Yes – specific consideration to span and river clearance required.
12	Sheerdown Peak gantry	Bluff bridge/gantry – propped and braced off rock with rock anchors/bolts	Natural Hazards Assessment Required – likely not viable.
13	Horse Bridge	Bridge – suspension	Yes – specific consideration to span and river clearance required. Additional heritage considerations required for the existing bridge.
14	Barren Peak spur stairs and Hine-te-awa Lower Bowen Falls viewing platform.	Viewing platform and stairs	Yes – detailed design to confirm appropriate construction details.
15	Lower Hine-te-awa Bowen Falls access.	Pontoon	Yes – detailed design to confirm separation distance and/or rockfall protection.