Milford Opportunities

MILFORD OPPORTUNITIES PROJECT- ENGINEERING FEASIBILITY REPORT

26 JUNE 2024

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REV	DATE	DETAILS
1	February 2024	Draft Structure – For client review
2	March 2024	Draft Structure – As per client feedback
3	May 2024	50% draft – Completed sections as of 14.05.2024
4	24 June 2024	Final
5	26 June 2024	Final - Revised following client comments.

	NAME	DATE	SIGNATURE
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1 PROJECT BACKGROUND

1.1 SCOPE

The scope of this report is to provide a summarised feasibility assessment based on various technical discipline inputs, for engineering infrastructure, to support the envisioned Masterplan for Milford Sound. This report is a summary of the technical discipline reports submitted by WSP, listed below:

- Milford Sound Piopiotahi Heliport Feasibility Assessment - Version 3 – 13 May 2024.
- High-level HAIL Assessment of Nodes - 13 May 2024.
- Knobs Flat Preliminary Site Investigation, Rev 004 – 19 April 2024.
- Summary Report - Contaminated Sites Assessment, Rev 006 – 13 May 2024.
- Natural Hazards Assessment – Part A: Preliminary Screening Analysis, Rev D – 26 March 2024.
- Natural Hazards Assessment – Part B: Basic Risk Assessment, Rev D - 11 June 2024.
- Three Waters Infrastructure Condition and Future State Assessments, Rev F – 17 June 2024.
- Critical Structures for walking and Cycling – Construction Feasibility, Rev 3 – 3 April 2024.
- Carbon Assessment, Rev 004 – 17 April 2024.
- Climate Change Risk Assessment, Rev D – 17 April 2024.
- Geotech Feasibility Assessment, Rev 2 – 24 April 2024.
- Vertical Infrastructure, Design Considerations and Construction Feasibility, Rev D – 10 June 2024.
- RMA Statutory Assessment, Rev B - 6 June 2024.
- Stage 2 Review of Cost Estimates, Rev 3 – 19 June 2024.

The reports mentioned above, contain specific details to the content included within this Optioneering and Feasibility assessment report.

The Masterplan has been developed for the Milford Opportunities Project to sustain and protect the natural environment in Milford Sound and improve the overall visitor experience. This future focused Masterplan ensures the spirit of Milford Sound is preserved. Visitor numbers are expected to go up following recovery from the Covid pandemic, with an estimated increase of 4.1% annually.

The Key concepts of the Masterplan are:

1 Recognise and develop landscape, conservation, and cultural experiences.
2 Establish a new governance model.
3 Facilitate broader Murihiku and Southland benefits.
4 Introduce a managed access and transportation model.
5 Charge international visitors an access fee.
6 Establish new Te Anau Hub and enhanced developments.
7 Develop multiple experiences along the corridor structured around key nodes.

8 Redevelopment to encourage sustainable practices, use of green technology, minimise visitor risk from natural hazards.

9 Reorganise Milford Sound Piopiotahi to remove visitor conflicts.

10 Modernise infrastructure at Milford Sound Piopiotahi.

The Masterplan includes the establishment of a corridor of nodes and short stop experiences between Te Anau and Milford Sound Piopiotahi. Feasibility of the type and size of infrastructure has been tested from an engineering lens, for the purposes of this report.

The engineering solutions align and respond to the seven pillars:

1 Mana Whenua values woven throughout.

2 A moving experience.

3 Tourism funds conservation and community.

4 Effective visitor management.

5 Resilient to change and risk.

6 Conservation.

7 Harness innovation and technology.

1.2 HUBS, NODES & SHORT STOPS

Table 1 lists the Hubs, Nodes and Short Stops from the MOP Master Plan that are part of this engineering feasibility assessment. The table also list some of the proposed facilities.

Table 1: MOP Master Plan Hubs, Nodes and Short Stops

NODE	NAME	PROPOSED FACILITIES
	Te Anau Hub	Visitor Centre Transport Interchange Town Centre
1	Te Rua-o-Te-Moko Fiordland National Park Gateway	Fiordland National Park Entrance
2	Eglinton Reveal	Visitor Shelter Car park Access Restriction Point
	Short stop: Mirror Lakes Waiwhakaata	Bus shelter Toilet Facilities
3	Te Huakaue / Knobs Flat	Accommodation Expansion Camping and Campervan Layout Accommodation at Kiosk Creek Short Walks – Trail Head Facilities
4	Ō-Tāpara Cascade Creek / Mistake Creek Overnight Walk	Flood Protection Infrastructure Camping and Campervan Sites Bus Shelter Toilet Facilities Facilities for Kayaking
5	The Divide / Whakatipu Trails Head (the final location of this node is not yet decided)	Lake Marian Visitor Shelter & Toilet Facilities Lake Marian Wānanga (Living Classroom) Lake Marian Car Park The Divide Car Park The Divide Visitor Shelter
6	Gertrude Valley	Flood Protection Infrastructure Visitor Shelter Car Park Gertrude Valley Walk – Trail Head Facilities
7	Cleddau Cirque	Rockfall Shelter Car Park

NODE	NAME	PROPOSED FACILITIES
	Short stop: The Chasm	Car Park Bus Shelter Toilet Facilities
	Milford Sound Piopiotahi Visitor Hub	Visitor Accommodation Staff Accommodation Visitor Hub Building Bus Terminal Car Park Barren Peak Spur Treetop Lookout Covered Walkways Foreshore Engagements (viewing decks)
	Freshwater Basin Node	Cable Car or Similar Lift Bowen Falls/Valley Walk Bowen Falls Viewing Platforms Bowen Falls Pontoon Walkway Refuge Redevelop the Boat Terminal
	Deepwater Basin Node	Car Park Boat Ramp Facilities for Kayaking Refuge Heliport
	Cleddau Delta Node	Water Viewing Decks Refuge Delta Link Bridge

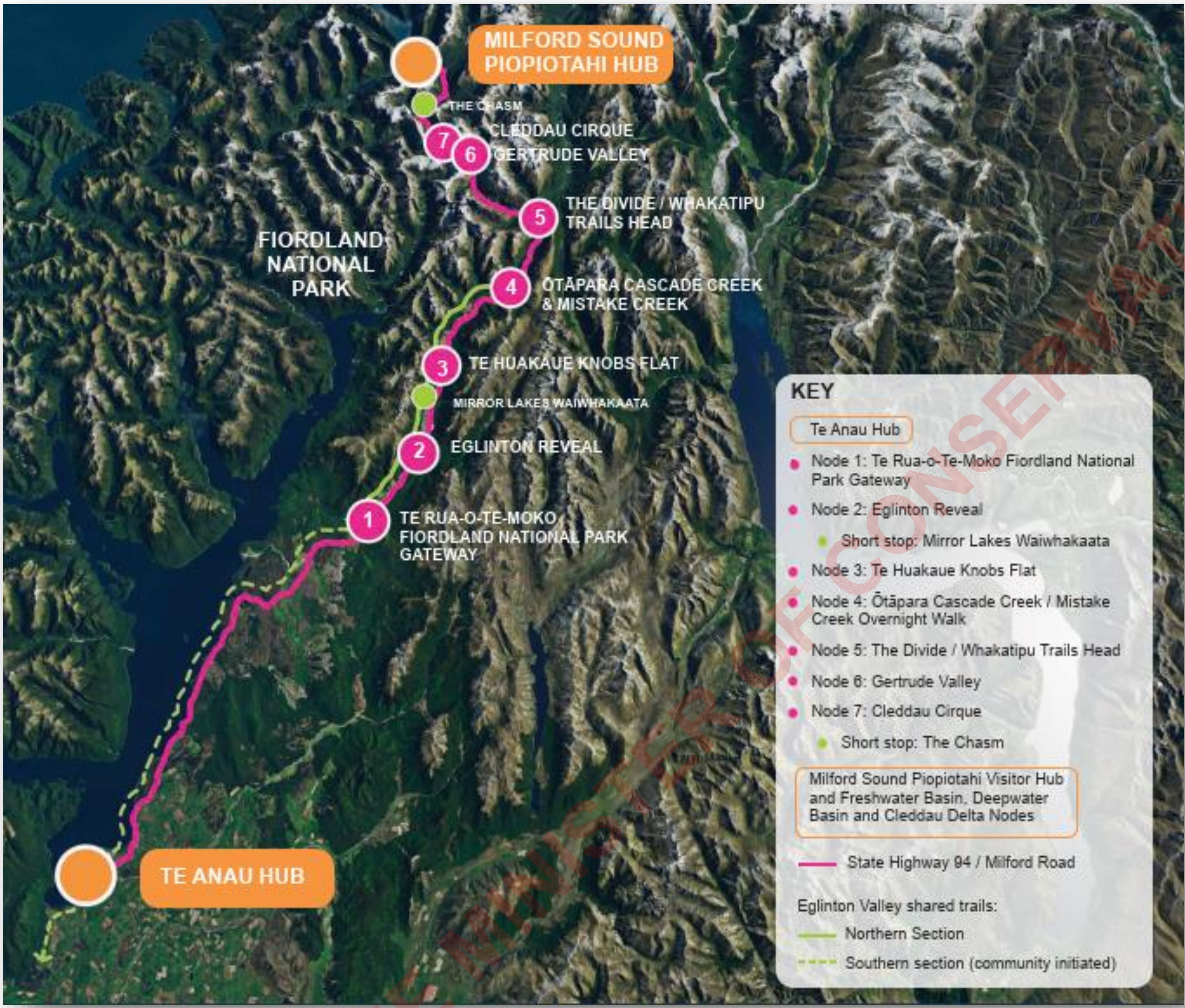


Figure 1: Masterplan Corridor: Nodes and Hub layout

2 TE ANAU HUB

NODE - TE ANAU HUB			
Proposal	Visitor Experience Hub, Transport exchange hub, Pavements, Landscaping, Wastewater, Potable water		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	Low	None Proposed – All sites are Class 1
	Long term Climate Change	Medium	Design should consider adverse weather and have mitigation measures for rain/flooding.
	Geotechnical Engineering	Medium	Simple lightly loaded structures designed with Shallow Strip or Spread foundations with minimal ground improvements
	Three Waters Infrastructure	Low	Locations to be confirmed, followed by additional investigations as required.
	Contaminated Sites	Not applicable	The assessment was not completed as the location of the sites was not finalised.
	Vertical Structures	Medium	All structures are assessed at importance level 3 due to crowd activity
Primary option	Notes - The overall risk for the proposal at Te Anau Hub is Low – Medium.		The elements proposed at Te Anau are feasible and the added costs for the mitigation measures are low.
Secondary option	Description – The best option would be to have a combined Visitor Centre and Transport Interchange in the Town Centre or close to Town Centre to provide better connectivity to the facilities for Pedestrians/cyclists. The parking facility around the transport Interchange can be developed in stages.		

2.1 NODE SUMMARY

Te Anau has been envisioned to be the primary hub for the Milford Opportunities Project. Te Anau is coined "the gateway to the Fiords". The Te Anau Hub will be a strategic location for visitors to make their journey to Milford Sound, owing to its transport connectivity and tourist infrastructure.

Infrastructure development planned for the Te Anau Hub is as follows:

1 *VISITOR CENTRE*

The visitor centre would operate day and night and contain static and interactive displays, audio visual, seminar rooms and guided experiences. Among other facilities, a café and toilets would also be provided.

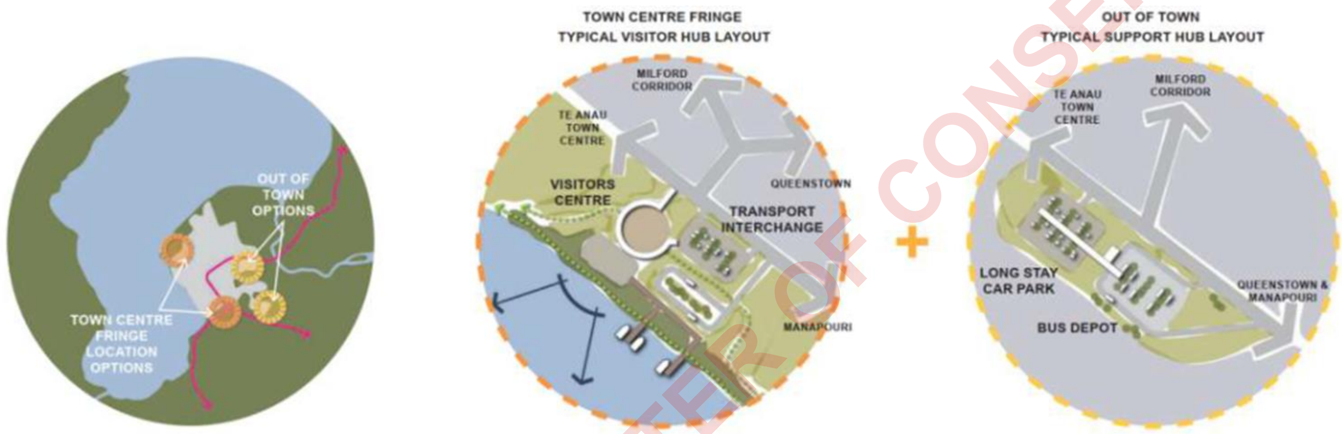


Figure 2: Te Anau Hub Locations and Concepts from Masterplan

2 *TRANSPORT INTERCHANGE.*

An essential starting point for bus focused visitor transport model through to Milford Sound Piopiotahi. The Transport interchange would serve primarily as a bus terminal for hop on/hop off buses and short stay coaches with cycle facilities and a modest carpark. Jetties for local water-based experiences and opportunities to use shuttle services to connect surrounding boats & seaplane operations.

The location for the Te Anau visitor centre and transport interchange needs to be determined. The engineering feasibility for the proposal can only be high-level conceptual. The following disciplines have been shortlisted for engineering feasibility assessment:

1 Geotechnical Engineering

2 Civil Engineering

3 Structural Engineering

2.2 PRIMARY OPTION FOR CONSIDERATION

The Option proposed in the Master Plan for Te Anau hub includes A Visitor Centre and a Transport Interchange. As per the engineering assessments both are feasible, although the locations of these is yet to be determined there are no major risks associated that needs to be addressed. The proposed structures are feasible from an engineering perspective. There are no major risks or costs associated with the maintenance and operating costs. There are opportunities to use economically sustainable materials in construction to minimise the carbon footprint.

2.3 SECONDARY OPTION FOR CONSIDERATION

The best option would be to have a combined Visitor Centre and Transport Interchange in the town centre or close to town centre to provide better connectivity to the facilities for Pedestrians/cyclists. The parking facility around the transport Interchange can be developed in stages. The location of The Visitor Centre and Transport interchange need to be confirmed for long term climate change flooding considerations and further Geotechnical testing.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

2.4 NATURAL HAZARD RISK ASSESSMENT

Te Anau Hub has been classified as a Class 1 site with an insignificant risk rating. There are no mitigation measures proposed for it. Class 1 sites are those with sufficiently low hazard probability or exposure time so that risk to visitors is minimal.

2.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Table 2: Climate Risk Summary – Te Anau Hub

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Te Anau HUB	BUILDINGS	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	GENERAL INFRASTRUCTURE	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	BUILDINGS	Late-century	N/A	High	N/A	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Late-century	N/A	High	N/A	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Late-century	N/A	High	N/A	Low	Moderate	Low	High

Extreme weather (high winds and storms) and heavy rain events represent the highest risk at this location. While current risk levels for these hazards are moderate, it is expected that their frequency and intensity will increase over time, and the risk would become high by late century. Although temperatures will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise that due to variability of rainfall, occasional dry periods will occur, during which drought and wildfire risk may be higher. The number of hot days (temperature > 25 degrees Celsius) will increase towards the end of the century, changing the risk from low currently to moderate, increasing the cooling requirements in buildings (i.e., HVAC systems).

This location has predominantly wide and flat conditions, therefore, avalanche risk is not applicable at this location.

2.6 GEOTECHNICAL ASSESSMENT

The following is noted of the Te Anau Hub:

- Site location not yet selected – Masterplan indicates site options could include the town centre, on the town fringe or out of town.
- The Masterplan structures listed at this site are a Visitor Centre, a Transport interchange and possible Town Centre upgrades.
- Elevation: The town ranges approximately between 215m above Sea Level (ASL) to 250 metres ASL.
- Closest Active Fault: Hauroko Fault, located approximately 20 kms south.
- Geological Map information: Te Anau is located within the mapped geological unit. Holocene River Deposits (Unconsolidated gravel, sand, silt, clay, and a minor peat of modern to postglacial flood plains, may be terraced).
- Environment Southland Liquefaction Risk Map. Medium Risk. Note mapping has been completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- No site visit completed.

Figure 3: Te Anau – Published Geology

Environment Southland liquefaction risk map lists Te Anau soils at a medium risk of liquefaction during a seismic event. However, the very dense soils and deep ground water at the primary school indicate a lower risk of liquefaction than the Environment Southland information. Soil conditions at other locations may not have the same, very dense soils and shallower ground water levels such as site closer to Lake Te Anau and the Upukerora River. As such it is recommended that a site-specific geotechnical investigation that includes a liquefaction assessment is completed for the Te Anau Hub site once it is selected. In addition, the lake and river may also create a free face, where the soil and body of water meet, which may experience lateral spreading during a seismic event. Therefore, if the site is located near either the lake or river, the investigation should include a lateral spreading assessment. Given the lack of available geotechnical investigation data it is not possible to determine if soils are likely to meet the definition of 'good ground' as defined in NZS3604:2011. However, simple, lightly loaded structures should be able to be designed and supported with shallow strip or spread footings. Shallow ground improvements may need to be considered depending on the actual ground conditions at the selected site. Ground investigation of the site will be required to confirm geotechnical parameters for design.

Multi-storey buildings or other more complex structures with higher loading requirements will require more complex foundation arrangements. Geotechnical investigation will be required to inform foundation design for these conditions, as it will be more extensive when compared to simple structures. At this stage it has been assumed that most of the structures are single storey, simple, lightly loaded structures for the purpose of determining the proposed geotechnical investigation program. The possible exception to this is the transport interchange which includes options for a parking structure up to three storeys.

Based on available information and development already present, it is geotechnically feasible to construct both simple, lightly loaded structures as well as more complex multi-storey structures within the Te Anau Town Centre. Once the final location, structure details are known, investigation and further assessment will be required to confirm the geotechnical feasibility and potential cost implications of constructing more complex structures.

2.7 THREE WATERS INFRASTRUCTURE CONDITION

2.7.1 WATER SUPPLY

The location of both facilities in Te Anau has not been finalised and a detailed assessment of the water supply network capacity has not been undertaken. Extension of the supply to service the Transportation Interchange may be required. Water infrastructure servicing requirements will need to be confirmed as the concept is developed.

There are two areas in the network where pressure is boosted by pump stations, being the upper terrace of Sandy Brown Road and Kepler Heights as well as Patience Bay. These were not configured accurately in the model due to the information available and were excluded.

If the Visitor Centre or Transportation Interchange were in these boosted areas, then supply may not be available without network upgrades to meet the required level of service. If the locations are outside of the boosted pressure areas, then the model can be updated to assess any effects on the network.

A breakdown of the anticipated water demand for the Visitor Centre and Transportation Interchange is presented in Table 3. The combined peak daily water demand for the Te Anau hub is 118 m3 per day.

Table 3: Te Anau Visitors Hub Water Demand Breakdown

	WATER DEMAND (L/DAY)	POPULATION	DAILY VOLUME (M^3)
Visitor Centre			
Day Visitors	10	7,000	70
Café	12	1,750*	21
Total Daily Volume (L)			**91**
Transportation Interchange			
Day Visitors (Park and Ride)	10	2,700	27
Total Daily Volume (L)			**27**

*Assumes 25% of day visitors go to Café

2.7.2 WASTEWATER

Like water supply, a detailed assessment of the existing wastewater network in Te Anau to accommodate flows from both facilities has not been undertaken as their locations have not been finalised. Extension of the network or on-site wastewater disposal may be required if a remote location is selected.

A breakdown of the anticipated wastewater volumes for both facilities is presented in Table 4. The combined peak daily water demand for the Te Anau hub is 118 m3 per day.

Table 4: Te Anau Visitors Hub Wastewater flows

	WATER DEMAND (L/DAY)	POPULATION	DAILY VOLUME (M^3)
Visitor Centre			
Day Visitors	10	7,000	70
Café	12	1,750*	21
Total Daily Volume (L)			**91**
Transportation Interchange			
Day Visitors	10	2,700	27
Total Daily Volume (L)			**27**

*Assume 25% of day visitors go to Café

SDC have confirmed that following the upgrade of their WWTP that they do not have concerns with plant operational capacity at peak loading. They do not have concerns with the additional demand created by the proposed Visitor Centre and Transportation Interchange.

SDC have advised that the sludges from Te Huakaue and Piopiotahi Milford Sound and waste collected from vaulted toilets are not received at Te Anau WWTP and instead hauled to other sites.

2.7.3 STORMWATER

SDC recently developed a stormwater network Masterplan for Te Anau (WSP, 2022). For new developments beyond the existing urban area (likely site of the Transportation Interchange), the Masterplan recommended all new developments manage stormwater through onsite treatment and disposal to soakage systems. For redevelopment sites in town (likely site of the Visitor Centre), it was recommended that opportunities to reduce hardstand areas and incorporation of rain gardens and swales be investigated.

The Te Anau Hub should allow for stormwater attenuation, treatment, and soakage on site. There are opportunities to incorporate stormwater management features into the design of both facilities in carparks, buildings, and green spaces. Table 5 presents an estimated cost for the stormwater management features only (does not include other site components such as buildings, paved surfaces, etc).

Table 5: Estimated Cost of Stormwater Management for Te Anau Hub

ITEM	ESTIMATED COST
Stormwater management (incorporated into carpark and greenspaces)	$400,000
Project overheads and delivery	$100,000
Total	**$500,000**

2.7.4 FEASIBILITY

The estimated peak water demand and wastewater discharge rate for both facilities in Te Anau is 118 m3 per day (91 m3 per day Visitor Centre and 27 m3 per day Transportation Interchange). Te Anau has established water and wastewater reticulation and treatment plants. The existing treatment plants have capacity, however the serviceability of sites via existing reticulation should be confirmed when a final location is selected.

The proposed Te Anau Hub is considered feasible. The next best alternative has not been considered as this is expected to be developed once the locations have been confirmed.

2.8 CONTAMINATED SITES ASSESSMENT

No HAIL sites in Te Anau to be considered.

2.9 VERTICAL STRUCTURES ASSESSMENT

TE ANAU VISITOR CENTRE HUB STRUCTURES – VISITOR CENTRE.

- Visitor Centre and focal point for entire visitor experience with no post – disaster function.
- Single level with close connection to Lake/ Jetty and bus/roading network / car parking. Available footprint may require two level structure. Importance Level 3.
- Likely greater than 300 visitors within the building so crowd activity is expected, approximate area 1000 m2.

- Available footprint might require two level structure. IL3.
- Construction feasible.

TE ANAU VISITOR HUB STRUCTURES – BUS STOP

- Te Anau Departure/ arrival structure. Shelter – No post disaster function.
- Single level with close connection to Visitor hub. Likely greater than 300 visitors within the building so crowd activity.
- Standard structure – Large spans to accommodate buses. Importance Level 3, likely to attract crowd activity. Construction is feasible.

TE ANAU VISITOR HUB STRUCTURE – JETTY

- Jetty aligned with Visitor Hub, No post – disaster function.
- Jetty Structure. Importance Level 2. Approximate area 50m2.
- Construction feasible.

TE ANAU TRANSPORT TERMINAL – BUSES

- Bus storage and maintenance facilities along with driver facilities. No post-disaster functions.
- Single level with close connection to terminal pavement and visitor experience. 1000m2.
- Standard structure with large spans to accommodate buses. Importance Level 3. Likely crowd activity.
- Construction is feasible.

3 NODE 1: TE RUA-O-TE-MOKO FIORDLAND NATIONAL PARK ENTRANCE

NODE 1 - TE RUA-O-TE-MOKO FIORDLAND NATIONAL PARK ENTRANCE			
Proposal	A natural gateway enhanced with a large, context appropriate, drive through signage, marker, or artwork.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	Low	No mitigation measures proposed.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	Low	Foundation will have to account for wind loading
	Contaminated Sites	Low	No mitigation measures proposed.
	Structures Assessment	Low	Standard design IL2 structures, robust to withstand wind loading
	Vertical Infrastructure	Low	IL2 structures proposed.
Overall Feasibility of the proposal	Description of the option: Pad foundations or footings to account for soil conditions and wind loading. Standard IL2 structures.		Masterplan proposal is feasible.
Next Best Option	Not applicable.		

3.1 NODE SUMMARY

The first threshold would be a stunning entrance at the legal boundary to Te Rua-o-Te-Moko Fiordland National Park and wider UNESCO Te Wāhipounamu – Aotearoa New Zealand World Heritage Area. A rural landscape threshold can exist with a distinct crossing into native bush that provides a natural gateway. This can be enhanced with a large, yet context appropriate, drive through signage, marker, or artwork like the themes that are already obvious throughout the corridor. However, this gateway is in a spatially constrained location that does not allow for development of a node with infrastructure or a stopping point.

Figure 4: Concept drawing (Masterplan) for Node 1.

3.2 PRIMARY OPTION FOR CONSIDERATION

The primary Option as per the Master Plan is to develop an opportunity for visitors to interact with the proposed pou whenua at the Te Rua – O- Te- Moko Fiordland National Park entrance. The proposal includes installation of drive through signage, markers, and artwork. The proposal is feasible from an engineering perspective. Pad foundations are recommended for the structures and must be designed for Wind Loading Importance Level 2.

3.3 SECONDARY OPTION FOR CONSIDERATION

The proposed signage, markers and artwork are feasible. There is an opportunity for developing a pull over area for people to take photos at the entrance with the artwork.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

3.4 NATURAL HAZARD RISK ASSESSMENT

3.4.1 PART A: ASSESSMENT

TE RUA-O-TE-MOKO FIORDLAND NATIONAL PARK ENTRANCE has been classified as a Class 1 site with an insignificant risk rating. Class 1 sites are those with sufficiently low hazard probability or exposure time so that risk to visitors is minimal.

3.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Extreme weather conditions (high winds and storms) and heavy rain events represent the highest risk at this location. While current risk levels for these hazards are moderate, it is expected that their frequency and intensity will increase towards the end of the century and the risk will be high.

Although temperatures will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise that due to variability of rainfall, occasional dry periods will occur, during which drought and wildfire risk will be higher. This location has predominantly wide and flat conditions, therefore, avalanche risk is not applicable at this location.

Table 6: Climate Risk Summary – Node 1 – Te Rua-O-Te-Moko Fiordland National Park

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain / Flooding	Heavy Rain / Slope Instability	Dry days/Drought	Hot days	Frost Nights - Avalanche	High winds / Storms
NODE 1 - Gateway	BUILDINGS	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	GENERAL INFRASTRUCTURE	Mid-century	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	BUILDINGS	Late-century	N/A	High	N/A	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Late-century	N/A	High	N/A	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Late-century	N/A	High	N/A	Low	Moderate	Low	High

3.6 GEOTECHNICAL ASSESSMENT

The following is noted for Te Rua-o-Te-Moko Fiordland National Park Gateway:

- The Masterplan structures listed at this site are rows of pou whenua on each side of the highway.
- Elevation: The site is approximately 300 m ASL.
- Closest active fault: Unnamed Fault #8429, located approximately 11 km northeast of the site.
- Geological Map Information: Site is located on the boundary between the following two mapped geological units, see Figure 5 below.
- Eastern Side Labelled: Boyd Creek Rock Formations (Discontinuous basal mudstone; thin-bedded graded sandstone, upper part is massive siltstone/mudstone with lenticular massive sandstone).
- Western Side Labelled: Outwash Deposits (Generally unweathered, well sorted, loose, sandy to boulder gravel forming large terraces and outwash plains).
- Environment Southland Liquefaction Risk Map: Negligible Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Based on the MOP Masterplan concept, a site visit and photographs, the site is likely to be situated on outwash deposits. It should be noted that a culvert is located within the site that appears to drain the eastern side of the highway to the west. It is likely that either shallow ground water or overland water flow should be expected, see Figure 6 below.

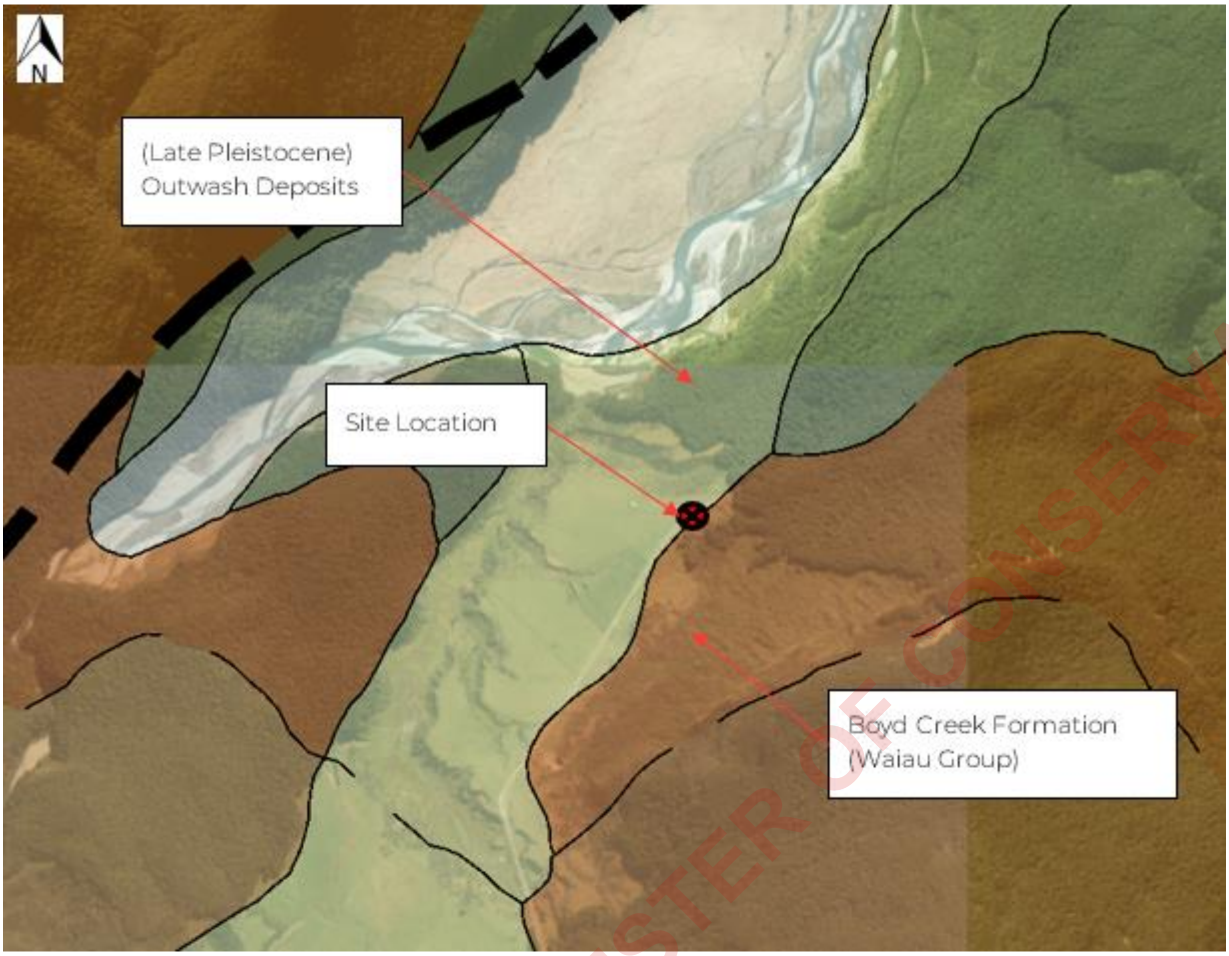


Figure 5: Te Rua-O-Te-Moko Fiordland National Park Gateway – Published Geology

Figure 6: Te Rua-o-Te-Moko Fiordland National Park Gateway – Eastern side of the site (vegetation types appear to indicate wet ground conditions)

Based on the available information, the site soils likely consist of outwash deposits over bedrock at depth. The outwash deposits are likely to consist of sandy gravels. A site visit noted a culvert draining east to west. The culvert indicates possible wet ground conditions at various times of the year. Based on Environment Southland mapping the site is considered to have a negligible liquefaction potential and available information indicates similar potential for liquefaction However, given the structures will consist of a series of pou whenua, it may be acceptable to rebuild them after a seismic event, if liquefaction occurs.

Due to the shape, the foundation will have to account for wind loading on the pou whenua. Foundation design will take this into account as part of the normal loading conditions.

Foundations for the pou whenua could be either pad footings or piled foundations. The choice will be dependent on the soils present on site and the cost to mitigate seismic damages verse the costs to replace / repair the pou whenua.

The development as shown in the MOP Masterplan, at this stage, is geotechnically feasible.

3.7 CONTAMINATED SITES

Hazardous Activities and Industries List (HAIL) rating is GREEN.

HAIL rating GREEN indicates that HAIL activities (current or past) are unlikely.

3.8 VERTICAL STRUCTURES

3.8.1 TE RUA O TE MOKO FIORDLAND NATIONAL PARK THRESHOLD

ENTRANCE/DEPARTURE STRUCTURE - POU WHENUA, SIGNPOST STRUCTURES

- A standard IL2 level structure has been proposed with signage and architectural features for the Fiordland National Park Threshold.
- Wind loads are likely to govern the design.
- Construction is feasible.

4 NODE 2: EGLINGTON REVEAL

NODE 2- EGLINTON REVEAL			
Proposal	Visitor activities to continue the experience, such as a river trail and interpretive viewing areas and support facilities like car parking and public toilets. The use of sunken areas, low profile structures and naturalistic bunding should integrate into the grassy flats and maintain the wide-open vistas		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	Low	Class 1 site with no significant risk
	Long term Climate Change	Low	Low Climate risk forecasted currently.
	Geotechnical Engineering	Low	Simple lightly loaded and require shallow timber piles or shallow strip or spread foundations
	Three Waters Infrastructure	Low	Containment toilets proposed for the node.
	Contaminated Sites	Low	Hail assessment is GREEN. No further investigation is required.
Primary Option	IL2 structures, simple lightly loaded with shallow timber piles or shallow strip or spread foundations. Containment toilets proposed for the node.		Proposal is feasible.

4.1 NODE SUMMARY

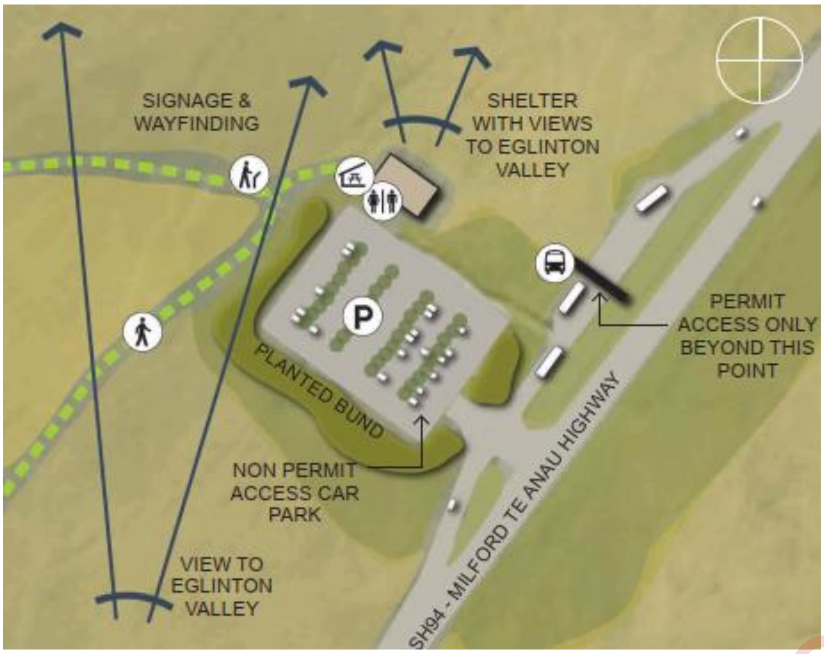


Figure 7: Concept drawing (Masterplan) for Node 2.

A key node at the iconic Eglinton Reveal, a visually dramatic exit from bush with a strong visual connection along the Eglinton Valley toward other key nodes along the Milford Corridor. This is a logical point to manage access through a permit system. Unrestricted access would be allowed to this point within Te Rua-o-Te-Moko Fiordland National Park, which would provide a stopping and turning area where visitors can experience one of the highlights of the Milford Corridor before managed access begins.

The Eglinton Reveal would also have other visitor activities to continue the experience, such as a river trail and interpretive viewing areas and support facilities like car parking and public toilets. An entrance barrier will need to be incorporated.

The Eglinton Reveal node would have suitable areas for infrastructure that are less ecologically sensitive, providing visual amenity is carefully managed. It is important the proposed expansion of this node maintains a sense of reference this landscape currently offers to visitors who emerge from the bush. The use of sunken areas, low profile structures and naturalistic bunding should integrate into the grassy flats and maintain the wide-open vistas strongly associated with this node.

4.2 PRIMARY OPTION FOR CONSIDERATION

The proposal is to create suitable areas for infrastructure that are less ecologically sensitive, providing visual amenity is carefully managed. Low profile structures earthen bunds with shelters and toilets for visitors. Changes to the road layout to provide access to the car park from SH94. The engineering assessments have deemed the above node as low risk. The structures proposed are feasible, vertical infrastructure to be designed to IL 2 standards and for wind loads. The toilets proposed are assessed as self-containment and will require emptying regularly. Storm water from the car park can be treated with bio-swale designs. The proposal is feasible from a constructability point of view as the proposed structures are similar to existing structures in Cascade Creek. Operation and maintenance costs are low. Design should consider the use of timber and source local materials to be sustainable.

4.3 SECONDARY OPTION FOR CONSIDERATION

Primary option is feasible. Further assessment will be required if running water is provided for hand washing at the toilets.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

4.4 NATURAL HAZARD RISK ASSESSMENT

4.4.1 PART A: ASSESSMENT

This node has been classified as Class 1 site and does not present a significant risk to potential trail users and workers and as such no further risk assessment is required for these tracks and trails. Class 1 sites are those with sufficiently low hazard probability or exposure time so that risk to visitors is minimal.

4.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Extreme weather (high winds and storms) and heavy rain events represent the highest risk at this location. While current risk levels for these hazards are moderate, it is expected that their frequency and intensity will increase towards the end of the century. This will increase the risk to infrastructure and assets due to a higher exposure over time.

Although temperatures will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise that due to variability of rainfall, occasional dry periods will occur, during which drought and wildfire risk will be higher. The number of hot days (temperature >25°C) will increase towards the end of the century changing the risk from low currently to moderate.

This location has wide and flat conditions; therefore, avalanche risk is not applicable at this location.

Given the location of Node 2 – Eglinton Reveal (inland), sea level rise is not applicable.

Table 7: Climate Risk Summary – Node 2

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Node 2 – Eglinton	BUILDINGS	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid-centur	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Mid-centur	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	GENERAL INFRASTRUCTURE	Mid-centur	N/A	Moderate	N/A	Low	Moderate	Low	Moderate
	BUILDINGS	Late-centur	N/A	High	N/A	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Late-centur	N/A	High	N/A	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Late-centur	N/A	High	N/A	Low	Moderate	Low	High

4.6 GEOTECHNICAL ASSESSMENT

The following is noted for the Eglinton Reveal node:

- The Masterplan structures listed at this site are a Visitor Shelter, a Car park, and an Access Restriction Point
- Elevation: the site is approximately 320 m ASL.
- Closest active fault: Unnamed Fault #8429, located approximately 4.3 km northeast of the site.
- Geological map information: Site is located within the mapped geological unit: Holocene fan deposits (Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree upslope) and valley alluvium. See Figure 8 below.
- Environment Southland Liquefaction Risk Map: Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Site visit and photographs indicate that the site is likely to be composed of alluvial fan sediment with ground water at shallow depth influenced by the river. See Figure 9 below.

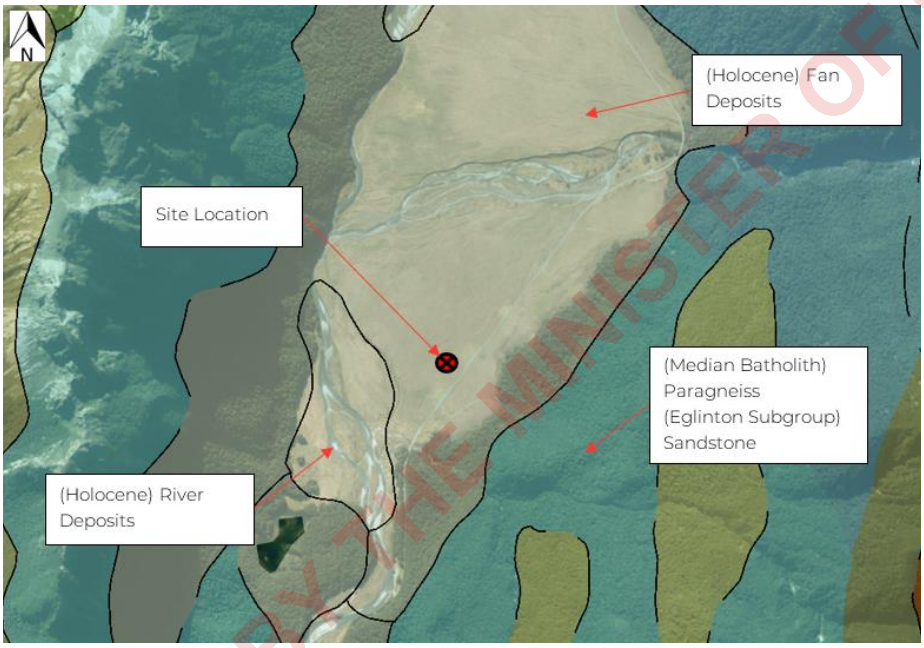


Figure 8: Eglinton Reveal – Published Geology

Figure 9: Eglinton Reveal looking East (left) and North (right) from the proposed location.

The site is likely underlain by alluvial fan deposits with bedrock at depth. The alluvial fan sediments are likely to comprise a wide distribution of grainsizes, from silt to gravel and cobbles. Based on the distance from the river, it is anticipated that groundwater will be encountered at shallow depths. At this stage the site is assumed to have a low liquefaction potential. Geotechnical investigation of the site will be required to confirm the soils onsite, whether groundwater is present at shallow depths and allow determination if further liquefaction assessment of the site is necessary.

The proposed structures at this site include a visitor shelter with interpretative viewing areas, toilet facilities, and an access restriction point. Based on the published geology and our site observations, the soils assumed to be present at the site should have adequate bearing strength at or near the surface to support structures of this type (assuming an Importance Level (IL) 1). These structures will most likely be simple lightly loaded and require shallow timber piles or shallow strip or spread foundations. It is not expected that structures will require deep piled foundations or significant ground improvements. If larger heavy structures are required, or the structures are of higher importance levels (IL2 or higher), then alternative foundations or ground improvements may be required.

The possible exception to this is the carparking at Eglinton Reveal. Beca's park and ride report identified Eglinton Reveal as one of the park and ride locations. The report proposes three options for carparks layouts at select locations. These are a single-storey carpark, a two-storey structure, and a three-storey structure. A multi-storey carpark structure will require more complex foundations and consequently will involve a more detailed geotechnical investigation and more complex design and construction. Shallow foundations (such as pad footings) may be suitable foundation for the structures depending on ground conditions and final loadings. However, if ground conditions are poor and or loads exceed acceptable limits, deep foundations (piles) maybe required.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Major determining factors for the feasibility of the site will be the Importance Level of the structures, the types of structures and their loading requirements, whether those structures need a liquefaction assessment, and the final site layout. Additional inputs from other disciplines may alter the site layout and structures feasibility.

4.7 THREE WATERS INFRASTRUCTURE

4.7.1 UPOKORORO EGLINTON REVEAL WASTEWATER

Four new toilets are proposed for Upokororo Eglinton Reveal.

Table 8 presents estimated wastewater generation rates with 1,000 uses per day using containment tanks.

Table 8: Estimated Wastewater Generation Rates

SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment Tank Only	0.2	0.2

To meet this demand, it is recommended four 4.5 m3 total containment units, along with a toilet building, be installed. Tanks are to be periodically emptied by septage tanker. This setup will ensure 80 days of storage capacity during peak use periods, based on the assumption that the tanks will be emptied once 4 m3 of waste have accumulated in each. As hand washing facilities are not recommended at this small site, hand sanitiser will need to be provided.

A solar level monitoring probe on each tank with Global System for Mobile Communications (GSM) link to notify of high level is recommended.

An estimated cost for incorporating toilets into the planned shelter is presented in Table 9.

Table 9: Upokororo Eglinton Reveal Containment Tanks Estimated cost

ITEM	ESTIMATED COST
Containment and toilet building	$300,000
Level monitoring	$10,000
Project overheads and delivery	$100,000
Total	**$410,000**

4.7.1.1 FEASIBILITY

It is recommended that the Upokororo Eglinton reveal wastewater system is a total containment tank as described above. This option is considered feasible.

The next best alternative is to provide total containment with water supplied for hand washing only. Water for hand washing can be harvested from the roof of the shelter. This option would require optimising rainwater catchments areas to onsite water storage. This would have the added benefit as stormwater discharge from the shelter roof is collected and would not need to be discharged.

The nearby Mackay Creek is also an option depending on the volumes required.

4.7.2 UPOKORORO EGLINTON REVEAL STORMWATER

The proposed development at Upokororo Eglinton Reveal includes a 900 m2 unsealed carpark. It is expected that bioswales would be appropriate at this location. It is assumed the cost of bioswales is included in the estimate for the carpark earthworks and landscaping as this is similar work.

4.8 CONTAMINATED SITES

It is considered unlikely that Hazardous Activities and Industries List (HAIL) activities are currently or have been occurring on the site. As such Node 2 has been classified as GREEN. No further investigations associated with potential land contamination are recommended at this stage of the project.

HAIL rating GREEN indicates that HAIL activities (current or past) are unlikely.

4.9 VERTICAL INFRASTRUCTURE

KIOSK AND "ROBUST" SHELTER STRUCTURE/VAULTED TOILETS – SINGLE LEVEL OPEN SIDED SHELTER

- A robust shelter in this location is achievable. Wind Loading is likely to govern the design. IL2 structure.

- Construction is feasible with similar requirements as the existing Cascade Creek Campsite buildings.

5 NODE 3: TE HUAKAUE KNOBS FLAT/MIRROR LAKES SHORT STOP

NODE 3: TE HUAKAUE KNOBS FLAT/MIRROR LAKES SHORT STOP			
Proposal	**Knobs Flat:** Proposed for redevelopment and expanding the existing accommodation with amenity buildings and simple cabins with a few extras, including Wi-Fi, seasonal food carts, bus stops, track access etc. Optimise existing campervan and camping access. **Mirror Lakes Short Stop:** The sealed carpark is prioritised to be a hop on/hop off bus service and express coaches with a small area for short-term vehicle and campervan parking. Additional infrastructure, including weather/bus shelter, interpretive displays, and toilet facilities.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	Medium	**Knobs Flat:** Various earthworks: formed bunds and cut drainage ditches along the eastern extent of the site to mitigate the potential flooding hazard. **Mirror Lakes SS:**
	Long term Climate Change	Medium	No mitigation measures proposed
	Geotechnical Engineering	Medium	**Knobs Flat:** Foundation design will depend on the geological locations. **Mirror Lakes SS:** Structures will most likely be lightly loaded and may be founded on shallow strip or spread foundations.
	Three Waters Infrastructure	Medium	Knobs Flat: Water supply will need upgrades, Waste water treatment plant will need upgrading to meet future wastewater flows. Stormwater discharge can be managed

NODE 3: TE HUAKAUE KNOBS FLAT/MIRROR LAKES SHORT STOP			
			with bioswales, stormwater wetlands or oil & grit separators.
	Contaminated Sites	High	DSI to assess risks to human health and the environment for any ground disturbance in the locality of the defined Pieces of Land.
	Vertical Infrastructure	High	IL4 structure for refuge areas.
Overall Feasibility of the proposal	Notes – The proposed structures and amenities are feasible. Further assessment is required to assess the natural hazard risk (flooding and landslide) and mitigation measures determined.		
Next Best Option	Description – Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.		Feasibility: Low due to High risk levels.

5.1 NODE SUMMARY

TE HUAKAUE KNOBS FLAT

Te Huakaue Knobs Flat is in a central location within the Eglinton Valley and the first of two combined experience and accommodation nodes within the Te Rua-o-Te-Moko Fiordland National Park section of the Milford corridor. It is currently a bus service stop.

There is potential for a range of family-friendly accommodation choices, depending on market demand to facilitate a diverse range of visitors. The Te Huakaue Knobs Flat side of the node is already a heavily modified grassy clearing. It is being proposed for redevelopment and expanding the existing accommodation with amenity buildings and simple cabins with a few extras, including Wi-Fi, seasonal food carts, bus stops, track access etc. It would also optimise existing campervan and camping access. Te Huakaue Knobs Flat and Kiosk Creek could also act as a key base for guided experiences within the corridor. Both are close to lowland Red Beech forests of high conservation value with ongoing research activity. It has the potential to be a key interpretive node at the mid-point along the corridor. It is proposed to co-locate the existing research base with a series of covered shelters containing interpretive displays, purakau cultural narratives with a looped nature trail and observation points that enhance existing tracks or new tracks carefully integrated into the forest, avoiding the more sensitive bush edges.

Figure 10: Te Huakaue Knobs Flat – Concept plan – Masterplan document

SHORT STOP: MIRROR LAKES WAIWHAKAATA

Located halfway between Te Anau and Milford Sound Piopiotahi on Milford Road, Mirror Lakes Waiwhakaata is an existing experience to view a series of small lakes with incredible reflective views of the surrounding wetlands and the Earl Mountains. This is proposed to remain as a short stop where the existing accessible boardwalk and viewing platform are located. Under the proposed access model, the sealed carpark is prioritised to be a hop on/hop off bus service and express coaches with a small area for short-term vehicle and campervan parking. The short stop will be enhanced with additional infrastructure, including weather/bus shelter, interpretive displays, and upgraded toilet facilities.

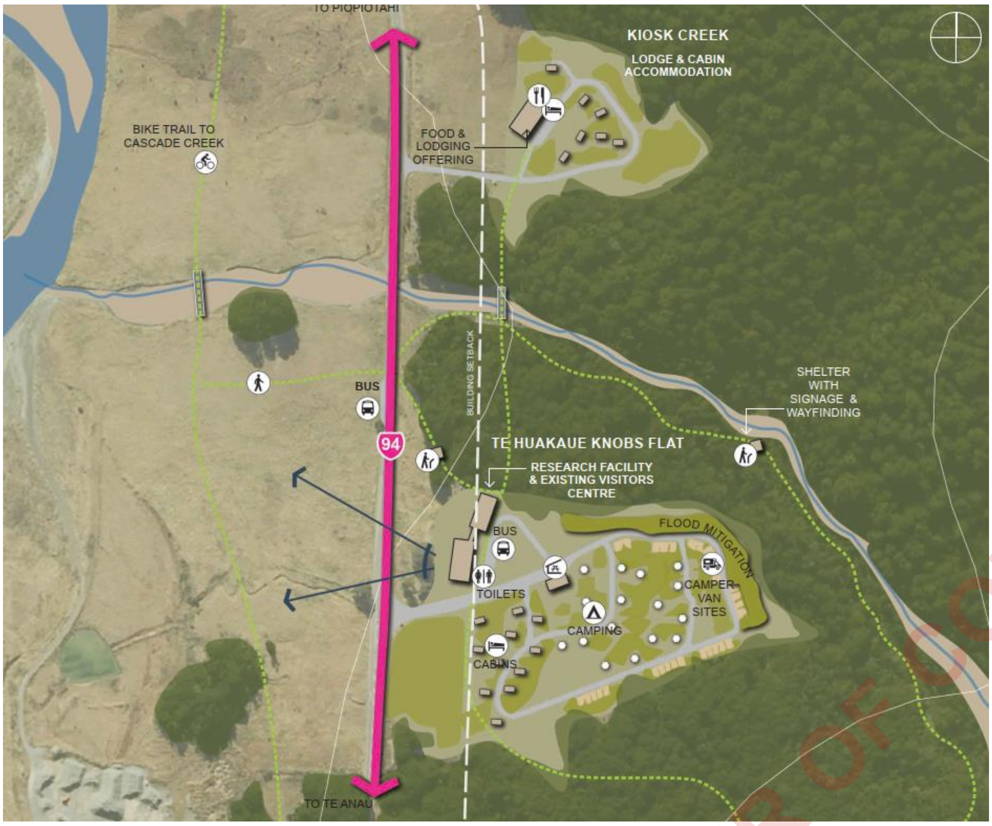


Figure 11: Knobs Flat – Concept plan – MOP Masterplan document

5.2 PRIMARY OPTION FOR CONSIDERATION

Te Huakaue Knobs Flat -The node has been classified as Class 2 for flooding and landslide risk. The node will require mitigation measures for flooding and landslides. The accommodation and Toilet block shelters have to be designed to IL4, which will require additional considerations with respect to maintaining services such as Power and 3 waters. The vertical infrastructures are feasible. The proposed upgrades for potable water are feasible. The wastewater treatment plant will require major upgrades to cater for the future wastewater flows. The assessment to risks to human health associated with potential contaminants of concern the PoL concluded a Low Risk at the site. The structures are geotechnically feasible. The foundations selection must take into account other disciplines such as natural hazard assessment to determine the foundation type.

MIRROR LAKES WAIWHAKAATA – Bus Shelter and toilet facilities are feasible.

5.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

5.4 NATURAL HAZARD RISK ASSESSMENT66

5.4.1 *PART A: ASSESSMENT*

Te Huakaue Knobs Flat (Node 3) is situated on an active alluvial fan located in the Eglinton River Valley and is assessed as being exposed to flood and debris flows from Kiosk Creek and Waterfall Creek which are tributaries of the Eglinton River. This site has been assessed as having a low probability of hazard occurrence due its distance from Kiosk Creek and Waterfall Creek and the implementation of various earthworks comprising formed bunds and cut drainage ditches along the eastern extent of the site to mitigate the potential flooding hazard. However, the site serves as an accommodation, as such the exposure time is assessed greater than 180 minutes which, when considering the hazard footprint, occurrence interval and exposure time, the site class is determined as Class 2. A Class 2 site has a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time.

MIRROR LAKES WAIWHAKAATA is assessed as a Class 1 site. Class 1 sites are those with a sufficiently low hazard probability or exposure time so that risk to visitors is minimal.

5.4.2 *PART B: ASSESSMENT*

Te Huakaue Knobs Flat (Node3) is exposed to Landslide and Flooding.

Table 10: DOC Risk levels and mitigation for visitors and workers

NATURAL HAZARDS	RISK	CATEGORY	MITIGATION MEASURES
Landslide	Substantial – High	Visitors	Continue with the proposal only after a high-level review. Close the site.
Landslide	Moderate to Substantial	Workers	Reduce the risk to as low as practicable. Continue with the proposal after a high-level review.
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation Measures suggested.

SOCIETAL RISK -LANDSLIDE

For the most likely event:

- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Te Huakaue Knobs Flat.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.

- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

5.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Extreme weather (high winds and storms) and heavy rain events represent the highest risk at this location. Current overall risk levels for these hazards are moderate. Frequency and intensity of these events increases over time, increasing the level of flooding risk to infrastructure and assets to high over time. Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires.

Table 11: Climate change Risk Summary: – Te Huakaue Knobs Flat

wsp			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Node 3 – Knobs Flats	BUILDINGS	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid-centur	N/A	Moderate	Moderate	Low	Moderate	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Mid-centur	N/A	Moderate	Moderate	Low	Moderate	Low	Moderate
	GENERAL INFRASTRUCTURE	Mid-centur	N/A	Moderate	Moderate	Low	Moderate	Low	Moderate
	BUILDINGS	Late-centur	N/A	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Late-centur	N/A	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Late-centur	N/A	High	High	Low	Moderate	Low	High

5.6 GEOTECHNICAL ASSESSMENT

KNOBS FLAT TE HUAKAUE & KIOSK CREEK

The following is noted for Knobs Flat Te Huakaue & Kiosk Creek

- The Masterplan structures listed at this site are an accommodation expansion, modifications to the camping and campervan layout, new accommodation at Kiosk Creek Te Huakaue and trail head facilities (refer Figure 15: Conceptual plan for Knobs Flat Te Huakaue & Kiosk Creek).
- Elevation: The site ranges from approximately 360 m to 370 m ASL.
- Closest active fault: Unnamed Fault, located approximately 6.5 km southeast of the site.
- Geological Map Information: Site is located within the mapped geological unit: Holocene fan deposits (loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium.
- Environment Southland Liquefaction Risk Map: Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- A geotechnical investigation was completed by GeoSolve and issued as a draft in July 2019 for the Knobs Flat Te Huakaue site. Note that the investigation did not include the Kiosk Creek area. The investigation consisted of 29 Test Pits (TP), 10 Super Heavy Dynamic Probe (DPSH) tests, 2 Scala Penetrometer Tests (Scala), 4 Sonic Boreholes (BH) and 1 Cored Borehole. The TPs were advanced to a maximum depth of 5.5m bgl and BHs to 20m bgl.
- Results from the GeoSolve investigation generally align with the published geological mapping. GeoSolve noted the presence of man-made uncontrolled fill up to 0.8m depth encountered in Test Pits 1, 2, 3, 7 and 8 and BH04. Alluvial fan deposits appeared to be underlain by dense glacial till.
- GeoSolve's report, site visit and photographs indicate that the site has been disturbed by historical construction and earthworks. It is likely that uncontrolled fill has been placed over alluvial fan deposits, such as the parking lots. The site will also likely have deposits from the Kiosk Creek, which passes close to the east and north sides of the site.
- GeoSolve notes that the site has a liquefaction potential of low to major with significant variance across the site. GeoSolve also indicates that the site might experience lateral spreading. Liquefaction and lateral spreading are only expected occur in the alluvial river and fan deposits.

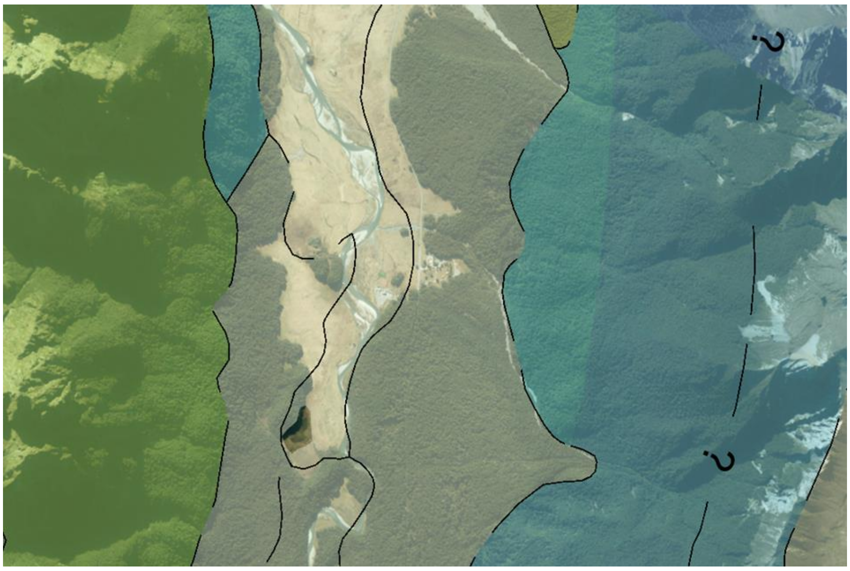


Figure 12: Knobs Flat Te Huakaue Kiosk Creek – Published Geology

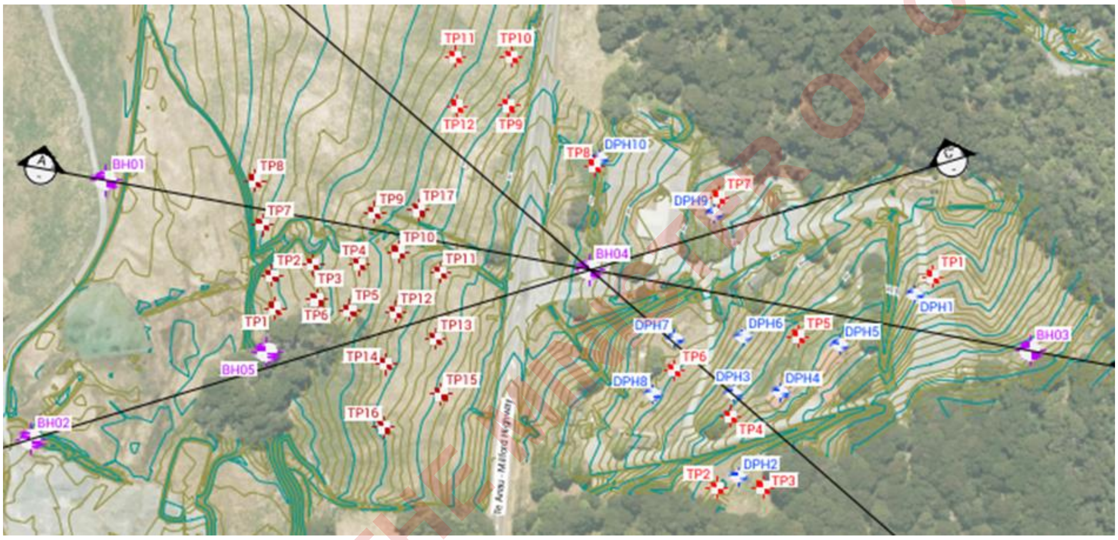


Figure 13: GeoSolve Map of their Geotechnical Investigation

Figure 14: Knobs Flat Te Huakaue parking lot with gravel stockpile

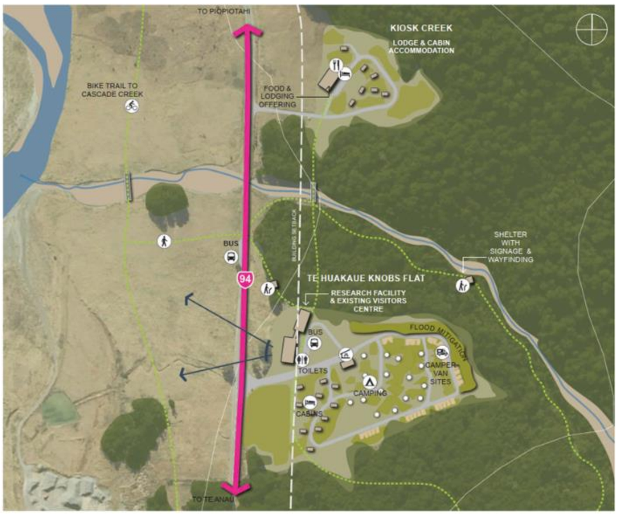


Figure 15: Conceptual plan for Knobs Flat Te Huakaue & Kiosk Creek

The site soils likely consist of alluvial fan deposits over bedrock at depth. The alluvial fan sediments are likely to be interbedded cobbles, gravels, sands, and silts with variable (in thickness and area) fine grained layers. Due to the activity on the site, uncontrolled fill is likely present over some areas.

Proposed additions to the site include expansion of the existing accommodation facilities, additional accommodation in the form of a small lodge at Kiosk Creek (to the north of the stream), optimising the existing camping and campervan layout, and trail head facilities for short walks. See Figure 15 for the conceptual plan for Knobs Flat Te Huakaue.

Due to the range and size of structures proposed for the site a range of foundations will likely be necessary. The structural details such as the shape, footprint and number of storeys will determine the types of foundations. For example, the bus stop will require a different foundation solution to the accommodation building. Ground conditions are also likely to vary across the site, which will impact the type of foundation recommended.

The draft geotechnical report by GeoSolve provides some preliminary foundation recommendations. The GeoSolve report was issued in 2019 and therefore, as discussed in Section above, it won't have used the new NSHM 2022 to assess the seismic hazard to the site. Therefore, the recommendations presented in the report should be used with caution and only as a high-level guide as the new model may alter the recommendations for the site. The GeoSolve recommendations are summarized in Table 12 below.

Table 12: Foundation types

STRUCTURE	FOUNDATION	LIMITATIONS
Timber Floor	Timber piles	Simple shapes, lightly loaded
Concrete Floor (1-2 storey Building	Ground improvements (reinforced gravel raft)	Smaller buildings (1-2 storey)
Lodge Accommodations (up to six storeys)	Bored Concrete Piles (CFA*) in conjunction with lateral spread protection	Up to six storey building

In addition, consideration of the natural hazards associated with the site will also influence the foundation selection. For example, ground improvements to raise the ground level to prevent inundation from flooding from Kiosk Creek may be required in combination with piles to support the structure. Detailed design of the foundations will need to incorporate the site assessment results from other disciplines, such as natural hazard assessment, to determine the final foundation options.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. A significant factor in selecting the foundations will be the structures final design and loading requirements.

SHORT STOP: MIRROR LAKES WAIWHAKAATA

The following is noted for the Mirror Lakes Waiwhakaata:

- The Masterplan structures listed at this site are a bus shelter and toilet Facilities.
- Elevation: the site is approximately 320 m ASL.
- Closest active fault: Unnamed Fault #8429, located approximately 2.4 km east of the site.
- Geological map information: Site is located on the boundary between the following two mapped geological units, see Figure 16 below:
- Underlying the road, carpark, and part of the walkway: Holocene fan deposits (Loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree upslope) and valley alluvium.
- Underlying the mirror lakes themselves and part of the walkway: Holocene River deposits (unconsolidated gravel, sand, silt, clay, and minor peat of modern to postglacial flood plains, may be terraced).
- Environment Southland Liquefaction Risk Map: Holocene Fan deposits listed as Negligible Risk; Holocene River deposits listed as Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.

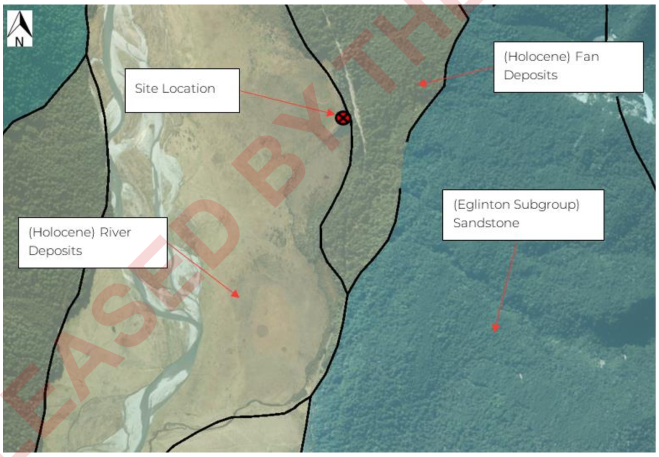


Figure 16: Short Stop: Mirror Lakes Waiwhakaata – Published Geology

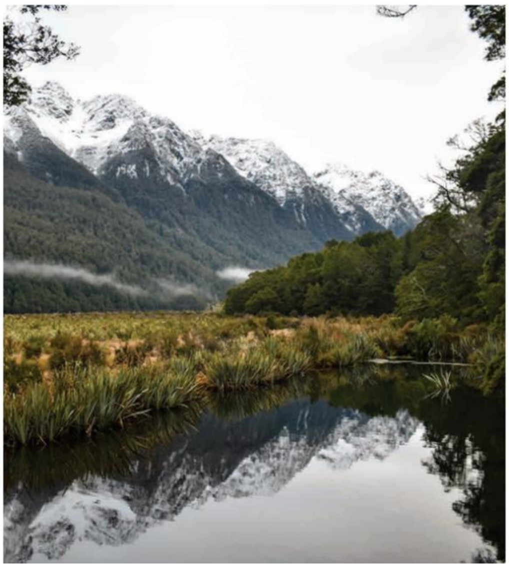


Figure 17: Short Stop: Mirror Lakes Waiwhakaata looking Northwest across the Eglinton Valley (MOP Masterplan, 2021)

Based on the MOP Masterplan the proposed structures are to be located at the current car park. This is relatively close to the lake, but elevated above the lake, and ground water is assumed to be at a depth relative to the lake level. Site observations indicate that the car park is founded on either the river deposits, and / or on the debris fan deposits with bedrock at depth. Based on the available information it is expected that the soils have negligible to low liquefaction potential, and that lateral spread is unlikely to occur.

The river sediments and debris fan sediments are likely to comprise a wide distribution of grainsizes, from silt to gravel. In the debris fan deposits it is likely that the soils will also have cobbles and boulders present in varying quantities. The river and fan deposits will be suitable for simple lightly loaded structures to be founded on. If large enough boulders are encountered additional effort may be required for excavation and construction to the required foundation depth.

Based on the MOP Masterplan, the proposed structures at this site include a bus stop, toilet facilities and interpretative displays. These structures will most likely be lightly loaded and may be founded on shallow strip or spread foundations. The expected soils at the site should have adequate bearing strength at relatively shallow depths to support structures of this type without piled foundations or significant ground improvement techniques.

The development as shown in the MOP Masterplan, at this stage, is geotechnically feasible.

5.7 THREE WATERS INFRASTRUCTURE CONDITION

5.7.1 WATER SUPPLY

5.7.1.1 EXISTING WATER SUPPLY

There is a water treatment system at Te Huakaue Knobs Flat that treats the water drawn from the Kiosk Creek tributary. The untreated water drawn from the tributary is stored in two 30,000 L PE tanks. The water from the tank is supplied to the water treatment plant, where it is filtered through 1 µm cartridge filters before passing through a UV reactor for disinfection. The treated water is provided to the site on demand, with no treated water storage tanks.

Considering the proposed development at Te Huakaue Knobs Flat and Kiosk Creek as well as day visitors who may use drink bottle fill points, the water supply will likely be classified as large under Taumata Arowai's Drinking Water Quality Assurance Rules (servicing a population of greater than 500 people).

There is a single ring main that services existing buildings on the site. The size and material of this watermain is unknown.

5.7.1.2 WATER DEMAND

SOURCE	CURRENT			FUTURE		
	Per Capita Demand (L/day)	Population	Daily Volume (m^3)	Per Capita Demand (L/day)	Population	Daily Volume (m^3)
Te Huakaue Knobs Flat Campground	80	50	4	80	150	12
Te Huakaue Knobs Flat Cabins	150	14	2.1	150	30	4.5
Kiosk Creek Campsite	-	20	-	80	50	4
Kiosk Creek Lodge	-	-	-	150	50	7.5
Te Huakaue Knobs Flat Public Toilet	5	2,000	10	5	3,500	17.5
DOC Accommodation	150	6	0.9	150	6	0.9
Total Daily Volume (m^3)			**17.0**			**46.4**
Average Demand (L/s)			0.20			0.54
Peak Demand (L/s)			0.60			1.61

As water for the Te Huakaue Knobs Flat supply is drawn from the hydro penstock, the quantity of source water is not seen as a constraint for the development of the three waters servicing for this site. However, a larger water take will require a new resource consent or permit. Instead, the

capacity of the wastewater treatment system to handle higher flows that will result from the introduction of a potable water supply represents the primary limitation.

5.7.1.3 TREATMENT UPGRADES

As there is no existing treated water storage at Te Huakaue Knobs Flat, it is recommended that sufficient storage for 24 hours peak demand be provided for security of supply. As shown in Table 13, a total treated water storage volume of no less than 50 m3 is recommended. The water storage could be either a longer life and more durable bolted steel tank or cheaper PE tanks.

The following upgrades will be needed for the water treatment to meet the large supply (>500 people served) requirements under the DWQAR:

- Turbidity, pH, and conductivity monitoring of the raw water.
- Differential pressure measurement across the cartridge filters.
- Flow, turbidity and UVT monitoring for the UV reactor.
- Chlorine dosing system.

- Flow, turbidity, pH, and free available chlorine monitoring for the treated water.

A cost estimate for upgrade of the Te Huakaue Knobs Flat and Kiosk Creek water supply is provided in Table 13. This estimate assumes water storage tanks are bolted steel.

Table 13: Te Huakaue Knobs Flat and Kiosk Creek Water Supply Upgrade Estimated cost

ITEM	ESTIMATED COST
Upgrade of Water Storage (50 m³)	$180,000 – Bolted steel tank

ITEM	ESTIMATED COST
Treatment Plant Upgrades	$120,000
Water Supply Pipeline to Kiosk Creek (below River)	$500,000
Total	**$800,000 – bolted steel tank**

No allowance for the upgrade of the existing ring main has been provided. WSP has not been provided with any history on any bursts or repairs on this main. As such its condition is assumed to be suitable.

The provision for treated water storage provides contingency during WTP outages and if the penstock intake is damaged. It is noted that if the penstock is damaged, there would be no power at the site and likely requiring evacuation until the power supply is repaired.

5.7.1.4 FEASIBILITY

The proposed upgrades to the water supply at Te Huakaue Knobs Flat are considered feasible. The next best alternative would be to utilise PE tanks for water storage which would cost an estimated $30,000 and provide cost savings of approx. $150,000. It is noted that plastic tanks are affected by UV which can cause degradation. Steel tanks will have longer life. Both will last >20 years and the estimated life of each depends on several factors. Steel is preferred.

5.7.2 WASTEWATER

5.7.2.1 EXISTING WASTEWATER SYSTEM

The size and materials of the existing sewers, manholes and cleaning eyes is unknown but expected to be 100 or 150mm in diameter. Kiosk Creek campground has toilets with containment tanks.

5.7.2.2 WASTEWATER TREATMENT

The current WWTP has been recently upgraded. This system, installed in 2023 is an Innoflow package system consisting of septic tanks, media textile biological stage, recirculation system, and UV disinfection with discharge to two soakage trenches. The resource consent permits up to 40 m3/d of treated effluent discharge. Data presented by Lowe Environmental shows good removal of BOD and TSS through the summer period (Lowe Environmental Impact, 2024). Flows are reported to average 15.3 m3/d during the peak tourist season (for the period of 25 October 2023 to 8 Feb 2024)

With a peak day of 27 m3/d at around the new year period. The current WWTP is designed to achieve the effluent limits in Table 14 based on the consent conditions.

Table 14: Te Huakaue Knobs Flat WWTP Consented Effluent Discharge Quality Limits

PARAMETER	EFFLUENT LIMITS
Total suspended solids	30 mg/l (in 3 of 4 samples)
BOD	30 mg/l (in 3 of 4 samples)
Total suspended solids	< 50 mg/l upper limit
BOD	< 50 mg/l upper limit
E Coli	< 200 (in 3 of 4 samples)

Effluent quality data provided shows the WWTP regularly does not achieve E coli and BOD requirements. Effluent monitoring data from 2023 shows that the upgraded WWTP is performing well for TSS removal and regularly achieves consent requirements.

Prior to the recent upgrades, effluent with 70 mg/L of ammonia (as N) was being discharged to bore soakage areas (Milford Sound Tourism Limited Knobs Flat Eco Lodge Wastewater Management Assessment of Treatment Options, John Cocks Limited, 2019). This level of ammonia is harmful to many species of aquatic life and effluent should be treated to a much higher standard. The O&M manual for the upgraded WWTP (Innoflow, 2023) shows the system was not designed for nutrient removal, so high levels of ammonia are expected in effluent, however Ammonia is not currently monitored. (Lowe Environmental, 2024).

5.7.2.3 EFFLUENT DISPOSAL

Two new effluent soakage trenches were constructed as part of the recent WWTP upgrade. It is assumed that ground conditions were deemed to be suitable given the new construction.

Investigations by Geosolve in 2019, as part of MSTL's proposed redevelopment of the site, assessed the areas for suitable land disposal. Permeability tests showed a variety of soil types in the area, which are composed of alluvial deposits, so have areas of sand, sandy silty and silt. The sand areas have greater permeability and are more suitable for land disposal. Underlying the fluvial deposits are glaciated bedrock and hummocks which may form a barrier to disposal, noting that where the water is unable to permeate to depth, localized tracking may occur resulting in indirect flow into the watercourse. This substratum means that a wastewater discharge will permeate to a shallow depth and then track laterally and may indirectly enter local streams. Usually there will be high dilution from rainfall contribution to groundwater and dilution in the stream, but in extended dry periods there is potential for effect on the receiving aquatic environment.

However, the impact of high ammonia concentrations as described above may have impact on the local aquatic environment and the same pathway may contribute human derived bacteria to surface water. It is therefore recommended that any WWTP upgrades produces a high quality of effluent that minimises impact of ammonia and human derived bacteria.

Table 15 provides an estimate of the future flows as based on the expansion plans in the Masterplan. Peak volume estimate is based on 2 x DWF. This assumes the network is constructed to a high standard with limited infiltration and ingress through network.

This is considered reasonable given the small size of the network and corresponds with the flow data provided. For existing conditions, the peak day volume approximately matches the observed peak 27 m3/d reported above.

The upgrades proposed in the masterplan will increase the estimated peak dry weather flow to approximately 100 m3/d. Increase in visitors to public toilets are assumed to be proportional to

total visitor number increase. While there are additional toilets proposed at other nodes proposed in the masterplan, Te Huakaue Knobs Flat has a reputation of being the last flush toilet before Milford Sound Piopiotahi and is a popular stop for coaches. This is expected to continue with the increase in visitors. The estimated future flow is above the current operational capacity of the existing WWTP.

It is understood that MSTL had previously developed plans for alternate development at Te Huakaue Knobs Flat. This assessment considers the masterplan proposal only.

Table 15: Existing Estimated Dry Weather Wastewater Flow at Te Huakaue Knobs Flat and Kiosk Creek

SOURCE	CURRENT		
	PER CAPITA CONTRIBUTION (L/DAY)	POPULATION	DAILY VOLUME (M^3)
Te Huakaue Knobs Flat Campground	80	50	4
Te Huakaue Knobs Flat Cabins	150	14	2.1
Kiosk Creek Campground	-	-	-
Kiosk Creek Cabins	-	-	-
Te Huakaue Knobs Flat Public Toilet	5	2,000	10
DOC Accommodation	150	6	0.9
Total Volume (m^3/d)			**17.0**
Estimated Peak Flow (m^3/d)			**34.4**

It is noted that the existing flow estimate corresponds to the recorded flows.

Table 16: Future Estimated Dry Weather Wastewater Flow at Te Huakaue Knobs Flat and Kiosk Creek

SOURCE	FUTURE		
	PER CAPITA CONTRIBUTION (L/DAY)	POPULATION	DAILY VOLUME (M³)
Te Huakaue Knobs Flat Campground	80	150	12
Te Huakaue Knobs Flat Cabins	150	30	4.5
Kiosk Creek Campsite	80	50	4
Kiosk Creek Lodge	150	50	7.5

SOURCE	FUTURE		
	PER CAPITA CONTRIBUTION (L/DAY)	POPULATION	DAILY VOLUME (M³)
Te Huakaue Knobs Flat Public Toilet	5	3,500	17.5
DOC Accommodation	150	6	0.9
Total Volume (m³/d)			**46.4**
Estimated Peak Flow (m³/d)			**92.8**

5.7.2.4 WASTEWATER NETWORK UPGRADES

The Stage 2 Infrastructure report (Stantec, 2021) identifies the wastewater at Kiosk Creek and at Te Huakaue Knobs Flat as separate systems. WSP recommend that to minimise capital and operational costs of facilities that these be integrated into one wastewater system. For wastewater this will require a transfer pump station to reach the location of the wastewater treatment system. This approach also increases the flexibility of the location of a WWTP which will be dictated by the availability of suitable land for disposal trenches.

5.7.2.5 WASTEWATER TREATMENT PLANT UPGRADES

LEVEL OF TREATMENT

Recent performance data and O&M information (LEI 2024, and Innoflow 2024) indicates that the WWTP is suitable for carbonaceous treatment only (removal of organic carbon compounds). It is not designed to lower nitrogen levels by nitrification and denitrification. It is therefore expected that continuing to use the existing system will not meet the proposed criteria. There are add-ons to the existing WWTP system that can reduce nitrogen, however it cannot be confirmed these will meet the proposed requirements.

SELECTION OF PREFERRED TREATMENT OPTION

To select the appropriate treatment option, a multi-criteria Analysis was undertaken.

This review considered the following options:

- Tankering wastewater offsite for treatment at suitable WWTP.
- Septic tank and Rotating Biological Contactor (RBC).
- Septic tank and Moving Bed Bioreactor (MBBR).
- Septic tank and porous media filter (PMF) (like existing Innoflow system).
- Septic tank and trickling filter (TF).
- Membrane Bioreactor (MBR).

The table below presents scoring for each criterion based on the advantages and disadvantages of each treatment option. All scores are relative to the base solution of the MBR as this system is the only solution that meets the minimum environmental performance criteria that was identified.

Table 17: Multi-criteria assessment scoring for Te Huakaue Knobs Flat and Kiosk Creek

PARAMETER	MBR	TANKER AWAY	SEPTIC TANK AND RBC	SEPTIC TANK AND MBBR	SEPTIC TANK AND PMF	SEPTIC TANK AND TRICKLING FILTER
Health and Safety	0	0	0	0	0	-1
Cost – Capital Expenditure	0	4	2	2	3	2
Cost – Operational Expenditure	0	-5	1	-2	-1	-1
Resilience to local climate	0	0	0	0	-1	-3
Effluent quality	0	0	-3	-2	-1	-2
Cultural Acceptability	0	0	-3	-2	-1	-2
Adaptability to changing load	0	-2	-2	-1	-1	-2
Constructability - Footprint	0	0	-2	-2	-4	-4
Operator Skill Level	0	2	3	2	2	2
Total Score	**0**	**-1**	**-4**	**-5**	**-4**	**-9**

Table 18: Estimated Operational Costs – Te Huakaue Knobs Flat and Kiosk Creek

ITEM	UNIT	MBR	TANKER AWAY	SEPTIC TANK	SEPTIC TANK AND RBC	SEPTIC TANK AND MBBR	SEPTIC TANK AND PMF	SEPTIC TANK AND TRICKLING FILTER
Daily Peak Volume	m^3	1.4	95	2	3	3	3	3
Tankers Per Year	$	17	1156	24	37	37	37	37
Tanker Cost	$	$ 34,070	$ 2,311,670	$48,670	$73,000	$73,000	$73,000	$73,000
Power Cost (@40c/kwh)	$	$ 14,020	$0	$0	$11,680	$23,360	$14,020	$9,450
Operator Hours/yr	hrs	408	120	132	232	376	252	356
Operator Cost @100/hr	$	$40,800	$12,000	$13,200	$23,200	$37,600	$25,200	$35,600
Membrane Replacement (Annualised)	$	$10,000	-	-	-	-	-	-
Total Opex	**$**	**$98,890**	**$ 2,323,670**	**$61,870**	**$107,880**	**$133,960**	**$112,220**	**$117,950**

The estimates of operational expenditure costs indicate that the MBR is more expensive than other treatment options which produce a lesser quality outcome.

RECOMMENDED TREATMENT OPTION

The recommended WWTP at Te Huakaue Knobs Flat is an MBR, consisting of the following:

- New inlet balance tanks to buffer peak loading.
- Inlet pumps to feed the treatment plant.
- 2 mm fine screens, mounted over the treatment reactor.
- An anoxic zone and aerated reactor zone.
- Membrane modules
- Washwater and backwash storage tanks.
- Pipe, pump, and blower room.
- UV disinfection.
- Control building with operations facility and sludge thickener.

Figure 18: Te Huakaue Knobs Flat indicative wastewater treatment plant layout

Figure 18 presents the indicative site layout. The existing septic tanks could be repurposed for sludge storage.

This location has been selected as the indicative site of the new WWTP as it is currently designated for wastewater treatment and is considered large enough for construction of the new plant with good vehicle access. The site layout for Te Huakaue Knobs Flat and Kiosk Creek are not finalised, and other locations may create visual or perceived nuisance to those plans.

It will be necessary to decommission the existing WWTP during construction, so may be managed through either retaining a single tank or use of a temporary tank for buffering and removal by tankering. This work should be undertaken off-peak to minimise the wastewater being removed from site, allow for safer working, and minimise disturbance.

RECOMMENDED EFFLUENT DISPOSAL OPTION

For Te Huakaue Knobs Flat it is recommended that high quality effluent from the MBR be discharged to land through gravel infiltration trenches. Due to varying groundwater, and if inflows exceed soakage capacity during wet periods, these trenches should be designed to overflow to a gabion channel before discharge to surface water. Effluent land contact before discharge to surface water is a cultural preference.

Iwi engagement on Te Mana o te Wai is recommended for all effluent discharges. This approach minimises the land requirements and the visual impact.

Surface irrigation was considered but is not considered suitable. There is unlikely to be public acceptance of spraying effluent and there are increased risks of odour. Furthermore, due to low winter temperatures and low volumes discharged, surface irrigation is impractical as the equipment may freeze.

Subsurface dripline irrigation may be possible but would require large areas which will be off limits to the public. Subsurface dripline irrigation always requires high effluent quality and regular maintenance is required to prevent clogging and loss of capacity.

Testing of gravel fan deposits found soakage rates of 6 x 10-5 to 1 x 10-4 m/s (Geosolve 2019). Assuming a site soakage rate of 1.73 m/day (6 x 10-5 m/s with a factor of safety of 3), the minimum required footprint to discharge 100 m3 of effluent per day is approximately 60 m2. This is suggested feasible if located west of the highway. This may be constructed as a series of 1 m wide trenches running parallel to the contours. Selecting the final location for effluent soakage will require further assessment during design development to confirm soakage rates and avoid non suitable areas.

Figure 19: Te Huakaue Knobs Flat indicative effluent disposal system and plant layout

Figure 19 presents an indicative layout of the proposed effluent soakage system layout. No Hazardous Activities and Industries List (HAIL) sites have been identified at the indicative soakage locations shown below (WSP, 2024).

5.7.2.6 DESIGN NEXT STEPS

During the development of the indicative WWTP and effluent disposal system, reference has been made to available information and assumptions have been made. The following next steps are recommended in developing the WWTP design for Te Huakaue Knobs Flat:

- The selected WWTP location is indicative only and has been selected as it is currently designated for wastewater treatment and is expected to be large enough for construction of the new plant. As the final layout for Te Huakaue Knobs Flat and Kiosk Creek is developed it should be confirmed this site is appropriate.
- Further characterisation of wastewater flows and loads should be undertaken for sizing treatment processes that can achieve performance criteria for the variable wastewater flows throughout the year. Monitoring at peak periods of flow and visitor numbers of each category will be required to calibrate the design. Alternatively, a conservative estimate may be used.
- Further geotechnical investigations are required confirm the indicative soakage location shown is appropriate and to develop details of this system.
- An Assessment of Environmental Effects of treated effluent discharges will be required. This document links to resource consent application, and demonstrates the expect impacts on the receiving environment as surface water, groundwater and odour emissions on water quality and ecology and the risks to public health.
- Hazards associated with construction, operation, maintenance, decommission and possible effects on the public are considered through a safety by design process.
- Engagement with iwi is required to confirm soakage of treated effluent to ground is acceptable at this location.

5.7.2.7 FEASIBILITY

The increase in wastewater volume because of the Masterplan proposal will require a larger capacity WWTP to meet future wastewater flows.

The proposed effluent quality requirements will also require an upgrade. An MBR system was used in the estimate as this provides the highest quality discharge. This is feasible and is considered BATNEC (Best Available Technology Not Incurring Excessive Cost).

Table 19: Kiosk Creek and Te Huakaue Knobs Flat Wastewater Upgrades Estimated Cost

ITEM	ESTIMATED COST
New WWTP (MBR)	$8,800,000
Wastewater network (includes pumping from Kiosk Creek)	$500,000
Land disposal upgrade	$1,000,000
Total	**$10,300,000**

The next best alternative to a new plant is to upgrade the existing Innoflow WWTP with additional reactor beds to handle the additional flow and additional tanks for denitrification. This will likely to be required at an alternative location to the existing plant due to space limitations. While the existing footprint is relatively small the additional area required for denitrification and additional capacity is much larger than existing.

Table 20: Kiosk Creek and Te Huakaue Knobs Flat Wastewater upgrades estimated cost – Next best alternative.

ITEM	ESTIMATED COST
Upgrade Existing Innoflow WWTP	$1,500,000
Wastewater network (includes pumping from Kiosk Creek)	$500,000
Land disposal upgrade	$1,000,000
Total	**$3,000,000**

The selection of which technology is most suitable for future needs will be made during an Assessment of Environmental Effects during the consent renewal process.

The cost estimates have been prepared bottom up, based on a similar sized project constructed in 2023. The cost estimate includes:

- Equipment purchase.
- Installation.
- Civil, mechanical, electrical, structural, piping and controls.
- Buildings.
- Gravel access road.
- Land disposal earthworks.
- P&G at 15%.

5.7.3 STORMWATER

There is existing stormwater infrastructure at Te Huakaue Knobs Flat. Improvements to these networks can be made to improve the quality of the stormwater discharge. Options here could include bioswales, stormwater wetlands or oil and grit separators. These options are considered feasible and should be considered when designs are being developed.

No estimate has been provided as there is no requirement to undertake improvements and the cost to implement can vary significantly.

5.7.4 MIRROR LAKES WASTEWATER

Two new toilets are proposed at the existing Mirror Lakes short stop.

Table 21 presents estimated wastewater generation with 500 users per day at this stop.

Table 21: Mirror Lakes Wastewater Generation Rates.

WASTEWATER SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment tank only	0.2	0.1

It is recommended two 3 m3 total containment units and toilet building. Tanks to be emptied periodically by septage tanker. As hand washing facilities are not recommended at this small site, hand sanitiser will need to be provided.

A level monitoring probe on each tank with GSM link to notify of high level is recommended.

An estimated cost for this option is presented in Table 22.

Table 22: Mirror Lakes Containment Tanks Estimated Cost

ITEM	ESTIMATED COST
Containment and toilet building	$150,000
Level monitoring	$5,000
Project overheads and delivery	$75,000
Total	**$230,000**

5.7.4.1 FEASIBILITY

It is recommended that the Mirror Lakes short stop wastewater system is a total containment tank with two pans as described. This option is considered feasible.

5.8 CONTAMINATED SITES

The overall contaminated land risk remains low as per the PSI carried out for Knobs Flat. Further assessment of the risk to human health and the environment should be completed should ground disturbance and potential mobilisation of contaminants occur with the defined pieces of land.

WSP recommends that:

- Should any ground disturbance be planned in the locality of the defined pieces of land a detailed site investigation be undertaken prior to further assess the risks to human health and environment.
- An accidental discovery protocol is put in place during ground disturbance on the site and a contaminated land specialist is to be contacted should any unexpected ground conditions be encountered.

The Hazardous Activities and Industries List (HAIL) assessment classifies the site as RED. HAIL activities (current or past) are likely or known.

5.9 VERTICAL INFRASTRUCTURE

5.9.1 TE HUAKAUE KNOBS FLAT

Accommodation includes Cabins, Toilet block shelters – Post Disaster function to be determined.

- Due to proximity to good road access this cannot be considered a back country hut and will need to comply with the New Zealand Building Code.
- It is considered that the NZBC dispensations available for back country huts will not apply here.
- The accommodation will not provide for crowd activities, but due to its remote location on the access corridor to Piopiotahi Milford Sound, the accommodation may have a post disaster function. IL2 or IL4
- An IL4. There are natural hazards at this site, but the construction of this structure is considered feasible. Many other structures have been successfully constructed within Eglinton Valley.
- An IL4 structure will require additional considerations with respect to maintaining services – power and wastewater.

TE HUAKAUE KNOBS FLAT INTERPRETATIVE EXPERIENCE: INTERPRETATIVE STRUCTURES, OPEN STRUCTURES / SHELTERS

- No post-disaster functions.
- Standard Structure with IL2 importance level. Construction is feasible.
- Many other structures have been successfully constructed within the Eglinton Valley.

TE HUAKUE KNOBS FLAT: INTERPRETATIVE BUILDING PROVIDING SHELTER AND HALL FACILITY – COMMUNITY FACILITY

- No post disaster function
- Single level 100m2. Standard Structure IL2.
- Small crowd actitivty – less then 100 people.
- Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.

TE HUAKAUE KNOBS FLAT: 3 WATERS- POTABLE WATER AND WASTEWATER INFRASTRUCTURE

- Structures associated with the potable and water treatment systems.
- No Post disaster function. Single level. Standard Structures. IL2
- WWTP buildings and plant support structures. Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.

TE HUAKAUE KNOBS FLAT – KIOSK CREEK ACCOMMODATION

- Proposed to be a 25-bed lodge with no post disaster function. 462m2 multilevel. Sleeping activity – fire protection required.
- Due to proximity to good road access, this cannot be considered a back country and hut and will need to comply with the New Zealand Building code. It is proposed to have an IL2 importance level.
- It is considered that the NZBC dispensations available for back country huts will not apply here.

- Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.

6 NODE 4: Ō-TĀPARA CASCADE CREEK CAMPSITE/MISTAKE CREEK OVERNIGHT WALK

NODE 4: - Ō-TĀPARA CASCADE CREEK CAMPSITE/MISTAKE CREEK OVERNIGHT WALK			
Proposal	Optimise the existing camping and campervan sites with improved landscape, Amenity facilities are also proposed with a few extra areas, including Wi-Fi, bus stops, track access, jetties, and boat storage etc.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic level risk analysis must be undertaken, and an advanced-level risk analysis may be required
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	Medium	Proposed upgrades to the site include flood protection infrastructure, simple lightly loaded structures, shallow timber piles or shallow strip or spread footing foundations.
	Three Waters Infrastructure	Low	Potable water will require upgrades. Wastewater upgrades are minimal.
	Contaminated Sites	Medium	PSI to further assess extent of possible HAIL activities on site, including site inspection.
	Vertical Infrastructure	Low	IL2 structure is feasible.
Overall Feasibility of the proposal	Notes – The proposed structures and amenities are feasible only if the Natural Hazards risks are further assessed and mitigated to as low as practicable.		

NODE 4: - Ō-TĀPARA CASCADE CREEK CAMPSITE/MISTAKE CREEK OVERNIGHT WALK		
Next Best Option	Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.	Feasibility: **Medium**

6.1 NODE SUMMARY

A tread lightly approach is proposed given the site's challenges with flooding and open landscape. It optimises the existing camping and campervan sites with improved landscape that breaks up and screens sites into clusters that can be individually booked. Amenity facilities are also proposed with a few extra areas, including Wi-Fi, bus stops, track access, jetties, and boat storage etc. The node would provide safe access opportunities for water-based experiences on Cascade Creek Ō-Tāpara /Lake Gunn and Eglinton River, such as kayaking and packrafting.

6.2 PRIMARY OPTION FOR CONSIDERATION

Ō-Tāpara Cascade Creek - The node has been assessed as Class 3 for Flooding / rockfall and landslide, and Class 2 for Tsunami. Further assessment of risk is necessary to determine the mitigation measures required to reduce risk. The proposed structures must be founded on elevated fill platforms to mitigate damage during floods. The flood protection infrastructure, optimised parking and campervan sites, a bus shelter, toilet facilities and support facilities for kayaking are feasible if the natural hazards risks are adequately addressed. The potable water upgrades is feasible. The existing toilets can be upgraded to cater for future requirements.

6.3 SECONDARY OPTION FOR CONSIDERATION

Detailed assessment of the Natural Hazards risk to be completed to reduce the risk as low as practicable. This will have an impact on the design of the proposed structures and amenities.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

6.4 NATURAL HAZARD RISK ASSESSMENT

6.4.1 PART A: ASSESSMENT

Ō-Tāpara Cascade Creek (Node 4) is the only site outside of Milford Sound Piopiotahi assessed as Class 3A for Tsunami, as per the GNS methodology, A Class 3 site indicates that Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic level risk analysis must be undertaken, and an advanced-level risk analysis may be required. Ō-Tāpara Cascade Creek is identified as a short stop and campsite location that is situated at the southern end of Lake Gunn on the confluence of Ō-Tāpara Cascade Creek and the upper Eglinton River.

The campsite is low-lying and is potentially exposed to flooding from both waterways. Large but infrequent landslides are also known to occur in the area such as the large-scale Lake Gunn landslide.

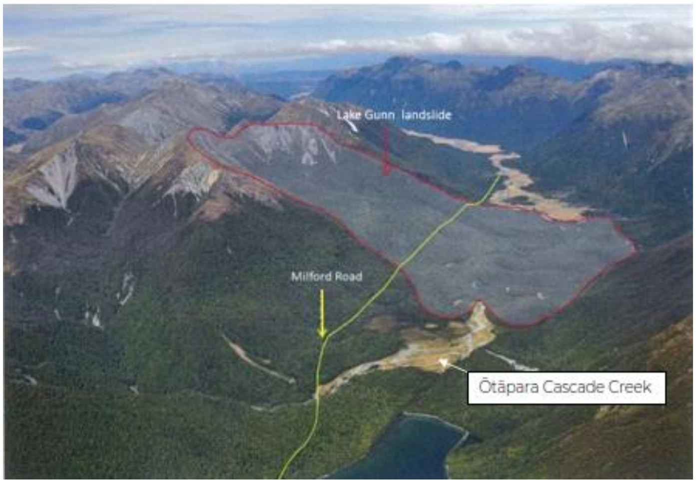


Figure 20: An aerial photograph of the Lake Gunn landslide (source: GNS Science)

TSUNAMI RISK

Lake tsunami can be triggered by either fault line activation or by landslide impacts. Land sliding caused by either earthquake or heavy rainfall into Lake Marian, Lake Gunn or Lake Fergus may in theory trigger a lake tsunami wave which could therefore impact the Ō-Tāpara Cascade Creek site.

Exposure at the Ō-Tāpara Cascade Creek site is estimated at over 180 minutes and therefore the site is assessed as a Class 2 site for landslide induced lake tsunami risk.

6.4.2 PART B: ASSESSMENT

Ō-Tāpara Cascade Creek site is exposed to Tsunami, Flooding and Landslide natural hazards.

Table 23: DOC Risk levels and mitigation for visitors and workers

Natural Hazards	Risk	Category	Mitigation Measures
Tsunami	Low	Visitors	Continue to monitor the site
Tsunami	Low to Moderate	Workers	Reduce to as low as reasonably practicable (lower priority) is recommended.
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Moderate to High	Visitors	Reduce to as low as reasonably practicable- Close the site
Landslide	Moderate to substantial	Workers	Reduce to as low as reasonably practicable. Continue with the proposal only after high level review.

6.4.2.1 SOCIETAL RISK – FOR TSUNAMI

For the most likely event:

— When the population at risk is 1, 5, or 40 we estimate there to be no fatalities.

For the maximum credible event:

— When the population at risk is 1, we estimate there to be no fatalities.

— When the population at risk is 5, we estimate there to be 5 fatalities.

— When the population at risk is 40, we estimate there to be 8 fatalities

6.4.2.2 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

— When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at, Ō-Tāpara Cascade Creek.

For the maximum credible event:

— When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.

— When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.

— When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10 – 40) at all sites.

6.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Given the proximity to the confluence of Cascade Creek and the upper Eglinton River and low flying areas, current flood risk levels are moderate. It is anticipated, however, that flood risk reaches extreme levels by the end of the century, as the frequency and intensity of extreme events increases over time.

It is also important to note that extreme weather (high winds and storms) and heavy rainfall events may also contribute to destabilise slopes and given that landslide hazards and debris flow hazards are also known to occur in the area, an increase in the frequency and intensity of these climate events over time could potentially see an increase in these risks.

Table 24: Ō-Tāpara Cascade Creek/Mistake Creek

WSP			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Node 4 – Cascade Creek	BUILDINGS	Cur t Y	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	BUILDINGS	Late- centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late- centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late- centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme

6.6 GEOTECHNICAL ASSESSMENT

The following is noted for Ō-Tāpara Cascade Creek:

- The Masterplan structures listed at this site are flood protection infrastructure, modifications to the camping and campervan sites, a new bus shelter and toilet facilities, and facilities for kayaking.
- Elevation: The site is approximately 480 m ASL.
- Closest active fault: Livingstone Fault #8262, located approximately 8.2 km northeast of the site.
- Geological Map Information: Site is located within the mapped geological unit: Holocene River deposits (unconsolidated gravel, sand, silt, clay, and minor peat of modern to postglacial flood plains, may be terraced). See Figure 21: Ō-Tāpara Cascade Creek – Published Geology below.
- Environment Southland Liquefaction Risk Map: Medium Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Proximity to Ō-Tāpara Cascade Creek increases likelihood that the site has been inundated during flooding events. These previous events would have deposited new soils across the site. The site has flood mitigation bunds installed around the Ō-Tāpara Cascade Creek camp site. At this time no records were available for works completed on site. Figure 21: Ō-Tāpara Cascade Creek – Published Geology below.

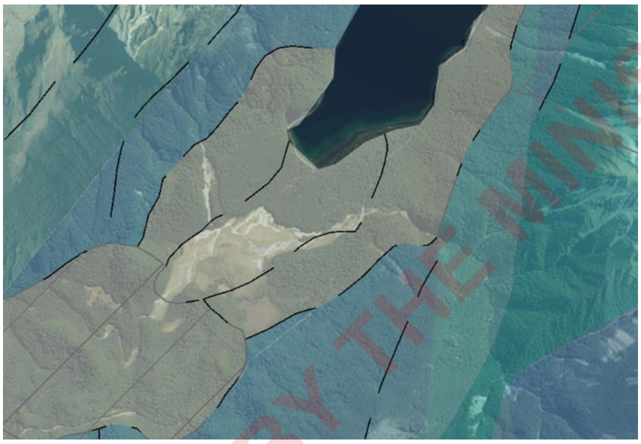


Figure 21: Ō-Tāpara Cascade Creek – Published Geology

Figure 22: Ō-Tāpara Cascade Creek looking south from the existing carpark.

The site likely consists of river deposits over bedrock at depth. The river deposits are anticipated to comprise well graded sediment from silts to gravels and cobbles. Based on the distance from the river, groundwater may be encountered at shallow depths. At this stage based on the available information the site is assumed to have a medium liquefaction potential. However, geotechnical investigation of the site will be used to confirm the soils onsite and whether groundwater is present at shallow depths and allow for determination if further liquefaction assessment of the site is necessary.

Proposed upgrades to the site include flood protection infrastructure, optimised camping and campervan sites, a bus shelter, toilet facilities and support facilities for kayaking. These are likely to be simple lightly loaded structures and shallow timber piles or shallow strip or spread footing foundations may be suitable.

As with Knobs Flat Te Huakaue, structures may need to be founded on elevated fill platforms to mitigate damage during floods. Detailed design of the foundation will incorporate the site assessment results from other disciplines, such as natural hazards, to determine the final foundation options.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point.

6.7 THREE WATERS INFRASTRUCTURE CONDITION

6.7.1 *WATER SUPPLY*

Both shelters at Cascade Creek Ō-Tāpara collect rainwater in two small polyethylene tanks (2 m3 each) which campers can use. The collected rainwater is currently not treated and is not suitable for drinking.

6.7.1.1 WATER DEMAND

Table 25: Cascade Creek Ō-Tāpara Water Demand Breakdown

SOURCE	WATER DEMAND (L/DAY)	POPULATION	DAILY VOLUME (L)
Campers (4 per site)	10	480	4,800
Day Visitors (Assumed)	4	100	400
Total Daily Volume (L)			**5,200**

The estimated roof area of the shelters at Cascade Creek Ō-Tāpara Campsite is 110 m2.

Table 26: Rainwater available from existing shelters

MONTH	HISTORICAL AVERAGE DAILY RAINFALL (MM)	AVERAGE DAILY VOLUME COLLECTED (M^3)
January	15.2	1.67
February	10.9	1.20
March	14.6	1.61
April	7.6	0.84
May	13.5	1.49
June	13.8	1.52
July	9.5	1.05
August	9.3	1.02
September	19.4	2.13
October	14.0	1.54
November	17.8	1.96
December	16.2	1.78

6.7.1.2 WATER SUPPLY OPTIONS

ROOF WATER

Assuming the user population is above 500 people for no more than 60 days per year, the Drinking Water Acceptable Solution for Roof Water Supplies could be used instead of the DWQAR rules, which would reduce cost and complexity. An on-demand treatment system consisting of filtration and UV disinfection could be used to supply treated water to a single supply point/building. As the site does not currently have power, a new power supply would be needed.

Table 27: Cascade Creek Ō-Tāpara Roof Water Supply Upgrade options estimated cost.

ITEM	ESTIMATED COST
Additional Roof Area (Assumed 110 m^2)	$110,000
Upgrade of Water Storage (Assumed 240 m^3 Additional Storage Required)	$60,000
Reticulation	$150,000
Treatment Plant Upgrades (including shed)	$250,000
New Power Supply	$20,000
Total	**$590,000**

BORE WATER

The existing water storage would be sufficient to provide 1 days' water storage. Like the roof water option, assuming the user population is above 500 people for no more than 60 days per year, the Drinking Water Acceptable Solution for Spring and Bore Water Supplies could be used instead of the DWQAR rules, which would reduce cost and complexity. An on-demand treatment system consisting of filtration and UV disinfection could be used to supply treated water to a single supply point/building. As the site does not currently have power, a new power supply would be needed. The bore would require a larger power supply than the roof water but is unlikely to make a material difference. In addition, the bore and treatment plant could be in a discrete location with reticulation supplied to each shelter.

Table 28: Cascade Creek Ō-Tāpara Bore Water supply upgrade options estimated cost.

ITEM	ESTIMATED COST
Bore Installation	$150,000
Reticulation	$100,000
Treatment Plant Upgrades (including shed)	$250,000
New Power Supply	$20,000
Total	**$520,000**

SURFACE WATER

Another potential source is a direct draw from the Creek. The water quality from the surface water sources in the area is good however may have quality issues during heavy rain. This is the poorest quality water of the three source options and therefore require the most treatment. This option would also be the most difficult to implement from an environmental perspective as it would require installing down or through the banks of the creek and into the creek itself. From this perspective we do not recommend that the surface water source is utilised.

6.7.1.3 FEASIBILITY

The upgrade to provide potable water to users of the Cascade Creek Ō-Tāpara is considered feasible with water being sourced using a bore and supplied to each of the existing shelters. The next best alternative would be to provide a supply using rainwater harvesting.

6.7.2 WASTEWATER

In 2017 DOC installed 4 double toilet blocks with each having an accessible toilet. There are several other single vault toilets around the camping ground. All toilets are total containment and are regularly emptied by septic tank trucks.

WSP have considered the population served the Cascade Creek Ō-Tāpara campsite and visitor toilets. As no population data is available, the analysis of the wastewater removal data indicates that around 218 m3 of wastewater was removed from the campground location annually, which equates to approximately 1,100 uses of toilets.

It is considered that by installing GMS linked level sensors the existing assets can be used to provide a more optimized service, so removing the need for additional facilities.

If hand washing was included at all facilities the estimated annual wastewater volume would increase to 1,800 m3. This volume is both impractical for tankering and will increase demand on water sources. The inclusion of hand washing facilities is not recommended and therefore hand sanitiser will need to be provided.

Table 29: Cascade Creek Ō-Tāpara Wastewater Estimated cost.

ITEM	ESTIMATED COST
Level Monitoring	$20,000
Total	**$20,000**

6.8 CONTAMINATED SITES

A review of historical aerials revealed Ō-Tāpara Cascade Creek was previously used as a Ministry of Works (MOW) campsite. Anecdotal evidence suggests that M.o.W campsites generally comprised prefabricated timber huts, that were moved along during the construction of the Milford Road. Hazardous Activities and Industries List (HAIL) activities may have occurred at Cascade Creek in the past. The site is classified ORANGE.

ORANGE indicates that HAIL activities (current or past) are likely or known.

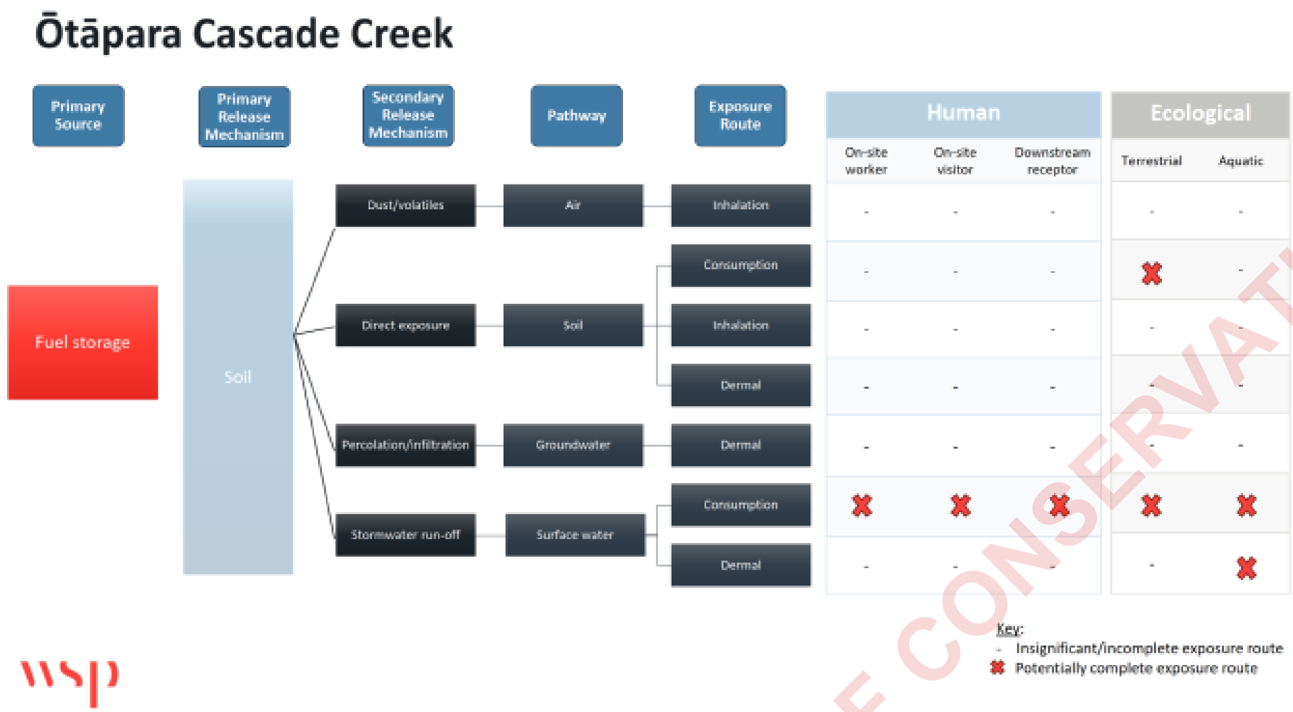


Figure 23: HAIL activities Conceptual Site Model – Cascade Creek Ō-Tāpara Cascade Creek

6.9 VERTICAL INFRASTRUCTURE

Ō-TĀPARA CASCADE CREEK TOILETS: TOILETS SUPPORTS MODIFICATIONS TO EXISTING CAMPGROUNDS.

— Single level. Toilets with vaulted toilet system, it is proposed to have an importance level of IL2.

— Construction is feasible – numerous other buildings at this location with the same function.

7 NODE 5: WHAKATIPU TRAILS HEAD/THE DIVIDE SHORT STOP

NODE 5- WHAKATIPU TRAILS HEAD/ THE DIVIDE SHORT STOP			
Proposal	**Whakatipu Trails Head:** Observation points, interpretative displays, track information, shelter, toilets, and bus drop off / car park areas. Interpretation and infrastructure are to reinforce Te Ara Whakatipu and the associations and connections of Ngāi Tahu with the trails. **The Divide:** The existing car park is prioritised to be a hop on/hop off bus service and express coaches with a small area for short-term vehicle and campervan parking. The short stop will be enhanced with additional infrastructure, including weather/bus shelter, interpretative displays, and toilet facilities.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.
	Long term Climate Change	High	No mitigation measures proposed.
	Geotechnical Engineering	Medium	**Whakatipu Trails Head:** Additional geotechnical investigation and design maybe required to update or confirm the reports recommendations met the requirements of the new NSHM 2022. **The Divide SS:** Carpark is likely to be feasible with few or no ground improvements given the ground conditions assumed at the site.

NODE 5- WHAKATIPU TRAILS HEAD/ THE DIVIDE SHORT STOP			
	Three Waters Infrastructure	Low	Rainwater harvesting as water source is feasible. Containment toilets with hand washing facility can be provided at the toilets and at wānanga building.
	Contaminated Sites	Low	No mitigation measures proposed.
	Vertical Infrastructure	Medium	Hydrogeneration structure needs to be investigated further, Challenging site conditions.
Overall Feasibility of the proposal	Notes – The proposed structures and amenities are feasible only if the Natural Hazards risks are further assessed and mitigated to as low as practicable. Further investigation is required to confirm scope and feasibility of mini hydro generation.		
Next Best Option	Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.		Feasibility

7.1 NODE SUMMARY

The Whakatipu Trails Head would form a contemporary node that recognises the nearby convergence of Ara Tawhito (traditional trails), linking Whakatipu Waimāori Lake Wakatipu with the West Coast. The node and associated network of surrounding trails is significant to Ngāi Tahu who seek the return of their identity and connections to the mountains in this area. A wānanga / living classroom would be provided primarily for Ngāi Tahu rangatahi (young people) to learn about the protection and endorsement of tangible and intangible cultural heritage of Ngāi Tahu. Trail head facilities designed to serve a broad range of visitors would be provided to complement those at the eastern end of the Routeburn Track, including observation points, interpretative displays, track information, shelter, toilets, and bus drop off / car park areas. Interpretation and infrastructure are to reinforce Te Ara Whakatipu and the associations and connections of Ngāi Tahu with the trails.

The Divide is one of the few stopping points that is deep within lowland Beech Forest, with access to alpine areas with spectacular views. It could use a recently expanded car park at the start of the popular Lake Marian Track. Under the proposed access model, the existing car park is prioritised to be a hop on/hop off bus service and express coaches with a small area for short-term vehicle and campervan parking. The short stop will be enhanced with additional infrastructure, including weather/bus shelter, interpretative displays, and toilet facilities.

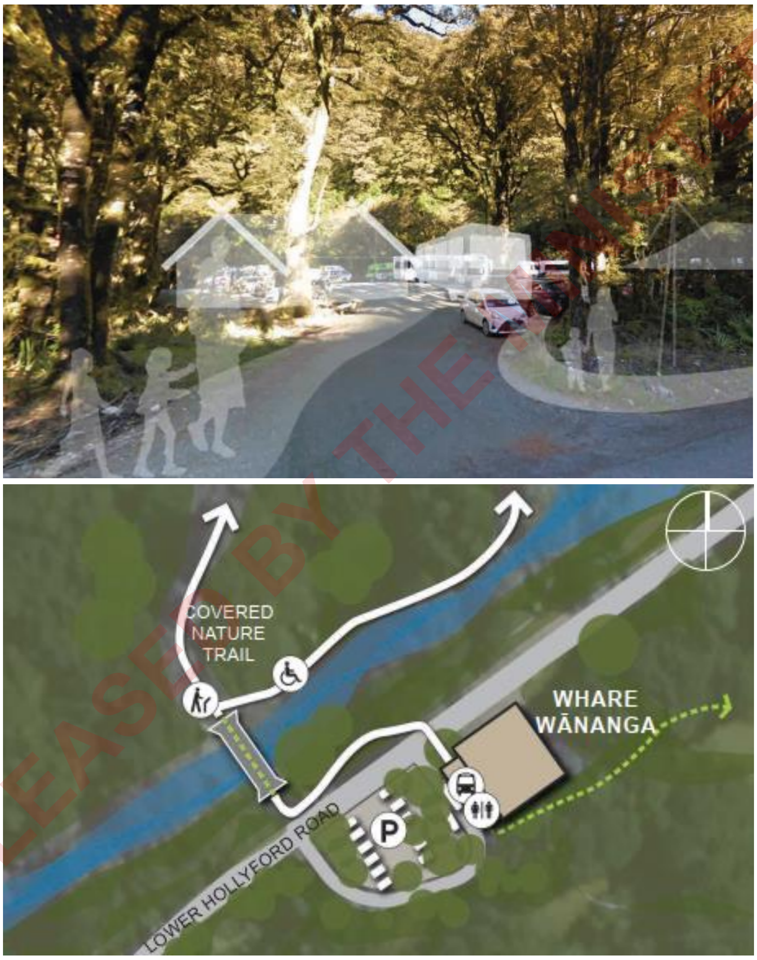


Figure 24: Whakatipu Trails Head conceptual diagrams - Masterplan

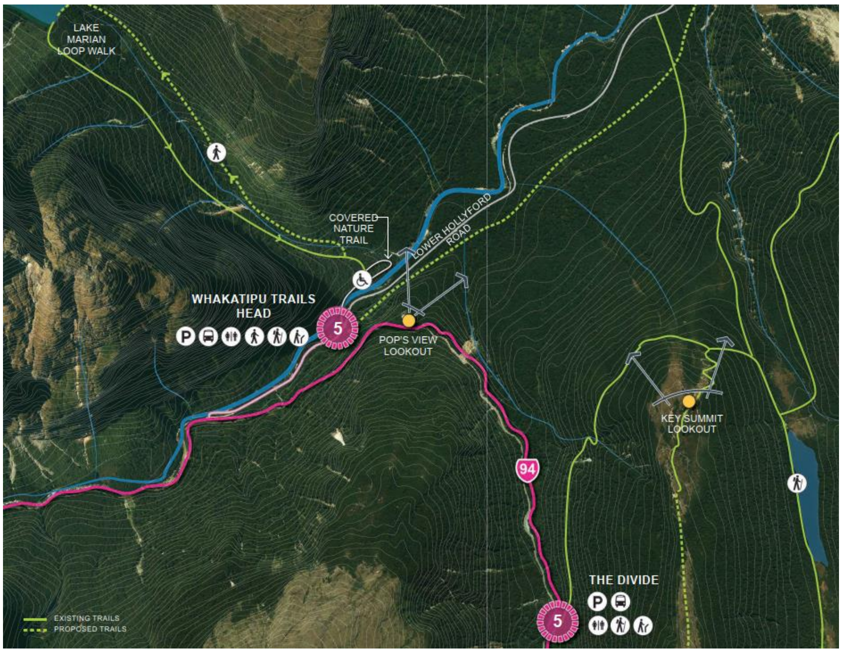


Figure 25: Whakatipu Trails Head conceptual context diagram – Masterplan

7.2 PRIMARY OPTION FOR CONSIDERATION

Whakatipu Trail Head –Proposed upgrades to the trails head include a wānanga (living classroom), visitor shelter and toilet facilities, and carpark improvements. They are feasible. The natural hazard risk for (Flooding and landslide) is high and will need further assessment to identify mitigation measures to reduce the risk to as low as practicable. Further assessment is required to confirm scope of works and feasibility of mini hydro generation.

The Divide – Proposed upgrades include Car Park and Visitor Shelter. They are feasible. The natural hazard risk for (Flooding and landslide) is high and will need further assessment to identify mitigation measures to reduce the risk to as low as practicable.

7.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

7.4 NATURAL HAZARD RISK ASSESSMENT

7.4.1 PART A: ASSESSMENT

7.4.1.1 THE DIVIDE (NODE 5A)

The Divide (Node 5A) is a recognised shelter location and trailhead stop point located on the roadside north of Lake Gunn and Lake Fergus. There is evidence of active debris flows in the gully located to the west of the site which may have the potential to impact the site, however no known impact at the site has been recorded. Debris flows are therefore estimated to be a medium-level hazard with a return interval of 100 – 1000 years. Exposure at this site is estimated to be 30 to 180 minutes as people use it as a start/finish point for nearby trails including the Greenstone and Routeburn Tracks. On this basis the site is assessed as being a Class 2 Site. Class 2 sites generally have a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time.

7.4.1.2 WHAKATIPU TRAILS HEAD (NODE 5B)

The Whakatipu Trails Head is situated on the Hollyford River and are exposed to flooding, rockfall/rock avalanche. The hazard footprint and recurrence interval are estimated to have a low probability of impacting the sites, whilst exposure is reasonably high as visitors use shelters/toilet and Homer Hut facilities. While this node is not exposed to avalanche hazards, the adjacent Lake Marian Tracks are. This node is a Class 2 site and hence has a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time. Class 2 sites generally have a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time.

Risk rating: **Significant to Substantial,** based on the GNS methodology which states Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

7.4.2 PART B: ASSESSMENT

7.4.2.1 THE DIVIDE (NODE 5A)

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Low to Substantial	Visitors	No risk reduction required but monitor for changes - Continue only after high level review
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable. Close the site.

7.4.2.2 WHAKATIPU TRAILS HEAD (NODE5B)

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Moderate to High	Visitors	Reduce to as low as reasonably practicable- Close the site
Landslide	Moderate to substantial	Workers	Reduce to as low as reasonably practicable. Continue with the proposal only after high level review.

7.4.2.3 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at the Divide and Whakatipu Trails Head.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

7.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Given that the frequency and intensity of these events are expected to increase towards the end of the century; the expected level of risk to elements-at-risk is expected to increase to extreme levels, as exposure to climate hazards increases over time. Current risk levels for these hazards are moderate.

Given that the frequency and intensity of these events are expected to increase towards the end of the century; the expected level of risk to elements-at-risk is expected to increase to extreme levels, as exposure to climate hazards increases over time. Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought.

Table 30: Climate change risk summary – The Divide/Wakatipu trails head.

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Node 5 – The Divide	BUILDINGS	Curre t Yea	N/A	Moderate	N/A	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Low	Moderate
	BUILDINGS	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid- centur	N/A	High	High	Low	Moderate	Low	High
	BUILDINGS	Late- centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late- centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late- centu	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme

7.6 GEOTECHNICAL ASSESSMENT

Node #5 has two distinct areas identified as The Divide and Hinepipiwai Lake Marian, which will be dealt with as separate sites.

THE DIVIDE

- The Masterplan structures listed at this site are a carpark and a visitor shelter.
- Elevation: The site is approximately 520 m ASL.
- Closest active fault: Livingstone Fault #8262, located approximately 3.3 km east of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene fan deposits (loose, commonly angular, boulders, gravel, sand, and silt forming alluvial fans; grades into scree (upslope) and valley alluvium) overlying Holocene landslide deposits within the Fergus Formation (Eglinton Subgroup) (massive to well bedded greyish green to grey feldspathic sandstone).
- Environment Southland Liquefaction Risk Map: Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- A geotechnical investigation was completed by WSP, and a report issued in November 2019 for The Divide site[1]. The report provided recommendations for the construction of new facilities at the site which were to include a new shelter, toilets, and upgrades to the carpark.
- A design report was issued by WSP in July 2020 to provide a design of a retaining wall to support the carpark upgrade. It is not clear, at this time, if the wall is required or still suitable for the proposed carpark upgrade outlined in the Masterplan. If the wall is required as part of the Masterplan carpark, the design will need to be assessed against the new NSHM 2022 and may require the wall to be redesigned.
- The investigation consisted of 4 Cone Penetrometer Tests (CPT) and were advanced to a maximum depth of 3.0 m bgl.
- Results from WSP's investigation generally align with the published geological mapping. The report noted the presence of gravel fill layer up to 1.0m thick was encountered over the current carpark area.
- Site visit and photographs indicate the site soils are likely fan deposits. The site is also likely to have been disturbed during the construction of the carpark and current structures at site and uncontrolled fill may have been placed on the site.

WHAKATIPU TRAIL HEAD

- The Masterplan structures listed at this site are a visitor shelter and toilet facilities, a new Wānanga (living classroom), and carpark upgrades.
- Elevation: The site is approximately 320 m ASL
- Closest active fault: Livingstone Fault #8262, located approximately 5.4 km southeast of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene fan deposits (loose, commonly angular, boulders, gravel, sand, and silt forming modern alluvial fans;

[1] Geotechnical Design Report, The Divide Carpark Upgrade, 14 July 2020, WSP

may include debris flow and avalanche deposits) overlying Consolation Formation (Eglinton Subgroup) (pale green to grey, bedded feldspathic sandstone, siltstone, and minor mudstone). See Figure 26 below.

- Environment Southland Liquefaction Risk Map: Site is located on the boundaries of Negligible, Low and Medium Risk zones. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Site visit and photographs indicate the site soils are likely fan deposits. The site is also likely to have been disturbed during the construction of the carpark and current structures at site and fill is likely to have been placed on the site. At this time no records were available for the placement of the fill. See Figure 27 below.

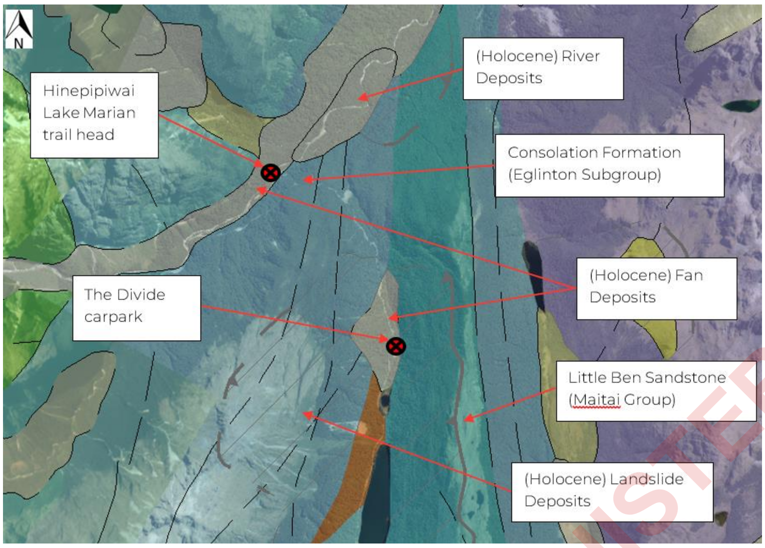


Figure 26: The Divide / Hinepipiwai Lake Marian Trails head – Published Geology

Figure 27: The Divide Carpark (left) and Lake Marian trails head carpark (right)

Both sites likely consist of alluvial fan deposits and debris over bedrock at depth. The alluvial deposits are likely to be angular and well-graded silts to gravels and cobbles. Based on the distance from the rivers in the area, groundwater may be encountered at shallow depths.

WSP's report assessed the liquefaction potential at The Divide site to be a negligible risk. It is noted that the assessment was completed before the new NSHM 2022 was available.

The Lake Marian Trails Head site ranges from Negligible to Medium liquefaction potential. This will affect the type of structure differently and at this stage the site is assumed to have a low liquefaction potential. However, a geotechnical investigation of the site will be used confirm the soils onsite and whether groundwater is present at shallow depths and allow determination if further liquefaction assessment of the site is required.

THE DIVIDE

The WSP reports have recommendations for the site upgrades that were proposed prior to the Masterplan. The report's recommendations may still be valid and an assessment of them should be completed, using the new NSHM 2022.

It should be considered that the proposed upgrades are technically feasible based on the report. However, it should also be noted that additional geotechnical investigation and design maybe required to update or confirm the reports recommendations met the requirements of the new NSHM 2022.

WHAKATIPU TRAIL HEAD

Proposed upgrades to the trails head include a wānanga (living classroom), visitor shelter and toilet facilities, and carpark improvements. The Importance Level required of the wānanga and visitor shelter in conjunction with the soils present at the site will dictate the recommended foundation type for these structures. At this stage it has been assumed that timber piles or shallow strip or spread footing will likely be suitable for the structures on site. However, if the sites liquefaction potential is higher than anticipated or the structures are a higher Importance Level, more significant foundations may be required.

Upgrades to the carpark are also proposed, these are likely to be feasible with few or no ground improvements given the ground conditions assumed at the site.

Both developments for The Divide and Lake Marian Trail Head as shown in the MOP Masterplan, at this stage, are feasible from a geotechnical point.

7.7 THREE WATERS INFRASTRUCTURE CONDITION

7.7.1 THE DIVIDE WATER SUPPLY

7.7.1.1 WATER DEMAND

A new shelter with hand washing is proposed for The Divide. It is assumed the existing vaulted toilets will remain in service with no provision of water for hand washing. Water provided at the shelter will be untreated, for hand washing only and not suitable for drinking.

The feasibility of using rainwater collected from the shelter roof for hand washing has been investigated using historical rainfall data. The anticipated water demand for hand washing is presented in Table 31 assuming 1,000 users per day.

Table 31: The Divide Water demand

SCENARIO	DAULY USERS	PER CAPITA DEMAND (L/DAY)	DAILY DEMAND (M^3/DAY)
Hand Washing Only	1,000	1	1

7.7.1.2 RAINWATER HARVESTING

The available roof catchment is likely feasible to meet demand. This calculation assumes 1,000 users per day and a shelter roof area of 140 m2 (as indicated on architectural drawings).

Table 32: The Divide Shelter Rainwater Harvesting Volumes

MONTH	HISTORICAL AVERAGE DAILY RAINFALL (MM)	AVERAGE DAILY VOLUME OF RAINWATER HARVESTED (M^3)
January	15.2	2.1
February	10.9	1.5
March	14.6	2
April	7.6	1.1
May	13.5	1.9
June	13.8	1.9
July	9.5	1.3
August	9.3	1.3
September	19.4	2.7
October	14	2
November	17.8	2.5
December	16.2	2.3

7.7.2 THE DIVIDE WASTEWATER

7.7.2.1 WASTEWATER DESIGN FLOWS

The Divide has three existing vaulted toilet units, and there are plans to add an additional five as part of the proposed shelter. As above, preliminary architectural drawings for this site include hand washing basins in the new toilets.

Table 33: The Divide Estimated Wastewater Generation Rates

SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment Tank Only	0.2	0.2

SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment Tank with Hand Washing	1	1

We consider total containment to be the most suitable wastewater management strategy for this site, considering costs, maintenance requirements, the sensitive receiving environment and respecting cultural values. We would assume that 4.5m3 septic tanks are installed in each toilet. This provides 22.5 m^3 of storage.

For the wastewater generation rates presented in Table 32 the new toilet facilities will require emptying every 110 days (3.5 months) if handwashing is not provided and once every 22 days (once every 3 weeks) if hand washing is provided.

As recommended for other sites, level monitoring of the containment tanks should be installed regardless of the water supply scenario to allow for remote management of the asset and inform if additional toilets are required.

7.7.2.2 COST ESTIMATE

It is recommended that a level monitoring system is included in the shelter design as well as the existing toilets. The estimated cost for installation of this system is $20,000.

7.7.2.3 FEASIBILITY

The Divide wastewater management system shown on preliminary architectural drawings for the new shelter is sufficient to meeting the anticipated usage for this site. In addition to what is shown on drawings, it is recommended that water collected from the shelter roof is used for hand washing (untreated) and a tank level monitoring system is installed.

This option should be progressed by optimising rainwater catchments areas (shelter roof) to onsite water storage.

Toilets with handwashing facilities are considered feasible.

The next best alternative would be to provide toilets with no handwashing.

7.7.3 WHAKATIPU TRAILS HEAD – WATER SUPPLY

It is expected that water at this stop will be sourced from rainwater harvesting. Assuming the user population is above 500 people for no more than 60 days per year, the Drinking Water Acceptable Solution for Roof Water Supplies is proposed instead of the DWQAR rules. An on-demand treatment system consisting of filtration and UV disinfection is proposed to supply treated water to the wānanga. It is assumed that power would be provided as part of the building.

Table 34: Whakatipu Trails Head Water supply estimated cost

ITEM	ESTIMATED COST
Filter and UV Treatment	$40,000
PE tanks	$20,000
Project overheads and delivery	$15,000
Total	**$75,000**

7.7.4 WHAKATIPU TRAILS HEAD – WASTEWATER

There is currently one existing containment toilet at this location that is emptied 3 times per year which is approx. 9m^3 annually. This equates to around 200 uses per day during peak summer season. It is recommended that wastewater systems consist of containment tanks and treated rainwater collected from rooftops is provided for hand washing only. The combined water demand and wastewater generation rates for Whakatipu Trails Head, assuming 1,000 users per day. This is based on 4 pans included in the wānanga.

Table 35: Whakatipu Trails Head water demand and wastewater generation rates

SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY VOLUME (M^3/DAY)
Containment Tank with Hand Washing	1	1

A review of historical rainfall data shows indicates a minimum rainwater catchment area to meet water demand for handwashing is 50 m2. A more detailed analysis of climate data will be required to optimise rainwater catchments areas and storage capacity to ensure there is sufficient water during dry periods. Consideration will also need to be given to pumping requirements. As recommended for other sites, level monitoring of the containment tanks should be installed to allow remote management of the asset and inform if additional toilets are required.

Table 36: Whakatipu Trails Head Containment Tanks Estimated cost.

ITEM	ESTIMATED COST
Containment and toilet building	$300,000
Level monitoring	$10,000

ITEM	ESTIMATED COST
Project overheads and delivery	$100,000
Total	**$410,000**

7.7.4.1 FEASIBILITY

The supply of potable water and toilets with hand washing at the Whakatipu Trails Head is considered feasible.

As the design for the wānanga/living classroom is progressed, rainwater catchments should be optimised to the onsite storage.

The next best alternative is to consider the flush toilets at the wānanga building. This would result less users being able to use the facility, however, is feasible with current users. This would require emptying every fortnight in peak summer season.

7.8 CONTAMINATED SITES

7.8.1 *NODE 5A: THE DIVIDE*

It is considered highly unlikely that HAIL activities are currently or have been occurring on the site. As such, NODE 5 – The Divide has been classified as GREEN.

HAIL rating GREEN indicates that HAIL activities (current or past) are unlikely.

7.8.2 *NODE 5B: WHAKATIPU TRAILS HEAD*

The site has been classified as GREEN, due to it being unlikely that HAIL activities have been or are currently occurring. No further contaminated land investigations are recommended at this stage of the project.

7.9 VERTICAL INFRASTRUCTURE

7.9.1 *WHAKATIPU TRAILS HEAD – NODE 5 (HINEPIPIWAI LAKE MARIAN)*

EXPERIENCE HUB – INFORMATION FACILITY

- No post disaster function. Single level 200m2.
- Standard Structures with an importance level of IL2. Construction is feasible.

BUILDINGS AND STRUCTURES FOR WATER AND WASTEWATER INFRASTRUCTURE

- Single level. No Post disaster function.
- Standard structures with Importance level IL2. Construction is feasible.

BUILDINGS AND STRUCTURES FOR MINI HYDRO GENERATION

- No Post disaster function.
- Challenging site conditions – hydrology, (high and low flow) and ground conditions (rock boulders).
- Constructability – site and penstock path will need to be determined.
- More investigation is required to confirm scope of works and feasibility.

8 NODE 6: GERTRUDE VALLEY

NODE 6- GERTRUDE VALLEY			
Proposal	Flood management, visitor parking, a new looped nature trail. Trail head facilities, including observation points, interpretative displays, track information, shelter, toilets, and bus drop off / car park areas. Strategically located bunding and a refuge for internal and external viewing areas.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	Medium	Structures are simple, and lightly loaded, shallow strip or spread foundations are likely to be the most effective and efficient
	Three Waters Infrastructure	Low	Rainwater harvesting for water supply and toilets are feasible.
	Contaminated Sites	Low	No mitigation measures proposed.
Overall Feasibility of the proposal	Notes - The proposed structures and amenities are feasible only if the Natural Hazards risks are further assessed and mitigated, to as low as practicable.		

Next Best Option	Description – Further assessment of the natural hazard risks is necessary to determine the location and alignment of the proposed structures and walkway.	Feasibility: Low due to High Risk for Natural Hazards

8.1 NODE SUMMARY

The node is proposed as a superior alternative to the previously popular upper Whakatipu-ka-tuku Hollyford Valley viewpoint near Homer Tunnel, which has been closed due to natural hazards and traffic congestion issues. It offers similar dramatic alpine and glacial scenery along with a wider range of other experiences. It is also located near existing infrastructure, including the Milford Road Operations Centre (Waka Kotahi) and Homer Hut (Aotearoa New Zealand Alpine Club). There are also future modifications planned concerning flood management and visitor parking.

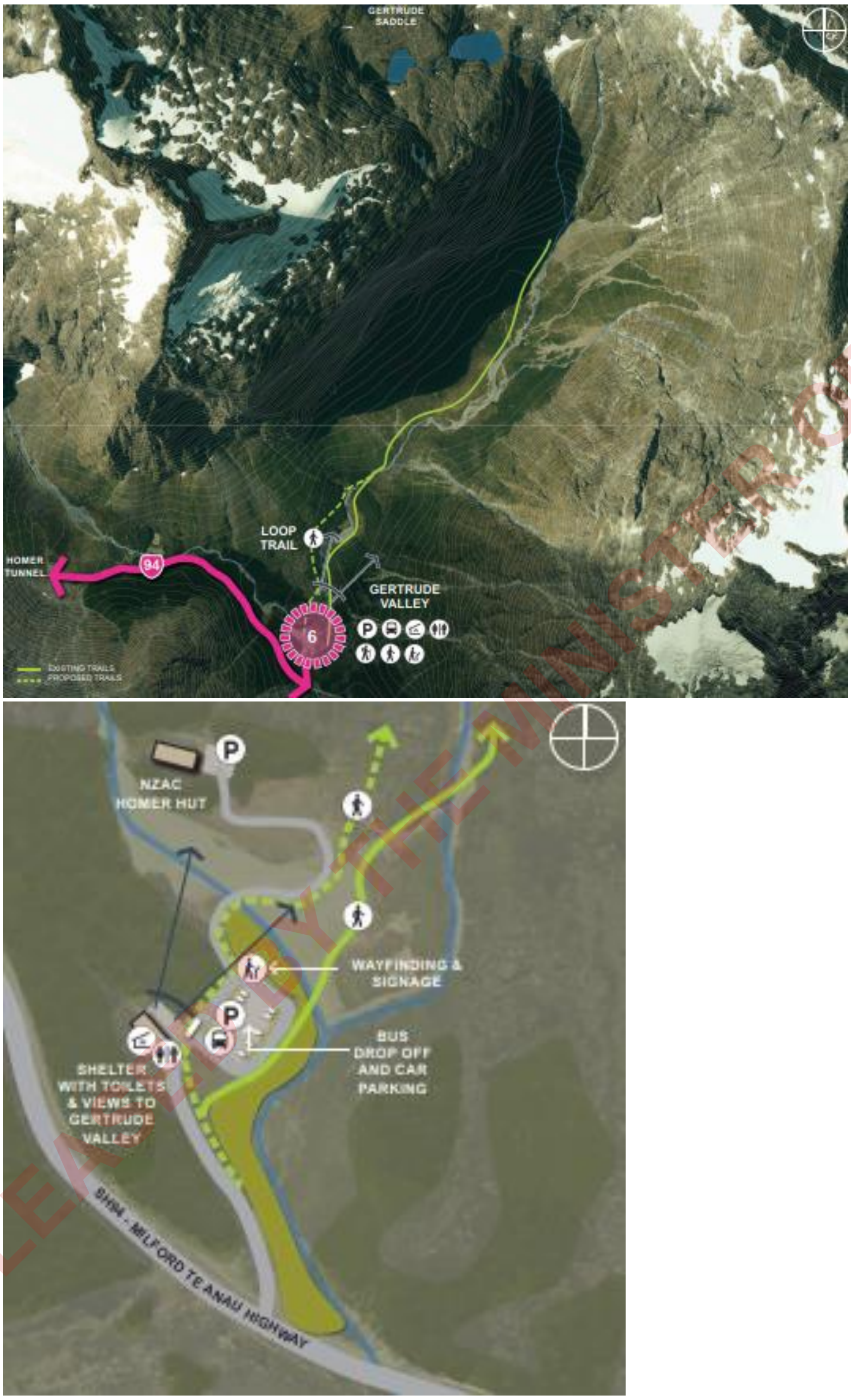


Figure 28: Gertrude Valley – conceptual plan diagrams – MOP Masterplan

8.2 PRIMARY OPTION FOR CONSIDERATION

Gertrude valley – The node is classified as Class 2 site for Natural Hazards and has high risk for Avalanche, Landslide and Flooding. The proposed developments at the site include flood protection infrastructure, visitor shelter, carpark upgrades, trail head facilities are feasible from engineering perspective. The water supply will be from rain harvesting and the toilets will be self-contained.

8.3 SECONDARY OPTION FOR CONSIDERATION

Further assessment of natural hazards is required to reduce the risk to as low as practicable, to determine the location and alignment of the structures and tracks. The next best option is to provide water for hand washing but this will result in increasing frequency of septic tank emoting and will require additional water storage.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

8.4 NATURAL HAZARD RISK ASSESSMENT

8.4.1 PART A: ASSESSMENT

Gertrude Valley (Node 6) is exposed to avalanches, particularly during the winter and avalanche season (May-November). The Node itself is in the lower Gertrude Valley close to the road and car park area situated within a forested area and has a natural resilience to avalanches. Avalanche hazard is likely to increase further up the Gertrude Valley with increasing elevation, reduced vegetation cover and proximity to the steeper mountain sides. Visitors are predominantly Short Stop Travellers (SST) and therefore an AHI is recommended for this site. Gertrude Valley is a Class 2 site which means it has a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time.

Risk rating: **Significant to Substantial,** based on the GNS methodology which states Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

8.4.2 PART B: ASSESSMENT

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Moderate to High	Visitors	Reduce to as low as reasonably practicable - Close the site
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable. Close the site.
Avalanche	Not assessed	Visitors/Workers	Further Avalanche assessment (AHI) is required. To be managed by using existing DOC management strategies.

8.4.2.1 SOCIETAL RISK - FOR LANDSLIDE

For the most likely event:

- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Gertrude Valley.
- For the maximum credible event:
- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

8.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Gertrude Valley has a high exposure and moderate risk to avalanche. It is important to note that this risk is currently managed at this node as part of the Milford Road Alliance Avalanche Programme. Extreme weather (high winds and storms) and heavy rain currently have moderate risks at this location but given that the frequency and intensity of these events are expected to increase towards the end of this century; the level of risk to elements-at-risk is expected to increase as well to extreme levels.

Risk from higher temperatures is expected to be lower than of extreme weather and rainfall. Although temperature will be higher, the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise however that, given the natural variability of rainfall, occasional dry periods will occur, over which drought and wildfire risk will be higher.

Table 37: Climate Risk Summary – Gertrude Valley

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Node 6 – Gertrude Valley	BUILDINGS	Current Year	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	TRANSPORT INFRASTRUCTURE	Current	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	GENERAL INFRASTRUCTURE	Current Year	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	BUILDINGS	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	TRANSPORT INFRASTRUCTURE	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	GENERAL INFRASTRUCTURE	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	BUILDINGS	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme

8.6 GEOTECHNICAL ASSESSMENT

The following is noted for Node #6:

- The Masterplan structures listed at this site are flood protection infrastructure, visitor shelter, and carpark upgrades.
- Gertrude Valley Walk – Trail Head Facilities
- Elevation: The site is approximately 780 m ASL
- Closest active fault: Unnamed Fault #9214, located approximately 9.5 km northeast of the site.
- Geological Map Information: Site is located on the boundary between the following two geological units, one covering the eastern side of the site and the other covering the western side. See Figure 29 below.
- Western Side: Holocene fan deposits (Loose, commonly angular, boulders, gravel, sand, and silt, forming modern alluvial fans; may include debris flow and avalanche deposits).
- Eastern Side: Glacier deposits (Unconsolidated, unweathered, angular, boulder till; mixtures of gravel/sand/silt/clay; in cirque or upper valley moraines).
- Environment Southland Liquefaction Risk Map: Site is located on the boundaries of Negligible and Low Risk zones. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Site visit and photographs indicate that the site is likely to be underlain by glacier deposits, with gravel visible at the surface and a stream reworking coarse alluvial sediments up to cobble sized, see Figure 30 below.

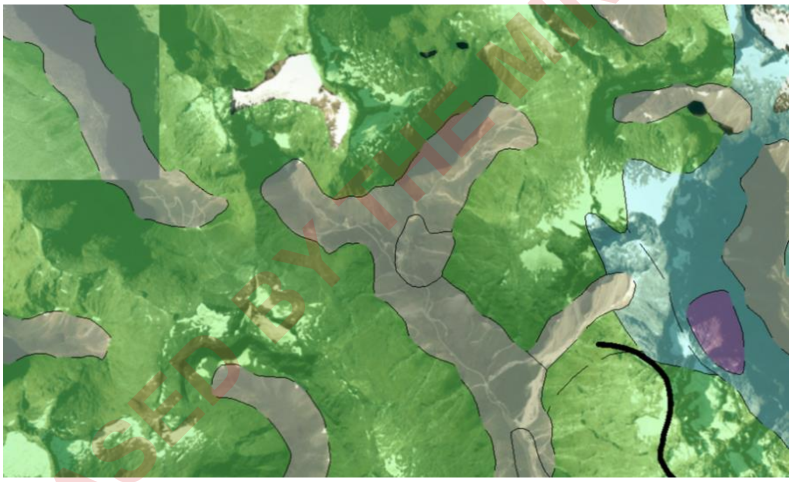


Figure 29: Gertrude Valley – Published Geology

Figure 30: Gertrude Valley looking southwest from the proposed location.

Site likely consists of glacial moraine and alluvial fan deposits over bedrock at depth. Both sediment types are likely to comprise a wide range of grainsizes from silts to gravels and boulders. At this stage the site is assumed to have a negligible to low liquefaction potential. However, geotechnical investigation of the site will be used confirm the soils onsite and whether groundwater is present at shallow depths and allow for determination if further liquefaction assessment of the site is required.

Proposed developments at the site include flood protection infrastructure, visitor shelter, carpark upgrades, trail head facilities. Assuming that structures are simple, and lightly loaded, shallow strip or spread foundations are likely to be the most effective and efficient. Piled foundations would likely be difficult to construct at this site due to the high likelihood of encountering boulders in the near surface soils.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point.

8.7 THREE WATERS INFRASTRUCTURE CONDITION

8.7.1 WATER SUPPLY

8.7.1.1 WATER DEMAND

The estimated water demand for at the Gertrude Valley node is summarised in Table 38. It is assumed that there are 500 visitors per day, with 25% utilising the potable water for filling a drink bottle or drinking.

Table 38: Gertrude Valley Water Demand

SCENARIO	PER CAPITA DEMAND (L/DAY)	DAILY WATER DEMAND (M^3/DAY)
Day Visitors	1	0.125

8.7.1.2 WATER SUPPLY

It is expected that the water supply could be met utilising rainwater from the shelter and toilet block. A 10 m^3 tank will provide for at least 2 months of storage.

As the user population less than 500 people, the Drinking Water Acceptable Solution for Roof Water Supplies can be used instead of the DWQAR rules. An on-demand treatment system consisting of filtration and UV disinfection is recommended to supply treated water. As the site does not currently have power, a new power supply would be needed. This is expected to be small scale solar.

Table 39: Gertrude Valley Water supply estimated costs

ITEM	ESTIMATED COST
Storage Tank (10,000 litre)	$20,000
Treatment Plant Upgrades (including shed)	$50,000
New Power Supply	$20,000
Project Overheads and Delivery	$20,000
Total	**$110,000**

8.7.2 *WASTEWATER*

The Gertrude Valley Short Stop has proposed toilets. It is assumed that 2 toilets are provided. Table 40 presents estimated wastewater generation rates with 500 uses per day using containment tanks.

Table 40: Gertrude Valley Estimated Wastewater Generation Rates

SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment Tank Only	0.2	0.1

With 4.5m3 septic tanks in each toilet these tanks would need emptied once every 3 months. There is capacity for growth at this site. As hand washing facilities are not recommended at this small site, hand sanitiser will need to be provided.

There is potential for level monitoring in these toilets which would allow the volume to be monitored remotely and volumes recorded. This would allow better management of the asset and inform if additional toilets are required.

The estimate for the toilets is provided below. The costs of the shelter are excluded as they are assumed to be included elsewhere. There is a possibility that these are part of one larger building.

Table 41: Gertrude Valley containment tanks estimated costs

ITEM	ESTIMATED COST
Containment and toilet building	$150,000
Level monitoring	$5,000
Project overheads and delivery	$75,000
Total	**$230,000**

8.7.3 OVERALL FEASIBILITY

The proposed toilets and water supply at Gertrude Valley are considered feasible.

The next best available option would be for water to be made available for handwashing. This would increase the frequency of septic tank emptying and require additional water storage but would provide a better level of service.

8.8 CONTAMINATED SITES

During the construction of the Homer Tunnel in 1935, the site comprised a MoW campsite. Often these campsites included prefabricated timber huts that got moved along during the construction of the Milford Road. As such, it is considered likely that the buildings were completely removed from the site when no longer required. As such, the site has been classified as GREEN and no further contaminated land investigations are recommended at this stage of the project. HAIL rating GREEN indicates that HAIL activities (current or past) are unlikely.

8.9 VERTICAL INFRASTRUCTURE

SHORT STOPS – BUS SHELTER LIGHT AND TOILETS

- Single level, Open sided shelter
- Standard "Light" structure deemed impractical for the location due to the extreme weather conditions – predominantly snow loading and wind loading. Provide permanent structures that comply with the New Zealand Building Code.
- IL2 Construction is feasible.

SHORT STOPS – BUS SHELTER – MINOR AND TOILETS

- Single level. Open sided shelter. No Post disaster function.
- Standard structures with Importance level IL2. Construction is feasible.
- "Minor" structure deemed impractical for the location due to the extreme weather conditions – predominantly snow loading and wind loading. Provide permanent structures that comply with the New Zealand Building Code.

9 NODE 7: CLEDDAU CIRQUE AND THE CHASM SHORT STOP

<table>
<tr><td colspan="4">NODE 7 – CLEDDAU CIRQUE AND THE CHASM SHORT STOP</td></tr>
<tr><td>Proposal</td><td colspan="3">Cleddau Cirque: An observation point for visitors specifically proposed to accommodate short stop visitation, optimised for 10 to 20-minute stops to maximise visitor satisfaction and reduce perceived crowding. It would be serviced by the hop on/hop off bus and could be incorporated into express coach schedules.

The Chasm: Existing easy walk and damaged viewing facility will be repaired, and the large, sealed car park repurposed. Under the proposed access model, the sealed area will be configured to service a hop on/hop off bus service and express coaches with a small area for short-term vehicle parking.</td></tr>
<tr><td rowspan="4">Engineering assessment</td><td>Major Risk</td><td>Risk Assessment</td><td>Mitigation Measures</td></tr>
<tr><td>Natural Hazards: Cleddau Cirque</td><td>Low</td><td>No mitigation measures required.</td></tr>
<tr><td>Natural Hazards: The Chasm</td><td>High</td><td>Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.</td></tr>
<tr><td>Long term Climate Change</td><td>Medium</td><td>No mitigation measures proposed.</td></tr>
</table>

NODE 7 – CLEDDAU CIRQUE AND THE CHASM SHORT STOP			
	Geotechnical Engineering: **Cleddau Cirque**	Medium	Once the final location, structure details are known, investigation and further assessment will be required to confirm the geotechnical feasibility and potential cost implications of constructing these complex structures. Natural hazard assessment will be critical to understanding the likely loading conditions and performance requirements to allow the design of the refuge.
	Geotechnical Engineering: **The Chasm**	Low	The structures are assumed to be simple lightly loaded structures and based on the likely soils on site, they should be able to be supported by shallow strip or spread foundations
	Three Waters Infrastructure	Low	Containment tank toilets
	Contaminated Sites	Low	No mitigation measures proposed. HAIL assessment GREEN
Overall Feasibility of the proposal	Notes - The proposed structures and amenities are feasible only if the Natural Hazards risks are further assessed and mitigated, to as low as practicable at Chasm. The proposed Road Layout, Car park and rockfall shelter are feasible at Cleddau Cirque.		
Next Best Option	Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk. Water for hand washing will provide a better level of service, but this would increase the frequency of septic tank emptying.		Feasibility – **Medium**

9.1 NODE SUMMARY

CLEDDAU CIRQUE

The node will provide an observation point for visitors to appreciate the dramatic glacial formed cirque that surrounds and elevated views down the upper Cleddau Valley toward Milford Sound Piopiotahi. Closer range experiences include alpine vegetation and one of the best opportunities for passive (non-interactive) observation of Kea. A safe observation facility and other safety features will protect the node from rock fall and avalanche risks, offering a safe viewing location in this dynamic alpine environment. The potentially iconic refuge design is intended to be of low visual impact, yet large enough to accommodate a minimum of 45 to 90 people or one to two coach loads at a time.

This is one of several nodes specifically proposed to accommodate short stop visitation, optimised for 10 to 20-minute stops to maximise visitor satisfaction and reduce perceived crowding. It would be serviced by the hop on/hop off bus and could be incorporated into express coach schedules.

Figure 31: Looking toward Milford Sound from above Node 7 – Cleddau Cirque, Masterplan document.

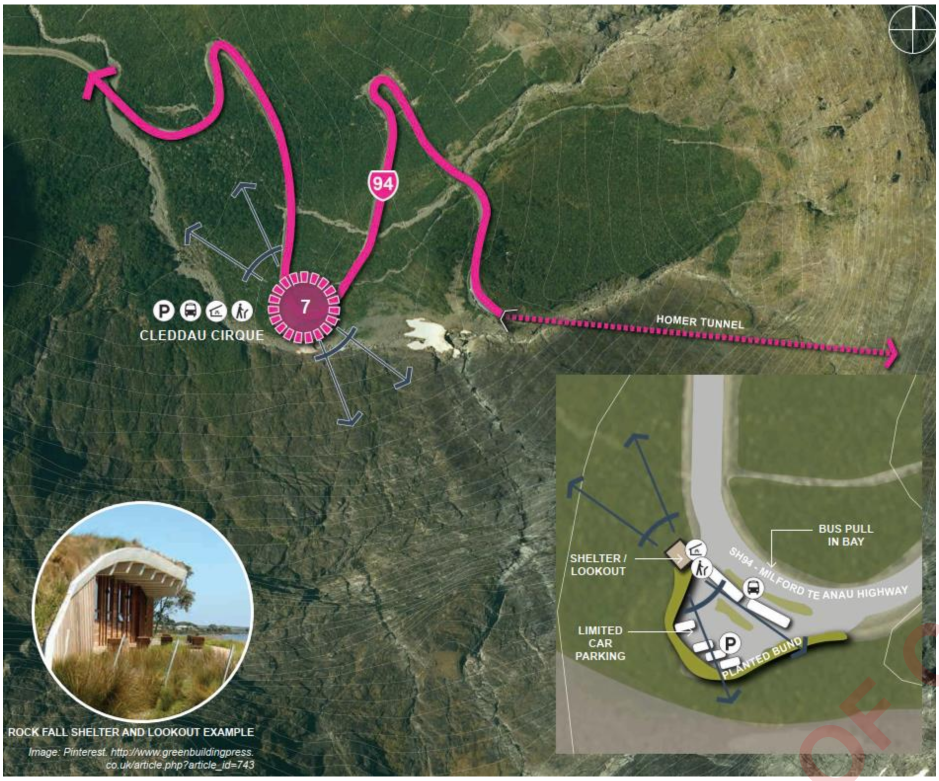


Figure 32: Location diagram with Node 7 – Cleddau Cirque conceptual diagram inset – Masterplan document.

SHORT STOP: THE CHASM

Located halfway between Homer Tunnel and Milford Sound Piopiotahi on Milford Road, The Chasm is an existing experience to view a dramatic series of waterfalls through water-sculpted rocks. This is proposed to remain as a short stop where the existing easy walk and damaged viewing facility will be repaired, and the large, sealed car park repurposed. Under the proposed access model, the sealed area will be configured to service a hop on/hop off bus service and express coaches with a small area for short-term vehicle parking. The node will be enhanced with additional infrastructure, including weather/bus shelter, interpretative displays, and toilet facilities. It will also be designed to accommodate an emergency evacuation area in the event of a natural disaster in Milford Sound Piopiotahi or other more vulnerable areas to improve resilience within the Cleddau Valley.

9.2 PRIMARY OPTION FOR CONSIDERATION

Cleddau Cirque – The Rockfall Shelter, car park improvements are feasible.

The chasm – is a Class 2 site for avalanche, landslide, and flooding hazards further assessment of the natural hazard risks to develop mitigation measures to reduce the risk to as low as practicable. The proposed bus shelter and toilet facilities, car park upgrades are feasible. The wastewater system of total containment tank is feasible.

9.3 SECONDARY OPTION FOR CONSIDERATION

Primary option is feasible, provided the natural hazards risk are adequately addressed.

9.4 NATURAL HAZARD RISK ASSESSMENT

9.4.1 *PART A: ASSESSMENT*

CLEDDAU CIRQUE

Class 1 site no further risk assessment is considered necessary and existing mitigation or hazard management plans are considered sufficient to manage the exposure to acceptable levels.

THE CHASM

There is the potential for avalanche hazards at The Chasm. Visitors are predominantly Short Stop Travellers (SST) and therefore an AHI is recommended for this site. The Chasm is a Class 2 site which means it has a greater probability of hazard occurrence or impact on the site area coupled with a longer exposure time.

Risk rating: **Significant to Substantial,** based on the GNS methodology which states Basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

9.4.2 *PART B: ASSESSMENT*

9.4.2.1 THE CHASM

Table 42: Natural Hazard Risk

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Low to Moderate	Visitors	No risk reduction required but monitor for changes - Reduce to as low as reasonably practicable
Landslide	Moderate to Substantial	Workers	Reduce to as low as reasonably practicable - Continue with the proposal only after high level review
Avalanche	Not assessed	Visitors/Workers	Further Avalanche assessment (AHI) is required. To be managed by using existing DOC management strategies.

9.4.2.2 SOCIETAL RISK – LANDSLIDE AT CHASM

For the most likely event:

- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at the Chasm.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

9.5 LONG TERM CLIMATE CHANGE ASSESSMENT

Node 7- Cleddau Cirque is one of the two nodes that are exposed to avalanche risk within the Milford Corridor. Currently Cleddau Cirque has a high exposure and a moderate risk to avalanche. It is important to note that this risk is currently managed at this node as part of the Milford Road Alliance Avalanche Programme. The effects of climate change on avalanche risk are complex and conditioned by several factors such as temperature fluctuation and precipitation, among others. Extreme weather (high winds and storms) and heavy rain currently have moderate risks at this location but given that the frequency and intensity of these events are expected to increase towards the end of the century. Extreme weather and heavy rainfall events may also contribute to increase the risk of slopes instability and given that landslide hazards, rockfall and debris flow hazards are known to occur in the area, an increase in the frequency and intensity of these climate events over time could potentially see an increase in these risks.

Table 43: Climate Risk Summary – Cleddau Cirque

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights - Avalanche	High winds / Storms
Node 7 Cleddau Cirque	BUILDINGS	Cur t Y	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	N/A	Moderate	N/A	Low	Low	Moderate	Moderate
	BUILDINGS	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	TRANSPORT INFRASTRUCTURE	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	GENERAL INFRASTRUCTURE	Mid-centur	N/A	High	High	Low	Moderate	Moderate	High
	BUILDINGS	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late-centur	N/A	Extreme	Extreme	Low	Moderate	Low	Extreme

9.6 GEOTECHNICAL ASSESSMENT

The following is noted for Node #7:

- The Masterplan structures listed at this site are a rockfall refuge and carpark upgrades.
- Elevation: The site is approximately 730 m ASL.
- Closest active fault: Unnamed Fault #9214, located approximately 11.5 km east of the site.
- Geological Map Information: Site is located on the boundary between the following two geological units, one covering the northern side of the site and the other covering the southern side. See Figure 33 below.
- Northern Side: Holocene fan deposits (Loose, commonly angular, boulders, gravel, sand, and silt forming modern alluvial fans; may include debris flow and avalanche deposits).
- Southern Side: Darran Leucogabbro gabbronorite (Variably deformed biotite leucogabronorite altered to hornblende diorite in west; trondjemite, pegmatite and quartz diorite dikes).
- Environment Southland Liquefaction Risk Map: Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Site visit and photographs indicate that the site soils are likely a mix of alluvial deposits and rockfall debris. The site has a rockfall protection bund constructed to protect the road and carpark, see Figure 34 below.

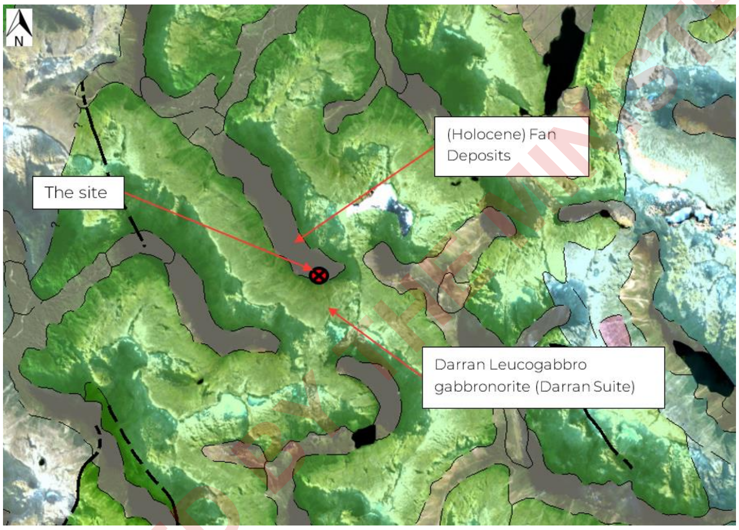


Figure 33: Cleddau Cirque – Published Geology

Figure 34: Cleddau Cirque looking east from the existing carpark.

Site likely consists of alluvial fan deposits over bedrock at depth. Based off site observations the site is likely to have rockfall debris covering the area. The underlying soils are likely to consist of gravels and cobbles. At this stage the site is assumed to have a low liquefaction potential. There is an active stream approximately 30 m to the south of the existing carpark.

Proposed upgrades to the site include a rockfall refuge, and carpark improvements. The rockfall refuge is assumed to be an Importance Level 4 structure and will be a much more significant structure than those proposed at previous nodes. The rockfall refuge will need to be designed to protect people during natural disaster events such as earthquakes, rockfall and avalanches.

The refuge will require a site-specific geotechnical investigation to determine the most suitable foundation design. The rockfall refuge will have significant costs involved in the geotechnical investigation, design, and construction.

Based on available information and development of the tunnel, it is geotechnically feasible to construct a refuge structure at the Cleddau Cirque. Once the final location, structure details are known, investigation and further assessment will be required to confirm the geotechnical feasibility and potential cost implications of constructing this complex structures.

SHORT STOP: THE CHASM

The following is noted for The Chasm:

- The Masterplan structures listed at this site are carpark upgrades, a bus shelter, and toilet facilities.
- Elevation: The site is approximately 210 m ASL
- Closest active fault: Unnamed Fault #9213, located approximately 12.5 km east of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene fan deposits (Loose, commonly angular, boulders, gravel, sand, and silt forming modern alluvial fans;

may include debris flow and avalanche deposits). See Figure 35: Short Stop: The Chasm – Published Geology below.

- Environment Southland Liquefaction Risk Map: Low Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Site visit and photographs indicate that the site is likely to be debris flow deposits, with the carpark seemingly built on a cut and fill bank of debris above the floor of the valley.

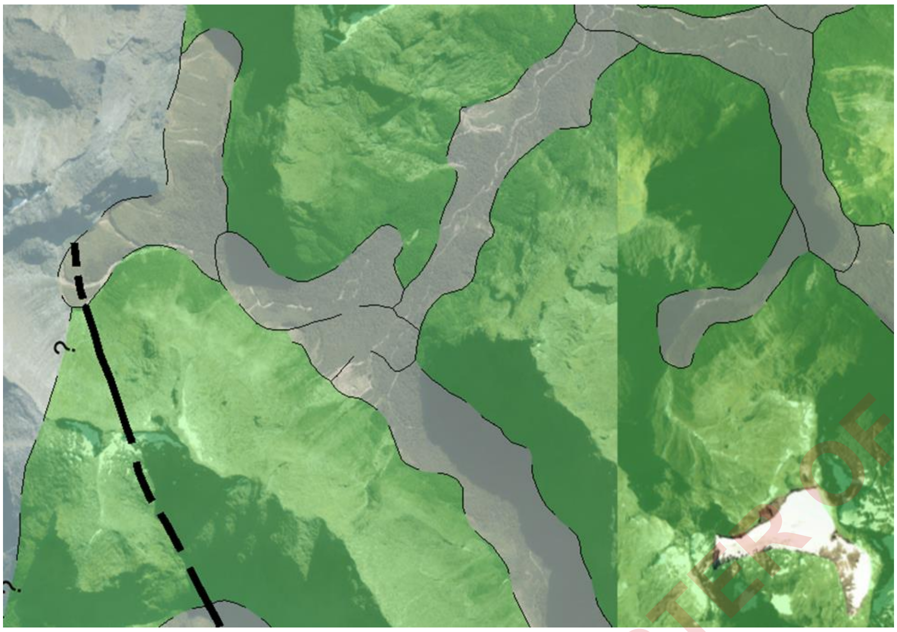


Figure 35: Short Stop: The Chasm – Published Geology

- Site likely consists of debris fan deposits over bedrock at depth. The fan deposits are likely to comprise a wide range of grainsizes from silt to gravels through to cobbles and boulders. At this stage the site is assumed to have a low liquefaction potential.
- The proposed upgrades to this site include a bus shelter, toilet facilities and upgrades to the carpark. The structures are assumed to be simple lightly loaded structures and based on the likely soils on site, they should be able to be supported by shallow strip or spread foundations. At this stage the upgrades to the carpark are anticipated to require only minor ground improvement. These assumptions should be verified through a geotechnical investigation.
- The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point.

9.7 THREE WATERS INFRASTRUCTURE CONDITION

9.7.1 WASTEWATER

Table 44: The Chasm Wastewater generation rates

WASTEWATER SCENARIO	PER CAPITA CONTRIBUTION (L/DAY)	DAILY WASTEWATER VOLUME (M^3/DAY)
Containment tank only	0.2	0.1

If each toilet has a 4.5m3 containment tank for storage, then the tanks will need emptied every 3 months. As hand washing facilities are not recommended at this small site, hand sanitiser will need to be provided.

A level monitoring system should be installed to allow volumes to be tracked remotely and emptying arranged when full.

Table 45: The Chasm containment tanks estimated costs.

ITEM	ESTIMATED COST
Containment and toilet building	$150,000
Level monitoring	$5,000
Project overheads and delivery	$75,000
Total	**$230,000**

9.7.2 FEASIBILITY

It is recommended that The Chasm wastewater system is a total containment tank as described above. This option is considered feasible.

The next best available option would be for water to be made available for handwashing. This would increase the frequency of septic tank emptying and require additional water storage but would provide a better level of service.

9.8 CONTAMINATED SITES

9.8.1 CLEDDAU CIRQUE

Historical aerials and the site walkover suggest the site was created a safe stop-over for visitors to take pictures. Due to the remote location of the site, it is assumed that the fill material for the construction of the carpark would originate from the surrounding area and likely compromise reworked natural materials. No concerning activities were noted on the aerials nor on site during the walkover, as such the site has been classified as GREEN. HAIL rating GREEN indicates that HAIL activities (current or past) are unlikely.

9.8.2 SHORT STOP: THE CHASM

Historic aerials and anecdotal evidence suggest the site was created for use as a carpark to facilitate a walking track to the waterfalls. Due to the remote location of the site, it is assumed that the fill material for the construction of the carpark would originate from the surrounding area. A temporary campsite was noted in the 1938 aerial; however, it is at a sufficient distance from the site, such that it is highly unlikely for there to be contaminants of concern in sufficient quantity to be considered as HAIL. As such the site has been classified as HAIL category GREEN.

9.9 VERTICAL INFRASTRUCTURE

SHORT STOPS – BUS SHELTER LIGHT AND TOILETS

- Single level, Open sided shelter
- Standard “Light” structure deemed impractical for the location due to the extreme weather conditions – predominantly snow loading and wind loading. Provide permanent structures that comply with the New Zealand Building Code.
- IL2 Construction is feasible.

SHORT STOPS – BUS SHELTER – MINOR AND TOILETS

- Single level. Open sided shelter. No Post disaster function.
- Standard structures with Importance level IL2. Construction is feasible.
- “Minor” structure deemed impractical for the location due to the extreme weather conditions – predominantly snow loading and wind loading. Provide permanent structures that comply with the New Zealand Building Code.

10 MILFORD SOUND PIOPIOTAHI VISITORS' HUB

MILFORD SOUND PIOPIOTAHI VISITORS' HUB			
Proposal	Visitor's center, Visitor hotel and Staff accommodation, bus terminal, foreshore enhancement, Barren Peak Spur Walkway & Treetop Viewing Structures, Potable and Wastewater treatment facilities.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	High	Variable water levels will need to be considered when designing structures that are in or near the lower lying area. Due to the proximity of the Alpine fault and refuge status of some structures, it should be expected that more detailed geotechnical investigations, strict design requirements and complex construction will be required for these structures. Inputs from Natural Hazards reports and others should be used to inform the geotechnical investigation planning to ensure that scoping will include relevant testing.

MILFORD SOUND PIOPIOTAHI VISITORS' HUB			
	Three Waters Infrastructure	High	The reticulated water supply network will need upgrades, will need further detailed assessment of the existing networks capacity and to develop the final layouts. Wastewater treatment plant will require upgrades. The proposal is feasible
	Contaminated Sites	High	DSIs to assess the risk to human health and the environment for any ground disturbance
	Vertical Infrastructure	High	IL4 structures required.
Overall Feasibility of the proposal	Notes – The Visitor hub is a Class 3A site for Tsunami hazard and poses a substantial risk for workers. The proposal can only be adopted after a high-level review of the natural hazard risks. The proposed structures and amenities are feasible only if the Natural Hazards risks are further assessed and mitigated to an acceptable level.		
Next Best Option	Description - Further assessment of the natural hazard risks is necessary to determine the location and alignment of the proposed structures and walkway.		Feasibility: Low (High Risk factors identified)

10.1 NODE SUMMARY

The Masterplan was developed to be respectful of the heritage, values and narratives of Ngāi Tahu while managing a range of limitations to improve conservation and landscape and provide a high-quality experience for mana whenua, visitors, recreationalists, and locals at Milford Sound Piopiotahi.

The proposed visitors' hub will be constructed in Freshwater Basin which is near Milford Village that currently occupies a central location near the end of Milford Road. It will consolidate much of the infrastructure proposed within the reimagined Milford Sound Piopiotahi, including a new bus terminal, visitors centre, interpretive marine centre, hotel and staff accommodation and a range of outdoor experiences.

The visitors' hub will be the most intensively used area within Milford Sound Piopiotahi and will be carefully optimised for a high-quality visitor experience by reducing cross flows, minimising perceived crowding, maximising quality time, managing safe vehicle movement and protecting visitors from inclement weather and natural hazards.

- Create a compelling sense of arrival
- Establish a new bus terminal
- Establish new co- located visitor
- Develop new visitor accommodation
- Relocate staff accommodation
- Common service lane and shared facilities
- Foreshore enhancement
  - Barren Peak Spur walkway and treetop viewing structures

10.1.1 MILFORD SOUND PIOPIOTAHI HUB ENGINEERING ASSESSMENT SCOPE

- Arrival at Milford Sound Piopiotahi/New Bus Terminal – implementing this proposal will be contingent on the proposal for the aerodrome to be removed being confirmed. Despite this, the Consultant must still assess the engineering feasibility of implementing the recommendation for a one-way inbound approach and bus terminal on/adjacent to the existing aerodrome taxiway.
- Co-located Visitor, New Visitor and Staff Accommodation – the proposal to co-locate these functions is centred around reducing the risk of loss of life in a rare severe natural event. To establish the feasibility of the proposal and identify the Recommended Option and Next Best Alternative the Consultant must determine the best location (e.g. hard up against the face of Barren Peak) and form of the structure(s) to achieve the objectives of this proposal. In addition, the Client may have difficulty negotiating access to this location for invasive site investigation purposes (a preliminary geotechnical report for concept design of a proposed multi-level carpark, to be located just east of the existing hotel site, is available for reference). As such from an engineering feasibility perspective this proposal may only be able to be assessed as high-level conceptual.

- Barren Peak Spur Walkway & Treetop Viewing Structures – co-ordinate with the consultant appointed to the Walking & Cycling Experiences Feasibility workstream to assess the feasibility of this proposal.
- Potable water must meet NZ Drinking water standards.
- Wastewater must be treated to a level capable of being consented by Environment Southland for disposal to land in Fiordland National Park/ Te Wāhipounamu South-West New Zealand World Heritage Area, in a high rainfall environment and within 'natural state' waterbody catchments. Wastewater is currently consented to discharge to the coastal marine area at Cleddau Delta. The current consent (held by Milford Sound Tourism Ltd) is due to expire in 2028. Other locations more likely to be consented for discharge are to be considered by the Consultant.

Figure 42: Visitors Hub Cluster Plan

10.2 PRIMARY OPTION FOR CONSIDERATION

Piopiotahi visitor hub – The node is a Class 2 site for Landslide, Avalanche and Flooding risk, but is a Class 3A site for Tsunami Risk. The risk to the workers and visitors is assessed to be substantial, the proposed plan for the node should only be progressed after a high-level review of the natural hazards.

Proposed upgrades to this site include visitor accommodation, staff accommodation, a visitor hub building, a marine research centre, bus terminal, carpark relocation, Barren Peak Spur treetop lookout and walkway, covered walkways between critical areas, and new viewing decks / upgrades to the existing foreshore experience. The proposed structures are feasible from engineering perspective. It is recommended further geotechnical investigations be conducted to determine the design considerations.

The reticulated water supply network services Cleddau Village and Milford Sound Piopiotahi. It is recommended that a detailed assessment of the existing network's capacity to service redevelopment be undertaken as the final layout is developed. The anticipated future peak flow to the Cleddau wastewater pumping station below its design capacity of 16 L/s. As the capacity and flows to smaller pumping stations that service the dump station, airport, Milford Sound Lodge and Deepwater Basin facilities are unknown, it is not possible to determine if they require upgrade. It is recommended that this also be considered part of a more comprehensive network assessment. The increase in wastewater volume as a result of the Masterplan proposal will require a larger capacity WWTP to meet future wastewater flows. The proposed effluent quality requirements will also require an upgrade. An MBR system was used in the estimate as this provides the highest quality discharge. This is considered to be feasible and is considered BATNEC. There is existing stormwater infrastructure at Milford Sound Piopiotahi. Improvements to these networks can be made to improve the quality of the stormwater discharge. Options here could include bioswales, stormwater wetlands or oil and grit separators. These options are considered feasible and should be considered when designs are being developed.

The visitor hub and accommodation will be multilevel IL4. Further detailed investigation and analysis is required to confirm if construction of an IL4, with resilience to the natural hazards specific to this location, post EQ.

10.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding, Tsunami, and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

10.4 NATURAL HAZARD RISK ASSESSMENT

10.4.1 PART A: ASSESSMENT:

For the purposes of this report, Milford Sound Piopiotahi area is defined as the area west of the Tūtoko and Cleddau River confluence. This area includes the following key sites: Little Tahiti, Milford Sound Lodge, Deepwater Basin, Cleddau Delta, and Freshwater Basin (Figure 36).

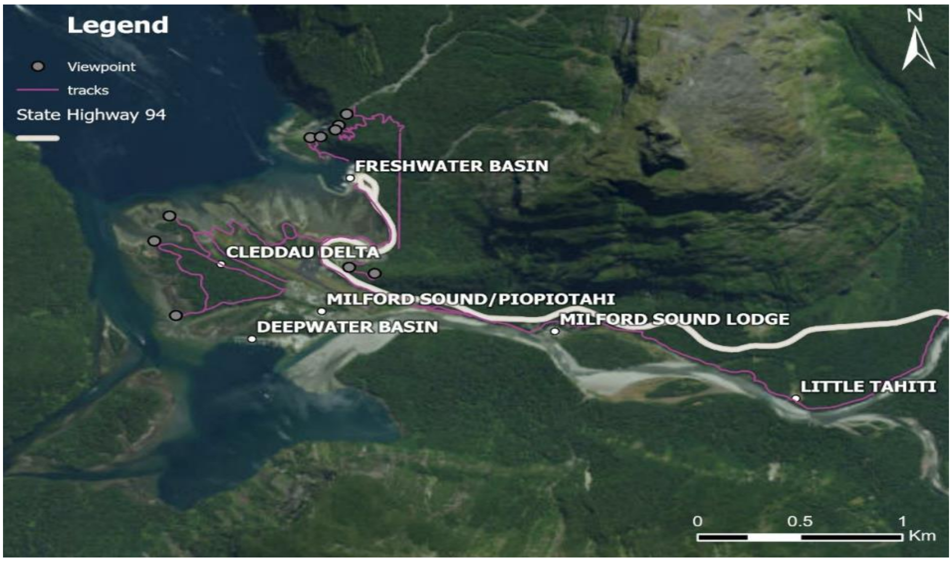


Figure 36: Aerial of Milford Sound Piopiotahi.

Figure 37: Milford Sound Piopiotahi sites under the MOP Master Plan (source: Stantec and Boffa Miskell)

10.4.2 LANDSLIDE, FLOOD AND AVALANCHE RISK

10.4.2.1 CLASS 2 SITES

As per the GNS methodology, a Class 2 site indicates that a basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

The Deepwater Basin and the Milford Sound visitor areas are situated on the Cleddau River delta which forms a reasonably flat peninsula surrounded by Milford Sound Piopiotahi.

The surrounding terrain is typically described as being steep heavily vegetated mountainous terrain. Previous studies and reports detail the extent of flood risk at Deepwater Basin and across the Cleddau Delta associated with the Cleddau River. There is extensive stop bank and rock armouring mitigation and control measures in place along the banks of the Cleddau at this site as a direct result of previous investigations and assessments of flood risk. Flood mitigation is based on existing data and reports, estimated to reduce the identified flood hazard to a low probability of occurrence, although exposure time remains high currently at these sites due to the presence of staff accommodation. If the proposal in the Masterplan to relocate staff accommodation from this area is implemented, then exposure times will significantly reduce.

The Deepwater basin and Cleddau Delta are assessed as Class 2 sites for flood risk associated with the Cleddau River. Visitors also use the constructed walkway between the Milford Sound visitor centre and the ferry terminal in Freshwater Basin. This area is typically low-lying and at the bottom of steep to very steep mountain side with near vertical faces such as that at the Bowen Falls areas north of Freshwater Basin. This area is prone to landslides, tree slides, and occasional rockfall which have occurred in recent years. Notably a tree slide and rockfall event caused considerable damage to a storage building in 2016.

Landslide and rockfall hazard probability at the Freshwater Basin is assessed qualitatively as medium. Rockfall and landslide hazard footprints in this area are mostly restricted to narrow chutes within existing gullies and on failed slopes while tree slides can occur in areas with mature vegetation outside of gullies.

Based on current usage of these areas site visitors and workers are expected to pass through hazard footprints in relatively short spaces of time and are unlikely to spend any significant time directly within the hazard footprint. Typical exposure windows of between 30 and 180 minutes have been determined in discussion with current site workers and operatives and future visitor use. The Freshwater Basin is assessed as a Class 2 site for landslides, tree slides, and rockfall.

On the Milford Sound Piopiotahi side of the Homer Tunnel, there are two sites on the Cleddau River assessed as being Class 2: Little Tahiti and Milford Sound Lodge. These sites are assessed as being exposed to flooding from the Cleddau River with a low probability of occurrence. However, the hazard at these sites is now somewhat mitigated due to the elevation of the sites above the existing river level and recent additional rock armouring placed along the riverbank at Little Tahiti and the Milford Sound Lodge. These sites were impacted by flood related scour and resulted in loss of the riverbank during the February 2020 storm events that impacted the Milford region. However, neither the Little Tahiti or Milford Sound Lodge site were flooded or inundated during the event.

In addition to flood risk, there is an established risk of contaminated land and associated impacts at Little Tahiti where previous investigation and reporting has determined the site to have been previously used as a dump site for construction wastes including asbestos containing materials. The associated risks with contaminated land hazards are not covered by this report and is addressed in the contaminated land assessments and planning for remedial works is currently underway. The contaminated land hazard occurrence and risk assessment is assessed and reported separately.

Figure 38: The flood mitigation stop bank on the northern margin of the Cleddau River looking out towards Milford Sound.

Figure 39: Freshwater Basin with an old tree slide scarp to the right of the image.

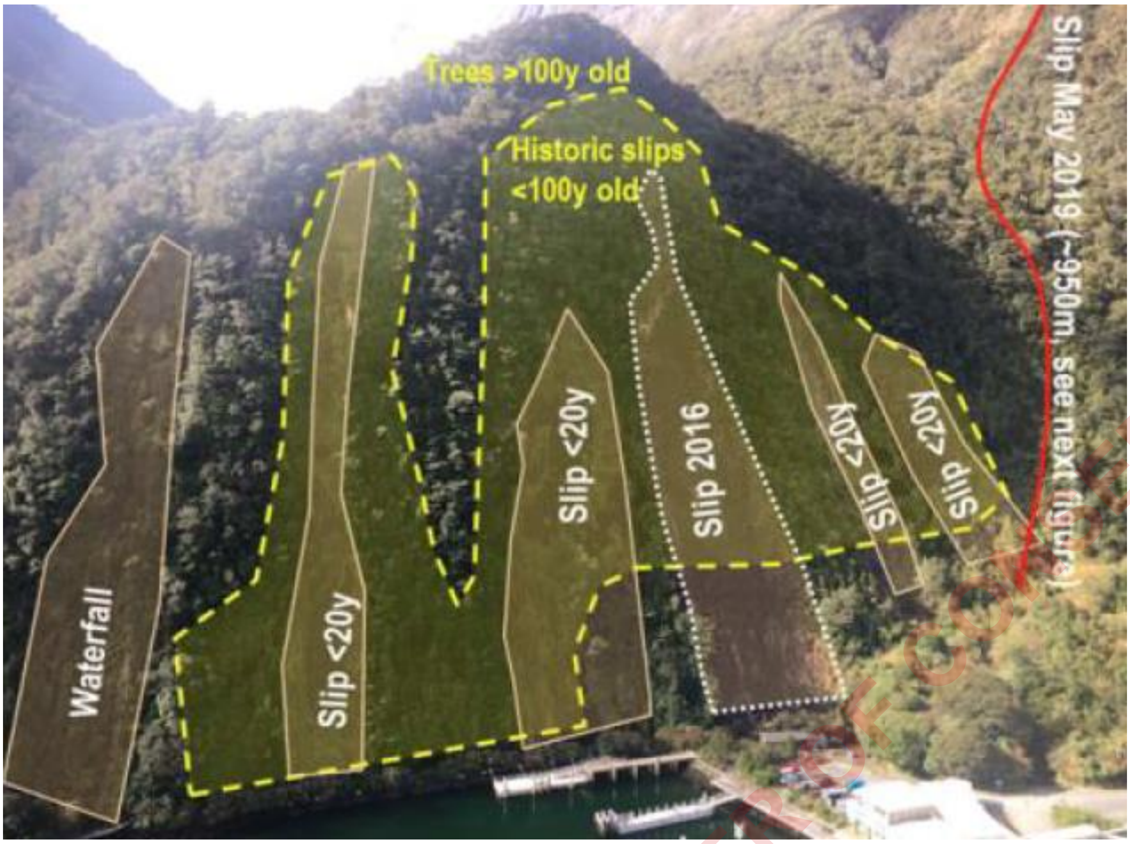


Figure 40: Tree slides and landslides in the hillslope next to Freshwater basin in Milford Sound (source: Stantec 2021)

Figure 41: Damage to a storage building in Milford Sound from a rockfall in 2016 (source: Tim Holland)

10.4.2.2 TSUNAMI RISK (CLASS 3A)

Defined by the GNS methodology, a Class 3A risk level indicates a “High to extreme” Significance level and falls under an “intolerable” DOC evaluation category. Risk Management Actions indicate that Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required. Class 3A represents the highest priority for further risk analysis and risk management actions.

The previous Stage 2 reporting identified the extent of tsunami risk in the Milford Sound area. Extensive studies and assessments of the occurrence of tsunamis within the sound or affecting the Milford Sound basin area have already concluded that there is a proven record of events having occurred over geological time.

As noted above there are typically two distinct sources of tsunami:

1. Landslide (rock avalanche) induced.
2. Earthquake induced sea floor rupture.

These are discussed and differentiated further in the Natural Hazards Part B report, however for the purpose of the screening analysis a review of the data presented in the Stage 2 works concluded that for the Milford Sound Piopiotahi area, the wave amplitude of a 100-year return interval tsunami (H50/100) was of the order of 1.3 – 1.9 m. This is based on the NTHM and only incorporates fault-induced tsunami.

For the Alpine Fault triggered landslide tsunami event, there is 150-year return interval for tsunami amplitudes ranging between 0.3 and 10 m at Freshwater Basin. For the Visitor Hub, Freshwater Basin, Deepwater Basin, and Cleddau Delta $S_{overland}$ (tsunami wave amplitudes required to impact the site) has been calculated as being 1.52 m, 1 m, and 0.5 m which are tsunami events all estimated to occur at least once every 100 years. Given the current use of the basin and population distributions around the area exposure times across the three sites in Milford Sound Piopiotahi have been determined as being greater than 180 minutes. Adopting the GNS methodology the Preliminary Analysis of tsunami risk as detailed in the tables presented in the Natural Hazards Part A assessment report, determines the site as being Class 3A for tsunami risk.

Due to the elevation and distance from the coast of the Milford Sound Lodge (~ 11 m above sea level and 1200 m away) and Little Tahiti (~19 m above sea level and 2400 m away), it is anticipated that a much larger tsunami wave at the Cleddau River Mouth would be needed before an actual impact at either site would occur.

For the Milford Sound Lodge $S_{overriver}$ has been calculated as 7.03 m which is equivalent to a tsunami with a return interval of 150 years (AF8 event). This hazard is qualitatively assessed as having a medium probability of occurrence. Exposure time at this site is also anticipated to be greater than 180 minutes. On this basis the Milford Sound Lodge is categorised as a Class 3A site for tsunami risk.

For the Little Tahiti site, $S_{overriver}$ has been calculated as 12.5 m. This is outside of the range of potential amplitudes from an AF8 event. A 12.5 m amplitude tsunami wave at Milford has been assessed as having a return interval of 555 years according to Dykstra (2012), > 2500 years according to Taig & McSaveney (2015), and >2500 years using theNTHM. This is assessed as a hazard with a low probability of occurrence and as such Little Tahiti is categorised as a Class 2 site for tsunami risk.

10.4.3 PART B ASSESSMENT

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested.
Landslide	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable- Continue with the proposal only after high level review.
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable – Close the site
Tsunami	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable – Continue with the proposal only after high level review
Tsunami	Substantial	Workers	Continue with the proposal only after a high-level review.

10.4.3.1 SOCIETAL RISK – TSUNAMI

LANDSLIDE INDUCED TSUNAMI

For the most likely event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 28 fatalities.
- When the population at risk is 2000, we estimate there to be 1120 fatalities.
- When the population at risk is 3000, we estimate there to be 1680 fatalities.

For the maximum credible event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 45 fatalities.
- When the population at risk is 2000, we estimate there to be 1800 fatalities.
- When the population at risk is 3000, we estimate there to be 2700 fatalities.

AF8 INDUCED TSUNAMI

- When the population at risk is 1, we estimate there to be no fatalities.
- When the population at risk is 50, we estimate there to be 21 fatalities.
- When the population at risk is 2000, we estimate there to be 840 fatalities.
- When the population at risk is 3000, we estimate there to be 1260 fatalities.

10.4.3.2 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

- When the population at risk is 1 at each site, we estimate there to be no fatalities at any site.
- When the population at risk is 5 at each site, we estimate there to be 1 fatality at Freshwater Basin.
- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Visitor Hub.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

10.5 LONG TERM CLIMATE CHANGE ASSESSMENT

The Milford Sound Piopiotahi Hub is the only location within the Milford Corridor to be exposed to Sea Level Rise. Given historical records of flooding at high spring tides at the Cleddau delta and current existing conditions, risk is moderate. Sea rise projections (including vertical land movement) towards the end of the century will raise risk up to extreme levels.

Extreme weather (high winds and storms) currently has moderate risk at this location; however, this is expected to reach extreme levels by late century. Similarly, flooding risk levels from extreme precipitation events are moderate, however future projections suggest that elements-at-risk will be more exposed to flooding from the Cleddau River over time, reaching extreme levels towards the end of the century.

It is important to note that extreme weather and heavy rainfall events may also contribute to increase the risk of slopes instability and given the evidence of rockfall and landslides at Freshwater and Deepwater basins, an increase in the frequency and intensity of climate events could potentially increase the risk of slope instability too.

Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher (hot days), the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise however, that, given the natural variability of rainfall, occasional dry periods will occur, over which drought and wildfire risk will be higher.

The number of hot days (temperature >25°C) will increase towards the end of the century, changing the risk from low currently to moderate, increasing the cooling requirements in buildings (i.e.: HVAC Systems).

Given the existing conditions around this location, avalanche risk is not applicable.

Table 46: Climate change risk summary – Milford Sound Hub

WSP			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Milford Sound Piopiotahi HUB	BUILDINGS	Curre t Yea	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	BUILDINGS	Mid-centur	High	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid-centur	High	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid-centur	High	High	High	Low	Moderate	Low	High
	BUILDINGS	Late-centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late-centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late-centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme

10.6 GEOTECHNICAL ASSESSMENT

Table 47: Complexity of the proposed structures

NAME - FACILITY		ASSUMED LIQUEFACTION POTENTIAL	GEOTECHNICAL INVESTIGATION	GEOTECHNICAL DESIGN	CONSTRUCTION COMPLEXITY (FOUNDATIONS)
Milford Sound Piopiotahi – Visitor Accommodation	Feasible – challenging	High	High Complexity	High Complexity	High Complexity
Milford Sound Piopiotahi – Staff Accommodation	Feasible – challenging	High	High Complexity	High Complexity	High Complexity
Milford Sound Piopiotahi – Visitor Hub	Feasible – challenging	High	High Complexity	High Complexity	High Complexity
Milford Sound Piopiotahi – Carpark Relocation	Feasible	High	Simple	Simple	Simple
Milford Sound Piopiotahi – Barren Peak Spur Treetop lookout	Feasible	High – low elevations Negligible – higher elevations	Simple	Walkway – Simple Lookout – Low Complexity	Walkway – Simple Lookout – Low Complexity
Milford Sound Piopiotahi – Covered Walkways	Feasible	High	Simple	Simple	Simple

The following is noted for Milford Sound Piopiotahi visitor hub:

- The Masterplan structures listed at this site are new visitor and staff accommodation, a visitor hub building, a bus terminal, car park upgrades, a Barren Peak Spur treetop lookout, new covered walkways, and new foreshore engagements (viewing decks).
- Elevation: The site is approximately 0 m – 5 m ASL
- Closest active fault: Anita Shear Zone #8756, located approximately 12 km west of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene River deposits (Unweathered, loose, boulder gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded).
- Environment Southland Liquefaction Risk Map: High Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- A preliminary geotechnical investigation was completed by GeoSolve with a report issued in February 2019. The report provided preliminary recommendations to upgrade the current carpark to a multi-storey carpark. The investigation consisted of 4 sonic boreholes completed a maximum depth of 18 m bgl. Two piezometers were installed to a depth of 6 m bgl for water

monitoring at the site. At this stage, it is not known if the piezometers are still installed on site or have been decommissioned.

- Results from the Geosolve investigation indicate that the site is underlain by fill, with deltaic sediment and interbedded organic swamp deposit below, and gabbro bedrock at a depth (5m to <18 m bgl). Groundwater level was encountered between 1.1m and 1.9m bgl.
- The near surface fill encountered in GeoSolve investigation is assumed to be engineered as part of a major upgrade of the Cleddau Flood Protection Scheme completed in the early 2010s. As built records to confirm the level of compaction achieved in the placed fill are not currently available, but may be available through DOC. These records may help to inform detailed planning of geotechnical ground investigations and preliminary foundation conceptual design.
- Geosolve notes that the carpark site has a liquefaction potential of high, it is likely that the surrounding areas also have high liquefaction potential. It should also be noted that this analysis was completed prior to the new NSHM 2022.
- A pavement assessment was completed by Stantec, and a report issued in May 2022, GeoSolve was contracted to provide a geotechnical investigation report for Stantec as part of the aerodrome runway pavement assessment report. GeoSolve's investigation included 4 test pits excavated to a maximum depth of 2.4 m bgl. Ground water was encountered at 2.3 m bgl. The investigation scope was restricted to section of runway adjacent to the taxi and fixed-wing parking area.
- Ground conditions encountered beneath the runway comprise asphalt placed onto native soils. The native soils consisted of loose to medium-dense sandy gravel with cobbles and boulders interspersed with woody organic material and some voids. Slumping issues observed in the runway pavement are likely caused by decomposition of buried logs (approximately 1.8 m bgl) in the natural subgrade, causing settlement, in one test pit, a void was encountered which GeoSolve noted was caused by decomposition of organic material.

10.6.1 COMMENTARY ON FEASIBILITY OF PROPOSED STRUCTURES

The reports outlined above give some information about the ground conditions at discrete locations on the site. Further investigations are required at each of the proposed structure locations to obtain site-specific information for design and to provide further detail on the spatial variability of ground conditions across the area.

Based on the available reports, the site likely consists of unknown depth of fill (engineered and possibly uncontrolled), underlain by interbedded sand, silt, and gravels (deltaic sediments) and organic swamp deposits. It is assumed that water is present at shallow depths below the site, fed by the Cleddau River and Milford Sound. Based on the likely presence of shallow water and the deltaic sediments, the site should be susceptible to liquefaction at this stage. Proposed upgrades to this site include visitor accommodation, staff accommodation, a visitor hub building, a marine research centre, bus terminal, carpark relocation, Barren Peak Spur treetop lookout and walkway, covered walkways between critical areas, and new viewing decks / upgrades to the existing foreshore experience.

It should also be noted that lower lying areas are currently affected by tidal changes within the Sound. Variable water levels will need to be considered when designing structures that are in or near the lower lying area.

It is possible that if individual geotechnical investigations of the various sites are completed in conjunction with each other, the amount of investigation can be optimized and will likely lead to efficiencies in investigation costs.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine fault and refuge status of some structures, it should be expected that more detailed geotechnical investigations, strict design requirements and complex construction will be required for these structures. These buildings will come with a significant cost associated with them when compared to other structures such as those located in other regions in New Zealand.

10.6.1.1 VISITOR ACCOMMODATION

A new hotel is proposed in an elevated position above the visitor and marine research centres. It will at a minimum be large enough to maintain the existing capacity within Milford Sound Piopiotahi. Based on Stage 2 Infrastructure Report – Appendix 211, this hotel is assumed to be designed to accommodate up to 100 visitors in a multistorey structure with an Importance Level of 4. The structure will need to withstand extreme events and act as a refuge.

Due to the importance of the structure a detailed geotechnical investigation and a site-specific seismic assessment should be completed to enable design of such a high importance structure.

To plan an appropriate investigation, a specific site location needs to be selected and some building details, such as footprint, and the number of levels be finalised. This will allow determination of the number of investigation points, types, and termination depths.

Given the above assumptions, and the likely presence of relatively weak near-surface soils, it is likely that the structure will be founded on a piled system. This may include piles socketed into bedrock (if shallow enough), but interpretation of the geotechnical investigation will determine the most suitable foundation type for the proposed structure. It has been assumed that any carparking associated with the visitor hub will be single storey and simple geotechnical investigations will be able to provide input to pavement designs.

10.6.1.2 STAFF ACCOMMODATION

A new purpose-built, multi-storey development has been proposed to replace the existing staff accommodation facility. The location of the staff accommodation has been identified as being located at either the Milford Sound Piopiotahi Visitor Hub or Little Tahiti.

If the staff accommodation is located at the Milford Sound Piopiotahi Visitor Hub, it is proposed to be located adjacent to the hotel. Based on MOP Stage 2 Infrastructure Report – Appendix 2, the assumptions and foundation recommendations for this structure are like the above Visitor Accommodation except for an increased capacity of 280 – 320 beds. At this stage it is assumed that the increased capacity will require a large building and as such an increase in the investigation scope will be needed when compared to the Visitor Accommodation.

It is anticipated that the foundation requirements will be like the visitor accommodation except for, possible increased loadings.

10.6.1.3 VISITOR HUB

The proposed new co-located facilities are to be located next to the existing hotel site. The ground level has been modified to elevate it above the surrounding area. At this stage it is not clear if the fill was placed in a controlled manner. The proposed building is a multi-storey structure that may double as a large refuge for visitors and staff. A rooftop helipad has also been proposed for the structure.

If this structure is designated as an emergency shelter, then it will require design to an Importance Level 4. This structure will have similar requirements to those for the Visitor and Staff Accommodations.

10.6.1.4 BUS TERMINAL

A new centralised bus terminal is proposed that uses the existing aerodrome taxiway, apron, and terminal area to optimise the coach services. This terminal is assumed to be a one or two storey structure with open spaces internally and covered outdoor area.

As noted above the proposed bus terminal is near the existing aerodrome runway. Investigations completed by GeoSolve in this area where settlement has occurred, found that the probable cause was due to decomposing organic matter. If areas of soft or organic ground are encountered, they will require over-excavation and backfilling with controlled fill to improve the subgrade. Further geotechnical investigation is needed to determine the sites suitability for the proposed bus terminal. This will include subsoil potential for settlement and assessment of the site's liquefaction potential.

10.6.1.5 CAR PARK RELOCATION

The existing foreshore public carpark is proposed to be relocated to the Cleddau Delta, south of the existing aerodrome runway. The ground in this area is assumed to be a combination of natural and reworked ground, with varying thicknesses of fill possible placed as part of the Cleddau Flood Protection Scheme.

10.6.1.6 BARREN PEAK SPUR LOOKOUT AND WALKWAY

An upgrade to the existing track leading up the Barren Peak Spur is proposed to connect to two treetop canopy viewing structures that are carefully configured to minimise the removal of mature Beech trees and to screen the built infrastructure of the visitor's hub below.

Based on the available information, it is assumed that the site is covered by shallow soils overlying gabbro bedrock. It is currently assumed that a foundation type such as above ground concrete footings anchored into the bedrock may be appropriate.

The liquefaction potential for the site varying from high potential at low elevations to negligible at high elevations where bedrock is assumed to be present.

Due to the sensitivity of the site, to minimise the disturbance to surrounding vegetation the geotechnical investigation will be confined to visual observations and a hand investigation to confirm depth to bedrock. Due to the limited geotechnical investigation, anchor design assumptions will need to be verified during construction.

10.6.1.7 COVERED WALKWAYS AND FORESHORE ENGAGEMENTS

At this stage the locations of the covered walkways are not known. It is anticipated that these are very lightly loaded structures and can be built with minimal geotechnical investigation and a standard footing detail could be developed for these structures.

10.7 THREE WATERS INFRASTRUCTURE CONDITION

10.7.1 WATER SUPPLY

10.7.1.1 EXISTING WATER SUPPLY

The existing Milford Sound Piopiotahi water supply is maintained and operated by Milford Sound Infrastructure. This supply services all properties in Milford Sound Piopiotahi, except for Milford Sound Lodge who source and treat water from their own bore.

Water for the supply is abstracted from hydro penstock which draws water from the Bowen River. Milford Power Holdings Limited holds a Water Permit (AUTH-20191733-01) to take and use surface water for the purpose of hydro-electric power generation and community water supply. This consent allows for a maximum abstraction rate of 313 L/s to a maximum volume of 27,000 m3/day and 7,884,000 m3/year. The consent expires 5 June 2045.

As needed, the supply can be supplemented by water from a bore located to the east of the main carpark. This source is used during maintenance of the hydro penstock or if required, during low flow periods in the Bowen River or when turbidity is high. Milford Sound Infrastructure holds a Water Permit (AUTH-20202219) to take groundwater from this bore at a maximum flowrate of 4 L/s, to a maximum volume of 346 m3/day and 34,560 m3/year no more than 80 days per year and for a continuous period of no more than 20 days. The consent expires 15 March 2047.

MSI has advised the peak demand on the water supply during peak summertime is 2.3 – 3 L/s. We assume the peak demand is for the treatment system rather than the supply from the tanks based on the expected peaks and population.

The supply has continuous online turbidity monitoring of the source water and when turbidity exceeds 3.5 NTU, this triggers an automatic switch over to the bore supply. Milford Sound Infrastructure staff have advised this has happened once since the bore was brought into service in 2022.

10.7.1.2 WATER DEMAND

Table 48: Milford Sound Piopiotahi Future Water Demand Breakdown

SOURCE	WATER DEMAND (L/PERSON/DAY)	POPULATION	DAILY VOLUME (M^3)
Accommodation - Visitors	250	200*	50
Accommodation - Staff	150	320	48
Day Visitors	10	7,000	70
Café/ Visitors Centre	12	1,750**	21
Total Daily Volume (m^3)			**189**
Average Flow (L/s)			**2.2**

The existing water treatment plant utilises filtration and UV disinfection. The flow through the UV is limited to 11.5 m3/h, which limits the daily maximum water production to 276 m3/day with no downtime.

There is currently 114 m3 of treated water storage split between two tanks of 76 m3 and 38 m3. This provides about 0.6 days' storage of treated water. We would suggest increasing this to a full days' storage. To meet the future demand, we recommend adding 75 m3 of additional storage. This could either be using a single large bolted-steel tank which would be more resilient and durable or multiple PE tanks which would be cheaper.

10.7.1.3 TREATMENT UPGRADES

To meet the compliance requirements for a large water supply (>500 people) under the DWQAR, the WTP needs to be upgraded. The compliance upgrades required are:

- Chlorination and monitoring equipment.
- Source water monitoring equipment (conductivity and pH).
- Flow monitoring through the UV.
- UVT and turbidity monitoring before or after the UV.
- Additional filter and UV capacity may be required depending on water demand.

Table 49: Milford Water Supply Upgrade Options Estimated Cost

ITEM	ESTIMATED COST
Treatment Plant Upgrades	$200,000
Water Storage Upgrade	$450,000 – Bolted Steel Tank Option ($38,000 – PE Tank Option – Next best alternative)
Total	**$650,000 – Bolted Steel Tank Option** ($238,000 – PE Tank Option - Next best alternative)

10.7.1.4 NETWORK UPGRADES

The reticulated water supply network services Cleddau Village and Milford Sound Piopiotahi. It is recommended that a detailed assessment of the existing network's capacity to service redevelopment be undertaken as the final layout is developed.

10.7.2 WASTEWATER

10.7.2.1 EXISTING WASTEWATER SYSTEM

RETICULATION

The Milford Sound Piopiotahi wastewater network was constructed in 1997 and has since grown to service development and new connections as septic tanks were decommissioned. The boat terminal is at the top end of the network. Wastewater from the boat terminal is pumped to a 300 mm PVC-U pipe that runs along State Highway 94 from the public toilets, below the runway. to the Cleddau Village pumping station (also servicing Cleddau Village). Wastewater is pumped from Cleddau Village pumping station into the WWTP. Several minor pumping stations pump into this main line, servicing the dump station, airport, Milford Sound Lodge and Deepwater Basin Facilities. The Cleddau Village pumping station was designed for a peak wastewater flow of 16 L/s.

WASTEWATER TREATMENT AND DISPOSAL

The WWTP consists of a number of septic tanks which then have flow pumped to a trickling filter and clarifier. Treated effluent passes through a UV disinfection before being discharged. The resource consent permits a discharge of up to 1,000 m3/d of treated effluent into the Deepwater Basin.

10.7.2.2 WASTEWATER FLOWS

Table 50: Milford Sound Piopiotahi current wastewater flow breakdown at peak population

SOURCE	PER CAPITA CONTRIBUTION (L/DAY)	POPULATION	DAILY VOLUME (M^3/D)
Cleddau Village Resident	210	260	54.6
Other overnight	210	250	52.5
Day Visitors	10	4,000	40
Café/ Visitors Centre*	12	1,000	12
Total			**159.1**
Average Flow (L/s)			**1.8**
Peak Flow (5 x ADWF) (L/s)			**9.2**

*Assume 25% of day visitors go to Café/ Visitors Centre

**Assume 2 people per bed

In addition to the flows presented in Table 50 there are several small sources including the dump station, airport, and Deepwater Basin toilets, which are estimated to have a total daily contribution of around 3 m3/d (Stantec 2018). The calculated flows have been compared to recent observed data. The flow data from 2023 provided shows an average dry peak daily flow of 142 m^3/day (November to February) and a maximum of 692 m^3/day (8 l/s) which is 4.9 times the average flow. This shows reasonable correlation with the current estimates for existing conditions.

Instantaneous peak flows are not reported and should be considered in the next stage of investigation as will influence system design. Additionally, as part of the next stage detailed analysis of flow should be undertaken to understand diurnal peaking and fluctuations, which can be obtained by logging flow data at 5-minute intervals.

Table 51: Milford Sound Piopiotahi Future wastewater flow breakdown at peak population

SOURCE	WATER DEMAND (L/PERSON/DAY)	POPULATION	DAILY VOLUME (M^3)
Accommodation - Visitors	250	200*	50
Accommodation - Staff	150	320	48
Day Visitors	10	7,000	70
Café/ Visitors Centre	12	1,750**	21
Total Daily Volume (m^3)			**189**
Average Flow (L/s)			**2.2**
Peak Flow (5 x ADWF) (L/s)			**10.9 (941 m^3/d)**

The current resource consent sets a maximum flow through the WWTP of 1000 m3/day. It is noted that the current plant has a capacity of 800m^3/day. The estimated peak flow is not estimated to exceed the current flow limit but may exceed the process plant capacity.

10.7.2.3 NETWORK UPGRADES

The anticipated future peak flow to the Cleddau wastewater pumping station (including a peaking factor of 5 as shown in Table 51) is below its design capacity of 16 L/s. As the capacity and flows to smaller pumping stations that service the dump station, airport, Milford Sound Lodge and Deepwater Basin facilities are unknown, it is not possible to determine if they require upgrade. It is recommended that this also be considered part of a more comprehensive network assessment.

10.7.2.4 TREATMENT UPGRADES

EXISTING CAPACITY

Based on current BOD load estimates derived from population, with 10% reduction through the WWTP septic tank stage, this will give a loading rate of 0.3 kg/m3/d on the existing trickling filter. A typical trickling filter loading rate will depend on the media, its roughness, and the ambient air temperature. For a rough stone media with 120 m2/m3 area, this loading rate is < 0.15 kgBOD/m3/d. to achieve < 25 mg/L BOD (Yorkshire Water Services design guidance (unpublished)). This indicates that in peak summer the trickling filter is likely overloaded, but in winter is suitably loaded. Loading rates of < 0.1 kg/BOD/m3/d are required to remove ammonia consistently. Where high concentrations of ammonia are expected, particularly where high numbers of day visitors occur will require additional recirculation to achieve better quality. On this basis to meet a higher ammonia standard at peak loading rates, the biological trickling filter will need to be 3 times larger than the existing system. To accommodate future loads, a further 4 trickling filters will be required. The footprint of this option will be limited.

If not upgraded the trickling filter will be excessively loaded and the media will block, leading to discharge of poorly treated wastewater through the outfall to Deepwater Basin. Odours are also likely.

High concentrations of ammonia may have localized toxic effects on fish and other aquatic life. It is expected that more stringent standards for BOD, suspended solids ammonia and probably total nitrogen will be applied for effluent on a future resource consent. The current treatment technology is not able to achieve this consistently.

SELECTION OF TREATMENT OPTION

There are several treatment options available which were described in Section 4.3.2.2 that would be suitable for the treatment of wastewater at Milford Sound Piopiotahi. To select the appropriate treatment option, a multi-criteria Analysis was undertaken.

- Tankering wastewater offsite for treatment at suitable WWTP.
- Septic tank and Rotating Biological Contactor (RBC).
- Septic tank and Moving Bed Bioreactor (MBBR).
- Septic tank and porous media filter (PMF) (like existing Innoflow system).
- Septic tank and trickling filter (TF).
- Membrane Bioreactor (MBR).

The below table presents scoring for each criterion based on the advantages and disadvantages of each treatment option. All scores are relative to the base solution of the MBR and no criteria weighing has been applied (all equally weighted). There is additional discussion below.

Table 52: Multi-criteria assessment scoring for Milford Sound Piopiotahi

PARAMETER	MBR	TANKER AWAY	SEPTIC TANK AND RBC	SEPTIC TANK AND MBBR	SEPTIC TANK AND PMF	SEPTIC TANK AND TRICKLING FILTER
Health and Safety	0	0	0	0	0	-1
Cost – Capital Expenditure	0	4	2	2	3	2
Cost – Operational Expenditure	0	-5	1	-2	-1	-1
Resilience to local climate	0	0	0	0	-1	-3
Effluent quality	0	0	-3	-2	-1	-2
Cultural Acceptability	0	0	-3	-2	-1	-2
Adaptability to changing load	0	-2	-2	-1	-1	-2
Constructability - Footprint	0	0	-2	-2	-4	-4
Operator Skill Level	0	2	3	2	2	2
Total Score	**0**	**-1**	**-4**	**-5**	**-4**	**-9**

Table 53: Estimated Operational Costs – Milford Sound Piopiotahi

ITEM	UNIT	MBR	TANKER AWAY	SEPTIC TANK AND RBC	SEPTIC TANK AND MBBR	SEPTIC TANK AND PMF	SEPTIC TANK AND TRICKLING FILTER
Daily Peak Volume	m^3	1.73		3	3	3	3
Tankers Per Year	-	21	11,449	37	37	37	37
Tanker Cost	$	$ 42,097	$ 22,897,670	$ 73,000	$ 73,000	$ 73,000	$ 73,000
Power Cost (@40c/kwh)	$	$ 35,040	0	$ 17,520	$ 46,720	$ 23,360	$ 17,520
Operator Hours	Hr	1416	120	432	532	492	700
Operator Cost (@$100/hr)	$	$ 141,600	$12,000	$ 43,200	$ 53,200	$49,200	$ 70,000
ITEM	UNIT	MBR	TANKER AWAY	SEPTIC TANK AND RBC	SEPTIC TANK AND MBBR	SEPTIC TANK AND PMF	SEPTIC TANK AND TRICKLING FILTER
Membrane Replacement (Annualised)	$	$20,000	-	-	-	-	-
Total Opex	**$**	**$ 238,737**	**$ 22,909,670**	**$ 133,720**	**$ 172,920**	**$ 145,560**	**$ 160,520**

RECOMMENDED TREATMENT OPTION

The recommended WWTP at Milford Sound Piopiotahi is an MBR, consisting of the following:

- New inlet balance tanks to buffer peak loading.
- Pumps to feed treatment plant.
- 2 mm fine screens, mounted over the treatment reactor.
- An anoxic zone and aerated reactor zone.
- Membrane modules
- Washwater and backwash tanks
- Pipe, pump, and blower room.
- UV disinfection.
- building with operations facility and sludge thickener.
- Reuse of septic tanks for sludge storage.
- The entire system should be constructed on a raised platform/earth mound.

Figure 42: Indicative Site Layout. The existing septic tanks could be repurposed for sludge storage.

RECOMMENDED EFFLUENT DISPOSAL SOLUTION

Land is constrained at Milford Sound Piopiotahi and increases in sea level will further reduce the available area. Section 4.3.2.4 presents a review of effluent disposal methods. For Milford Sound Piopiotahi the preferred option is an infiltration trench. The Cleddau Delta is largely sands and gravels with a shallow groundwater level that is influenced by tides. We have assumed a soakage rate of 300 mm/d can be achieved, therefore requiring a 350 m long, 1.5 m wide trench. This trench may be open (as water is disinfected before entry) but may be filled with cobbles to reduce the risk of public exposure.

Due the high groundwater levels, and if inflows exceed soakage capacity during wet periods, the trench should be designed to overflow to a gabion channel before discharge to the ocean. Effluent land contact before discharge to water is a cultural preference. Iwi engagement on Te Mana o te Wai is recommended for all effluent discharges. This approach minimises the land affected and the visual impact.

Figure 42 presents an indicative layout of the proposed effluent soakage system adjacent to the airport. There are several other locations that the soakage system could be located, and the final location should be determined as the design is developed and the final layout of the Masterplan is confirmed.

It is noted that there are several sites listed in the HAIL register in proximity to the proposed system that should be considered when selecting the final location. These include the extent of the airport itself, a historic refuelling compound on the southside of the runway and the old airport control tower (possible lead paints) (WSP, 2024). These sites present a potential risk that should be investigated as the preferred location of the effluent soakage is developed.

Additionally, previous studies have identified that the north-western end of the runway is affected by high groundwater levels during high tides, impacting drainage of the runway. These investigations recommended that this section of runway be raised to a minimum RL of 2.6 m to mitigate drainage issues (Stantec, 2022). The indicative soakage location requires the runway to be raised to this level to prevent groundwater inundation to the soakage system; if the elevation increase does not occur, an alternative location for soakage should be considered.

Figure 43: Milford Sound Piopiotahi indicative effluent disposal system layout

10.7.2.5 FEASIBILITY

The increase in wastewater volume as a result of the Masterplan proposal will require a larger capacity WWTP to meet future wastewater flows. The proposed effluent quality requirements will also require an upgrade. An MBR system was used in the estimate as this provides the highest quality discharge. This is considered to be feasible and is considered BATNEC.

Table 54: Milford Sound Piopiotahi Wastewater treatment upgrade estimated cost.

ITEM	ESTIMATED COST
Treatment Plant Upgrades	$10,300,000

The selection of which technology is most suitable for future needs will be made during an assessment of environmental effects during the resource consent renewal process.

The cost estimates have been prepared bottom up, based on a similar sized project constructed in 2023. The cost estimate includes:

- Equipment purchase.
- Installation.
- Civil, mechanical, electrical, structural, piping and controls.
- Buildings.
- Gravel access road.
- Land disposal earthworks.
- P&G at 15%.

The next best alternative solution for Piopiotahi Milford Sound is a conventional activated sludge treatment plant, if the resource consent quality standards permit. Our recent experience across New Zealand indicates similar capital costs for membrane systems as for conventional treatment systems.

10.7.2.6 DESIGN NEXT STEPS

During the development of the indicative WWTP and effluent disposal system, reference has been made to available information and assumptions have been made. The following next steps are recommended in developing the WWTP design for Piopiotahi Milford Sound:

- The selected WWTP location is indicative only and has been selected as it is currently designated for wastewater treatment and is expected to be large enough for construction of the new plant. As the final layout is developed it should be confirmed this site is appropriate.
- Further characterisation of wastewater flows and loads should be undertaken for sizing treatment processes that can achieve performance criteria for the variable wastewater flows throughout the year. Monitoring at peak periods of flow and visitor numbers of each category will be required to calibrate the design. Alternatively, a conservative estimate may be used.
- The selected effluent disposal system location is indicative only and has been sized based on assumed soakage rates for sands and gravels present on the Cleddau Delta (no field testing). Geotechnical investigations are required confirm the indicative location selected is appropriate and to confirm the footprint required. Consideration will also need to be given to higher coastal water levels.
- The indicative selected effluent disposal system location is adjacent to the airfield. There are proposals to change the usage of the airfield, and there are localised low spots are prone to flooding and a high-water table. These should be considered in developing the effluent disposal system layout.
- An Assessment of Environmental Effects of treated effluent discharges will be required. This document links to resource consent application and demonstrates the expect impacts on the receiving environment as surface water, groundwater and odour emissions on water quality and ecology and the risks to public health.
- The long-term viability and risks associated with the dump station in Piopiotahi Milford Sound will require specific consideration. The discharge of “Blue Loo” may have implications in the treatability of wastewater.

- Hazards associated with construction, operation, maintenance, decommission and possible effects on the public are considered through a safety by design process.
- Engagement with iwi is required to confirm soakage of treated effluent to ground is acceptable at this location.

10.7.3 STORMWATER

There is existing stormwater infrastructure at Milford Sound Piopiotahi. Improvements to these networks can be made to improve the quality of the stormwater discharge. Options here could include bioswales, stormwater wetlands or oil and grit separators. These options are considered feasible and should be considered when designs are being developed.

No estimate has been provided as there is no requirement to undertake improvements and the cost to implement can vary significantly.

10.8 CONTAMINATED SITES

10.8.1 VISITORS HUB

The MOP Masterplan proposed to redevelop the current Milford Village into a visitor's hub that consolidates much of the infrastructure proposed within the reimagined Milford Sound Piopiotahi, including a new bus terminal, visitors centre, interpretive marine centre, hotel and staff accommodation and a range of outdoor experiences.

10.8.2 IDENTIFIED HAIL ACTIVITIES

The PSI undertaken by e3Scientific (e3S) for the Visitor's Hub area has been reviewed and information obtained has been summarised in the sections below (e3Scientific, 2022e). It should be noted that the PSI refers to this geographical area as Freshwater Basin, while the Masterplan names the same area as the Visitor's Hub.

As Hazardous Activities and Industries List (HAIL) activities have been identified on the site, the Visitor's Hub has been classified as RED requiring further assessment to the risks to human health and the environment prior to development. A summary of the identified HAIL activities is provided in Table 55 below, with a HAIL activity location plan presented in Figure 44.

RED – HAIL assessment indicates activities (current or past) are known.

Table 55: Summary of Identified HAIL Activities

HAIL ID	Location	HAIL Activity	Dates	Comment	Likelihood
SLUS-00000097	MPH Generator Shed	A17. Storage tanks or drums for fuel, chemicals, or liquid waste.	1950s – present	Diesel fired backup generator. Remediation undertaken but may not be complete.	Registered site (ES)
FWB1	Ex-Fire Station	F4. Motor vehicle workshops.	1930s (?) – 2000s	Fire station likely to be constructed when road crew where present, presence of inspection pit indicates vehicle maintenance occurred on site.	More likely than not.
SLUS-00000217	Allied Petroleum Self Service Station	F7. Service stations including retail or commercial refuelling facilities.	1960s – ongoing	Mobil sold to Allied Petroleum early 2000s, provision of fuel for visitor and local traffic.	Registered site (ES)
FWB2	MPL	A17. Storage tanks or drums for fuel, chemicals, or liquid waste.	1950s – present	After the Milford Highway was completed, it is likely that any coal or wood burners were replaced with diesel fired boilers.	Certain
FWB3					
FWB4					
FWB5	MPL and surrounding buildings	E1. Asbestos products manufacture or disposal including sites with buildings containing asbestos products known to be in a deteriorated condition.	1930s – present	Asbestos has been identified as a building material at the hotel. During its lifetime it is more likely than not that the buildings have been in deteriorated conditions either through fire or long-term use.	More likely than not.
		I. Any other land that has been subject to the intentional or accidental release of a hazardous substance in sufficient quantity that it could be a risk to human health or the environment.	1900s – present	Potential discharge of degraded hazardous building materials (e.g., lead paint) to soil; 3m halo around all long-term structures in Milford Township.	Unverified

Figure 44: HAIL activity location plan

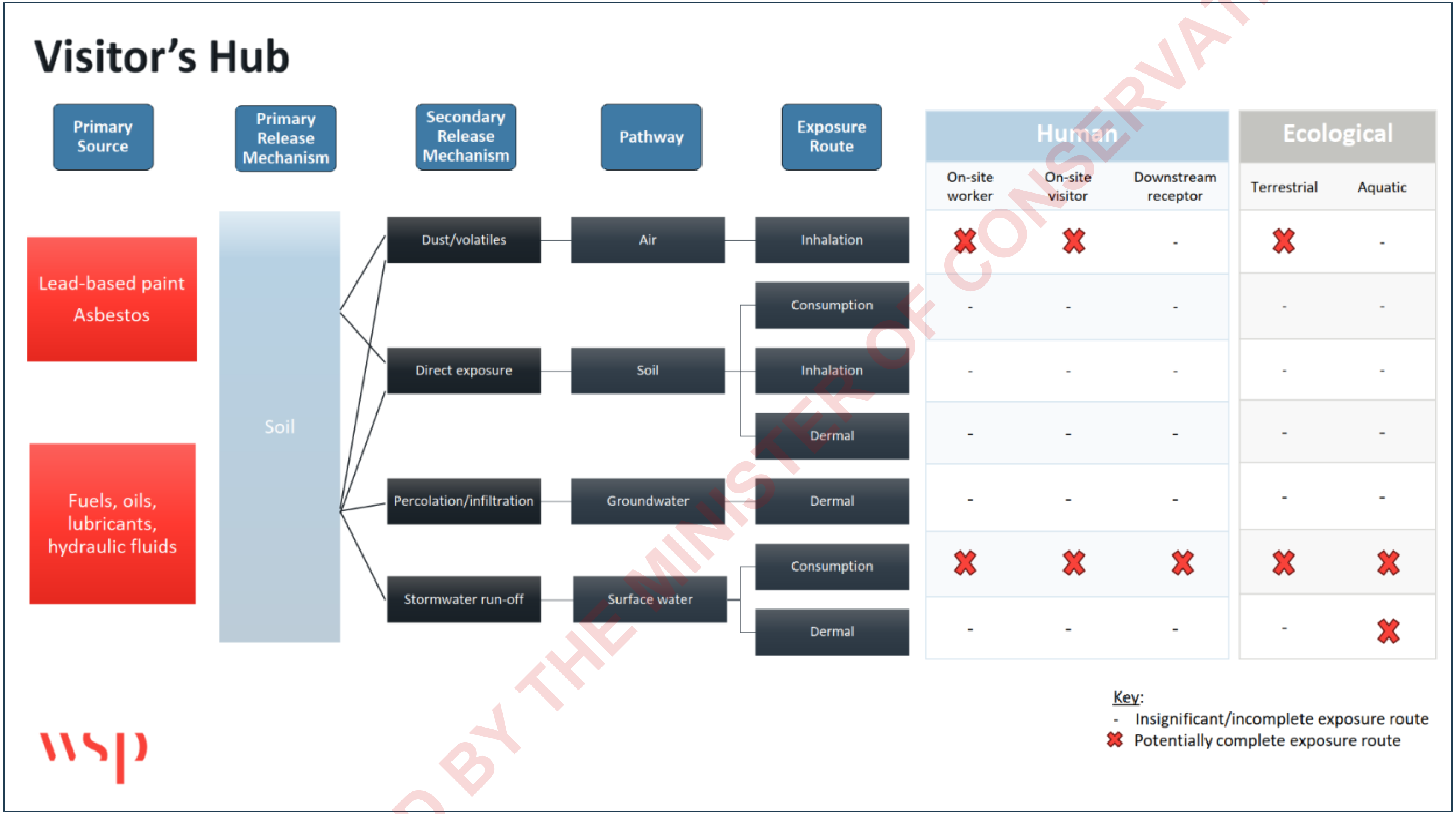


Figure 45: Conceptual Site Model: Visitors Hub

10.8.3 FURTHER ASSESSMENT

HUB	DSI SCOPE OUTLINE	CONTAMINANTS OF CONCERN	DSI COST ESTIMATE
Visitor's Hub	DSIs to assess the risk to human health and the environment for any ground disturbance in the locality of the pieces of land defined in the sections above	Heavy Metals, TPH, PAH, BTEX, PCB's Asbestos	$45,000 - $50,000

10.9 VERTICAL STRUCTURES

10.9.1 PIOPIOTAHI VISITOR HUB

The vertical infrastructure at the Piopiotahi visitor hub cluster includes a visitor experience centre along with visitor accommodation and staff accommodation. This will be a complex group of buildings with multi-purposes. The hub structures will be the key arrival location for visitors to Piopiotahi Milford Sound and will provide restaurant and restroom facilities along with activities and accommodation. The buildings will have multi-levels and will also serve as an emergency refuge.

Specific considerations that will drive the detailed design of these structures are the crowd activities and the requirement for emergency refuge/post disaster functionality. The visitor and staff accommodation that have a post disaster function will have an Importance Level 4. The proximity of Piopiotahi Milford Sound to the Alpine Fault will require significantly robust structures to resist an SLS2 Earthquake and still be functional. Serviceability Limit State 2 (SLS2) is defined in the New Zealand Loadings standard, Australia/New Zealand Standard, Structural design actions (AS/NZS 1170.0), and is used to determine the earthquake design load limit at which the structure maintains operational continuity.

An additional challenge is the risk of inland tsunami on the structures. Alpine Fault earthquakes are the dominant trigger for landslide-induced tsunami in Milford Sound. Tsunami amplitudes are estimated to range between 1.2m and 9.7m at Freshwater Basin. Specific studies will be necessary to determine the tsunami load on the structures together with debris loading. It is possible that the refuge areas may need to be located at second, third, or fourth floor levels depending on the design wave run-up scenarios adopted. Immediate access and egress ways from these higher floor levels out to higher ground that do not require egress through the lower levels of the building should be considered. It may be possible to consider locating the refuge area at higher elevations to reduce the risk, although this may be unacceptable due to its impact on the surrounding native vegetation.

The buildings that will not function as an emergency refuge but have crowd activities will have an Importance Level of 3, however consideration of how all the buildings interact with each other is important. A level 2 or 3 building must not have a detrimental impact on the Level 4 emergency refuge building(s). It may be necessary for all buildings within the visitor hub to be designed to IL4. The buildings should include specific consideration to the local climate with appropriate and specific design with respect to durability and stormwater management. Architectural design will need to consider large eaves and avoid internal gutters, amongst other specific detailing, to ensure weather tightness in the harsh environment. The remote site also requires specific consideration with respect to fire protection as firefighting capabilities are limited. In addition to early warning heat and smoke detection, sprinkler protection should be a consideration. Geotechnical considerations for the site should include the risk of liquefaction. Not for just the structures but the adjacent access roads to maintain emergency access.

The IL4 buildings will require emergency power generation and backup diesel generators are likely to be necessary.

10.9.2 STRUCTURAL SYSTEM

The structural system for the Piopiotahi visitor hub will be standard structures with structural frames and shear walls on heavy reinforced concrete slab with potentially deep piled foundations or ground bearing slabs with ground improvements. The Visitor Hub site is located on the Cleddau delta and is in a similar location to the location of geotechnical investigations undertaken by GeoSolve Ltd for Milford Sound Tourism Limited. The site ranges from shallow to deep soils with the potential for liquefaction under seismic loading. The design should have emphasis on prefabrication to minimise on site works and minimise in-situ concrete. The main structure frame materials could be structural steel and/or possibly engineered timber (LVL. CLT, Glulam). This civic building will benefit from large open spaces with large roof spans.

PIOPIOTAHI VISITOR HUB

- Visitor centre and focal point for entire visitor experience.
- 1800m2 Multi – level. IL4 – Crowd Activity. No Post disaster functions. However, it is proposed that the visitor Hib will be part of the complex that includes the visitor accommodation which will be an IL4 structure.
- Footprint constraints will likely require multi- level(s).
- Fire Protection – early warning smoke/heat detection and sprinklers.

PIOPIOTAHI VISITOR ACCOMMODATION

- 100 bed accommodation. Emergency refuge – post disaster function. 1540 m2 Multi level.
- Footprint constraints will require multi-levels.
- Fire Protection – early warning smoke/heat detection and sprinklers.
- Providing an IL4 structure with provisioning for emergency refuge(s) in this remote location, with significant natural hazards, will be very complex and challenging.
- The selection of sites should consider geotechnical conditions and the potential for natural events that may impose substantial loads. This includes not only the primary hazard such as earthquake loads but also secondary impacts from tsunamis and landslides.
- Alpine Fault earthquakes are considered to be the dominant trigger for landslide-induced tsunami in Milford Sound. Tsunami amplitudes are estimated to range between 1 to 9m at Freshwater Basin.
- Location to allow the ground floor level to be at an appropriate level above flood/tsunami wave level or the lower floors of buildings could be designed to withstand tsunami/debris flow with refuge area at second/third floor.
- An initial tsunami evacuation point could be at high ground near the site (Barren Peak Spur) and the affected people could then retreat to the accommodation post EQ.

- Further detailed investigation and analysis is required to confirm if construction of an IL4 structure, with resilience to the natural hazards specific to this location, is feasible.

PIOPIOTAHI STAFF ACCOMMODATION

- 280 – 320 bed accommodation. Emergency refuge – post disaster function. Multi-level 5100m2.
- IL4 – post-disaster function.
- Footprint constraints will require multi-levels.
- Fire Protection – early warning smoke/heat detection and sprinklers.

PIOPIOTAHI ARRIVAL STRUCTURES – BUS STOP

- Bus Stop shelter – No Post disaster function. A covered way with open side(s) for bus access. Single level.
- IL3- Designed for crowd activities – AS/NZS 1170.0, Table 3.2, requires airport terminals, principal railway station with a capacity greater than 250 to have an Importance Level of IL3. No post-disaster function.
- It is estimated that the average visitor numbers to Piopiotahi Milford Sound will be an average of 6,000/day with a peak of 1,000/hour. A significant number of these people will use the facility.
- The construction of the arrival structures is feasible but further investigations are necessary to confirm how the loading from natural hazards are mitigated. With the arrival structures not having a post-disaster functionality the structure can be designed to resist the design earthquake loads but the detailed design may be able to justify a reduction in the resilience of the structure to withstand tsunami loading.

PIOPIOTAHI ARRIVAL STRUCTURES – COVERED WALKWAY

- Covered Walkway from bus shelter to Visitor Experience centre.
- Single level. Basic Shelter from wet weather. Open one side.
- 6000 users per day with a peak of 1,000 per hour expected- but transit only and not considered a crowd activity.
- IL2. Construction is feasible but similarly to the Phub7 / arrivals structures users will be expected to retreat to higher ground immediately after an earthquake.

PIOPIOTAHI WASTEWATER SERVICES

- Structures associated with the WWTP. Post disaster function. Single level plantroom(s) and treatment pipework.
- Post-disaster function to support IL4 accommodation and emergency refuges.
- WWTP Buildings and plant supports.
- Construction is feasible but the site location requires careful consideration with respect to ground conditions and natural hazards. The smaller footprint of services buildings may allow them to be located on higher ground or on a raised platform/earth mound. Further investigations and detailed analysis are required to confirm the site height above sea level.

PIOPIOTAHI WATER SERVICES

- Structures associated with Water Services. Post Disaster function. Single level plantroom(s) and treatment pipework.

- Post-disaster function to support IL4 accommodation and emergency refuges.
- WTP Buildings and plant supports.
- Construction is feasible. See PHub12 for additional comments about resilience.

PIOPIOTAHI POWER SERVICES

- Structures associated with Power Services. Turbine and generator house. Intakes and penstocks. Post – disaster function. Single level plantrooms.
- Post – disaster function to support IL4 accommodation and emergency refuges.
- Powerhouse buildings and plant supports.
- Emergency diesel power generation at the accommodation maybe required as part of the power supply scope.
- Construction is feasible.

PIOPIOTAHI VIEWING DECK WALKWAY

- Treetop canopy viewing platforms linked to the Visitor Hub.
- Raised structures with walkways and stairs, likely to be constructed with timber.
- Construction is feasible. Standard structures. IL2.

11 FRESHWATER BASIN NODE

FRESHWATER BASIN NODE			
Proposal	Redevelopment of the boat terminal, iconic refuge, nature walk loop, Hine-te-awa Bowen Falls experiences, lower pontoon walkway, Hine-te-awa Bowen falls top links.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	High	Should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures
	Three Waters Infrastructure	N/A	Covered in Visitor Hub
	Contaminated Sites	High	DSIs to assess the risk to human health and the environment for any ground disturbance
Overall Feasibility of the proposal	Notes – Primary Masterplan proposal may need review owing to lack of feasibility owing to High risk levels for Natural Hazards, Geotechnical Engineering and Contaminated Sites.		
Next Best Option	Description - Further assessment of the natural hazard risks is necessary to determine the location and alignment of the proposed structures and walkway.		Feasibility: Low (High risk factors identified)

11.1 NODE SUMMARY

The Freshwater Basin node will be based around the existing boat terminal and jetties located in a sheltered basin between the (Lady) Hine-te-awa Bowen Falls and Cleddau Deltas. It will primarily be used as an experience node for visitors with a short road link and separated boardwalk along the foreshore from the Visitor Node. This will allow travel through the Beech Forest, which is one of the few readily accessible places where the forest extends all the way from the bush to the fiord.

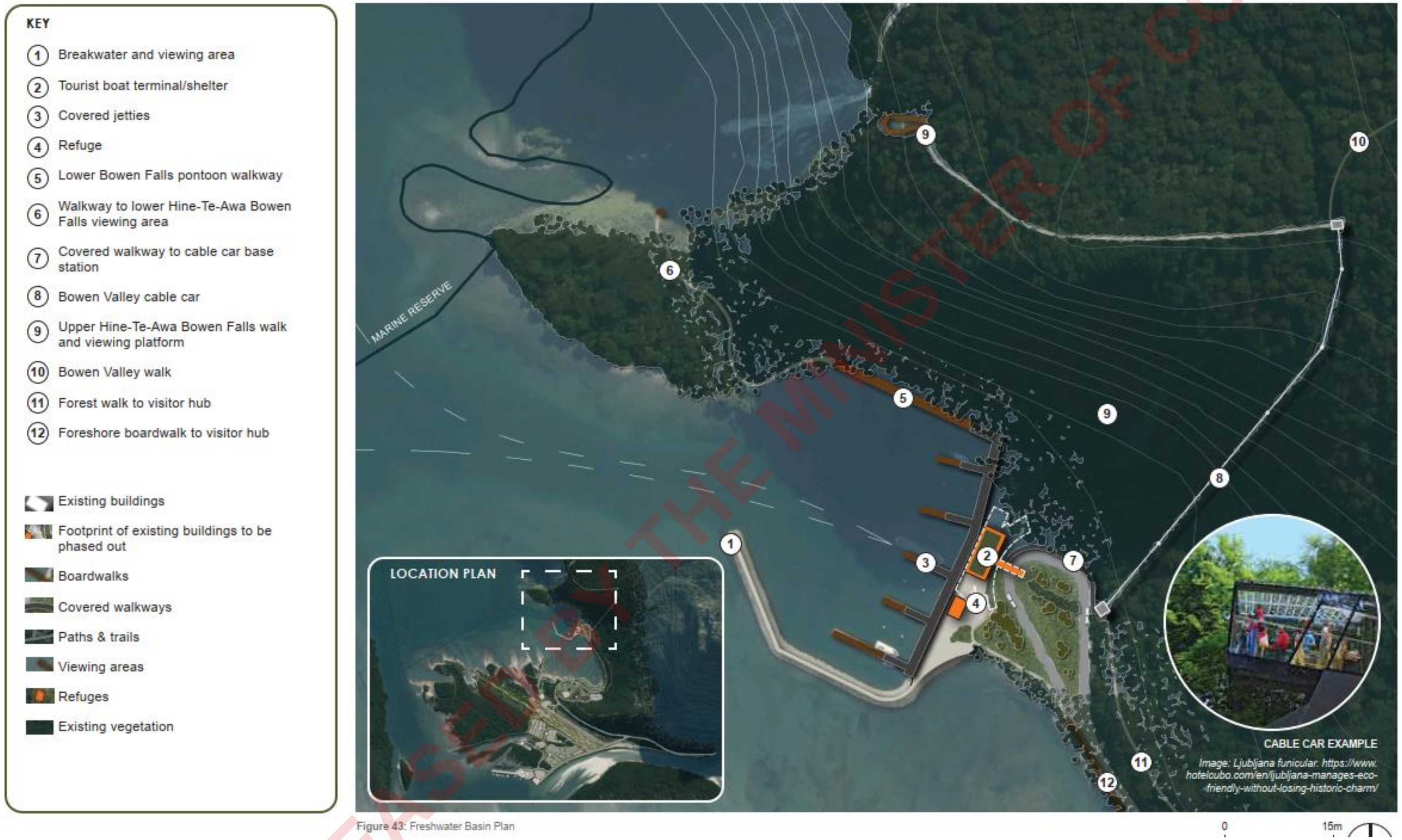


Figure 43: Freshwater Basin Plan

11.1.1 REDEVELOP THE BOAT TERMINAL

The introduction of centralised ticket validation at the visitor centre, along with more even spread of boat cruises throughout the day will reduce the time visitors need to wait at the boat terminal. This change could either enable downsizing of the terminal to serve as a covered gateway to boat services or repurposing of existing internal terminal spaces for other activities (e.g., observation deck). Development of the consolidated bus terminal and shuttle service from the visitor hub to Freshwater Basin will also support this with more coordinated drop off times. This will provide opportunities to minimise transport along the foreshore and replace coach parking at the boat terminal with better landscapes and reduced impermeable surfaces.

This approach would see the existing boat terminal modified or replaced with a more fit for purpose and lower profile, shelter structure that heightens the experience of the steep land/water interface at Freshwater Basin.

11.1.2 ICONIC REFUGE

As part of a series of iconic designed, natural hazard refuges throughout Milford Sound Piopiotahi, one will be provided a Freshwater Basin to protect visitors from rock fall and tsunami and will inform visitors about the risks. As a day-to-day landmark and shelter, it could be integrated with the boat terminal gateway structure to also provide a range of facilities, including waiting areas and weather protection, accompanied by interpretive displays.

11.1.3 NATURE WALK LOOP

To complement the existing foreshore boardwalk a new nature trail is proposed through the Beech Forest to create a return loop. This will provide a short walk experience, or alternative to the shuttle bus, for all ages and abilities with interpretation continued along the route.

11.1.4 HINE-TE-AWA BOWEN FALLS EXPERIENCES

(Lady) Hine-te-awa Bowen Falls is the tallest of two permanent waterfalls within the fiord and near the Freshwater Basin Node. It has a distinctive plume at its head, which adds to its visual interest and significance for Ngāi Tahu.

11.1.5 LOWER PONTOON WALKWAY

This existing coastal and waterfall experience is currently accessed by a short, on-demand boat service. A new floating pontoon walkway is proposed to avoid rock fall hazards, linking the most northern jetty of the boat terminal with the Hine-te-awa Bowen Falls Delta. It will connect to an existing track that takes visitors through the bush to Cemetery Point for unimpeded views out to Milford Sound Piopiotahi, and a boardwalk and lookout structure at the base of the dramatic Hine-te-awa Bowen Falls. Both will be enhanced to manage visitor growth while maintaining the sense of solitude and drama of the experience.

11.1.6 HINE-TE-AWA BOWEN FALLS TOP LINKS

A new fixed cable car up to the hanging Bowen Valley is proposed that will provide access to the top of Hine-te-awa Bowen Falls, via a nature walk, and toward the head of the Bowen River on a longer walking track. This will allow visitors to experience rising views over Milford Sound Piopiotahi, natural bush setting and dramatic views from an iconic cantilevered lookout structure at the top of the Hine-te-awa Bowen Falls. In addition to aerial perspectives over the Falls and Delta below, longer views will be available over Milford Sound Piopiotahi, directly into Sinbad Valley and across to the steep northern faces of Rahotu Mitre Peak. This would provide visitors with a world-class activity, an alternative to the boat trip on the water, potentially reducing the number of boat trips. A cable car alignment would originate from a base building near the boat terminal and follow the steep alignment of the existing hydro pipeline. Although technically challenging and subject to significant detailed investigation, there is an opportunity to combine the provision of a cable car as part of the planned upgrade to the penstock infrastructure needed to service growing electricity demand.

11.2 PRIMARY OPTION FOR CONSIDERATION

Freshwater Basin Node – The node is a Class 2 site for Landslide, Avalanche and Flooding risk, but is a Class 3A site for Tsunami Risk. The risk to the workers and visitors is assessed to be substantial, the proposed plan for the node should only be progressed after a high-level review of the natural hazards.

Proposed upgrades to this site include a cable car (to access the upper Hine-Te-Awa Bowen Falls), Bowen Falls/Valley walk, Bowen Falls viewing platforms, Bowen Falls pontoon walkway, an iconic natural hazard refuge, and redevelopment of the existing boat terminal.

As with the structures, all significant (IL2 or above) structures proposed in this area will require site specific investigation and design. The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures.

11.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

11.4 NATURAL HAZARD RISK ASSESSMENT

11.4.1 PART A: ASSESSMENT:

For the purposes of this report, Milford Sound Piopiotahi area is defined as the area west of the Tūtoko and Cleddau River confluence. This area includes the following key sites: Little Tahiti, Milford Sound Lodge, Deepwater Basin, Cleddau Delta, and Freshwater Basin (Figure 46).

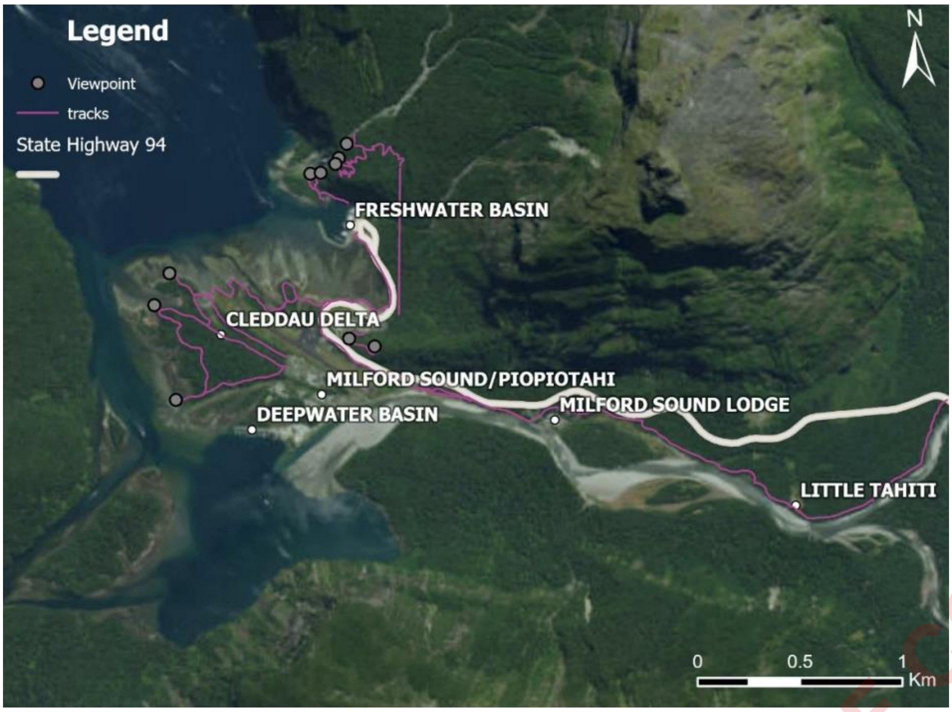


Figure 46: Aerial of Milford Sound Piopiotahi.

Figure 47: Milford Sound Piopiotahi sites under the MOP Master Plan (source: Stantec and Boffa Miskell)

11.4.2 LANDSLIDE, FLOOD AND AVALANCHE RISK

11.4.2.1 CLASS 2 SITES

As per the GNS methodology, a Class 2 site indicates that a basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

The Deepwater Basin and the Milford Sound visitor areas are situated on the Cleddau River delta which forms a reasonably flat peninsula surrounded by Milford Sound Piopiotahi.

The surrounding terrain is typically described as being steep heavily vegetated mountainous terrain. Previous studies and reports detail the extent of flood risk at Deepwater Basin and across the Cleddau Delta associated with the Cleddau River. There is extensive stop bank and rock armouring mitigation and control measures in place along the banks of the Cleddau at this site as a direct result of previous investigations and assessments of flood risk. Flood mitigation is based on existing data and reports, estimated to reduce the identified flood hazard to a low probability of occurrence, although exposure time remains high currently at these sites due to the presence of staff accommodation. If the proposal in the Masterplan to relocate staff accommodation from this area is implemented, then exposure times will significantly reduce.

The Deepwater basin and Cleddau Delta are assessed as Class 2 sites for flood risk associated with the Cleddau River. Visitors also use the constructed walkway between the Milford Sound visitor centre and the ferry terminal in Freshwater Basin. This area is typically low-lying and at the bottom of steep to very steep mountain side with near vertical faces such as that at the Bowen Falls areas north of Freshwater Basin. This area is prone to landslides, tree slides, and occasional rockfall which have occurred in recent years. Notably a tree slide and rockfall event caused significant damage to a storage building in 2016.

Landslide and rockfall hazard probability at the Freshwater Basin is assessed qualitatively as medium. Rockfall and landslide hazard footprints in this area are mostly restricted to narrow chutes within existing gullies and on failed slopes while tree slides can occur in areas with mature vegetation outside of gullies.

Based on current usage of these areas site visitors and workers are expected to pass through hazard footprints in relatively short spaces of time and are unlikely to spend any significant time directly within the hazard footprint. Typical exposure windows of between 30 and 180 minutes have been determined in discussion with current site workers and operatives and future visitor use. The Freshwater Basin is assessed as a Class 2 site for landslides, tree slides, and rockfall.

On the Milford Sound Piopiotahi side of the Homer Tunnel, there are two sites on the Cleddau River assessed as being Class 2: Little Tahiti and Milford Sound Lodge. These sites are assessed as being exposed to flooding from the Cleddau River with a low probability of occurrence. However, the hazard at these sites is now somewhat mitigated due to the elevation of the sites above the existing river level and recent additional rock armouring placed along the riverbank at Little Tahiti and the Milford Sound Lodge. These sites were impacted by flood related scour and resulted in loss of the riverbank during the February 2020 storm events that impacted the Milford region. However, neither the Little Tahiti or Milford Sound Lodge site were flooded or inundated during the event.

Figure 48: The flood mitigation stop bank on the northern margin of the Cleddau River looking out towards Milford Sound.

Figure 49: Freshwater Basin with an old tree slide scarp to the right of the image.

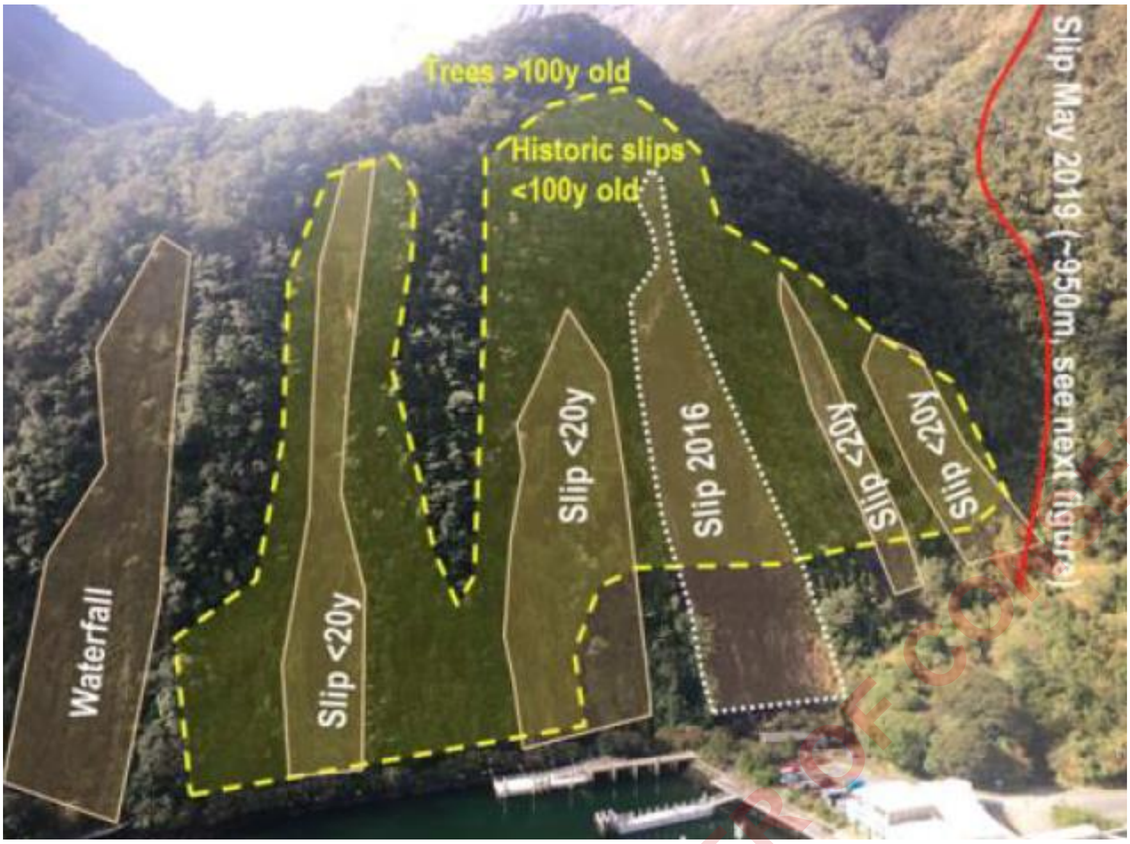


Figure 50: Tree slides and landslides in the hillslope next to Freshwater basin in Milford Sound (source: Stantec 2021)

Figure 51: Damage to a storage building in Milford Sound from a rockfall in 2016 (source: Tim Holland)

11.4.2.2 TSUNAMI RISK (CLASS 3A)

Defined by the GNS methodology, a Class 3A risk level indicates a "High to extreme" Significance level and falls under an "intolerable" DOC evaluation category. Risk Management Actions indicate that Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required. Class 3A represents the highest priority for further risk analysis and risk management actions.

The previous Stage 2 reporting identified the extent of tsunami risk in the Milford Sound area. Extensive studies and assessments of the occurrence of tsunamis within the sound or affecting the Milford Sound basin area have already concluded that there is a proven record of events having occurred over geological time.

As noted above there are typically two distinct sources of tsunami:

1. Landslide (rock avalanche) induced.
2. Earthquake induced sea floor rupture.

These are discussed and differentiated further in the Part B report, however for the purpose of the screening analysis a review of the data presented in the Stage 2 works concluded that for the Milford Sound Piopiotahi area, the wave amplitude of a 100-year return interval tsunami (H50/100) was of the order of 1.3 – 1.9 m. This is based on the NTHM and only incorporates fault-induced tsunami.

For the Alpine Fault triggered landslide tsunami event, there is 150-year return interval for tsunami amplitudes ranging between 0.3 and 10 m at Freshwater Basin. For the Visitor Hub, Freshwater Basin, Deepwater Basin, and Cleddau Delta $S_{overland}$ (tsunami wave amplitudes required to impact the site) has been calculated as being 1.52 m, 1 m, and 0.5 m which are tsunami events all estimated to occur at least once every 100 years. Given the current use of the basin and population distributions around the area exposure times across the three sites in Milford Sound Piopiotahi have been determined as being greater than 180 minutes. Adopting the GNS methodology the Preliminary Analysis of tsunami risk as detailed in the Natural Hazards Part A assessment report, determines the site as being Class 3A for tsunami risk.

Due to the elevation and distance from the coast of the Milford Sound Lodge (~ 11 m above sea level and 1200 m away) and Little Tahiti (~19 m above sea level and 2400 m away), it is anticipated that a much larger tsunami wave at the Cleddau River Mouth would be needed before an actual impact at either site would occur.

For the Milford Sound Lodge $S_{overriver}$ has been calculated as 7.03 m which is equivalent to a tsunami with a return interval of 150 years (AF8 event). This hazard is qualitatively assessed as having a medium probability of occurrence. Exposure time at this site is also anticipated to be greater than 180 minutes. On this basis the Milford Sound Lodge is categorised as a Class 3A site for tsunami risk.

For the Little Tahiti site, Soverriver has been calculated as 12.5 m. This is outside of the range of potential amplitudes from an AF8 event. A 12.5 m amplitude tsunami wave at Milford has been assessed as having a return interval of 555 years according to Dykstra (2012), > 2500 years according to Taig & McSaveney (2015), and >2500 years using theNTHM. This is assessed as a hazard with a low probability of occurrence and as such Little Tahiti is categorised as a Class 2 site for tsunami risk.

11.4.3 PART B ASSESSMENT

Table 56: DOC Risk levels

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Not assessed	Visitors/Workers	Information unavailable at this stage for assessment. General mitigation measures suggested. Further assessment is recommneded
Landslide	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable- Continue with the proposal only after high level review.
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable – Close the site
Tsunami	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable – Continue with the proposal only after high level review
Tsunami	Substantial	Workers	Continue with the proposal only after a high-level review.

11.4.3.1 SOCIETAL RISK – TSUNAMI

LANDSLIDE INDUCED TSUNAMI

For the most likely event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 28 fatalities.
- When the population at risk is 2000, we estimate there to be 1120 fatalities.
- When the population at risk is 3000, we estimate there to be 1680 fatalities.

For the maximum credible event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 45 fatalities.
- When the population at risk is 2000, we estimate there to be 1800 fatalities.
- When the population at risk is 3000, we estimate there to be 2700 fatalities.

AF8 INDUCED TSUNAMI

- When the population at risk is 1, we estimate there to be no fatalities.
- When the population at risk is 50, we estimate there to be 21 fatalities.
- When the population at risk is 2000, we estimate there to be 840 fatalities.
- When the population at risk is 3000, we estimate there to be 1260 fatalities.

11.4.3.2 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

- When the population at risk is 1 at each site, we estimate there to be no fatalities at any site.
- When the population at risk is 5 at each site, we estimate there to be 1 fatality at Freshwater Basin.
- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Visitor Hub.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

11.5 LONG TERM CLIMATE CHANGE ASSESSMENT

The Milford Sound Piopiotahi Hub is the only location within the Milford Corridor to be exposed to Sea Level Rise. Given historical records of flooding at high spring tides at the Cleddau delta and current existing conditions, risk is moderate. Sea rise projections (including vertical land movement) towards the end of the century will raise risk up to extreme levels.

Extreme weather (high winds and storms) currently has moderate risk at this location; however, this is expected to reach extreme levels by late century. Similarly, flooding risk levels from extreme precipitation events are moderate, however future projections suggest that elements-at-risk will be more exposed to flooding from the Cleddau River over time, reaching extreme levels towards the end of the century.

It is important to note that extreme weather and heavy rainfall events may also contribute to increase the risk of slopes instability and given the evidence of rockfall and landslides at Freshwater and Deepwater basins, an increase in the frequency and intensity of climate events could potentially increase the risk of slope instability too.

Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher (hot days), the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise however, that, given the natural variability of rainfall, occasional dry periods will occur, over which drought and wildfire risk will be higher.

The number of hot days (temperature >25°C) will increase towards the end of the century, changing the risk from low currently to moderate, increasing the cooling requirements in buildings (i.e.: HVAC Systems).

Given the existing conditions around this location, avalanche risk is not applicable.

Table 57: Climate change risk summary – Milford Sound Hub

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Milford Sound Piopiotahi HUB	BUILDINGS	Current Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Current Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Current Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	BUILDINGS	Mid-century	High	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid-century	High	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid-century	High	High	High	Low	Moderate	Low	High
	BUILDINGS	Late-century	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late-century	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late-century	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme

11.6 GEOTECHNICAL ASSESSMENT

The following is noted for Freshwater Basin Node:

- The Masterplan structures listed at this site are Bowen Falls cable car, Bowen Falls/Valley walk, Bowen Falls viewing platforms, a pontoon walkway to access Bowen Falls, a refuge, and redevelopment of the boat terminal. See Figure 52 below.
- Elevation: The site is approximately 0 m – 5 m ASL.
- Closest active fault: Anita Shear Zone #8756, located approximately 12 km west of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene River deposits (Unweathered, loose, bouldery gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded). See Figure 53 below.
- Geological Map Information: Site is located on the boundary between the following two geological units, one covering the low-lying area of the site and the other covering the elevated ridge that forms Bowen Falls.
- Low Lying Area: Holocene river deposits (Unweathered, loose, bouldery gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded).
- Elevated Ridge: Gneissic hornblende diorites and garnet-biotite gneiss; intruded by abundant amphibolitic to felsic dikes.
- Environment Southland Liquefaction Risk Map: High Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Existing geotechnical investigation information (as per Figure 52 Milford Sound Piopiotahi Visitor Hub) indicates that the site is likely to be underlain by uncontrolled fill of varying thickness with deltaic sediment and interbedded organic swamp deposit below, and gabbro bedrock at unknown depth. Depth to groundwater level is assumed to be approximately 2 m. See Figure 53 below.

KEY

1. Breakwater and viewing area
2. Tourist boat terminal/shelter
3. Covered jetties
4. Refuge
5. Lower Bowen Falls pontoon walkway
6. Walkway to lower Hine-Te-Awa Bowen Falls viewing area
7. Covered walkway to cable car base station
8. Bowen Valley cable car
9. Upper Hine-Te-Awa Bowen Falls walk and viewing platform
10. Bowen Valley walk
11. Forest walk to visitor hub
12. Foreshore boardwalk to visitor hub

- Existing buildings
- Footprint of existing buildings to be phased out
- Boardwalks
- Covered walkways
- Paths & trails
- Viewing areas
- Refuges
- Existing vegetation

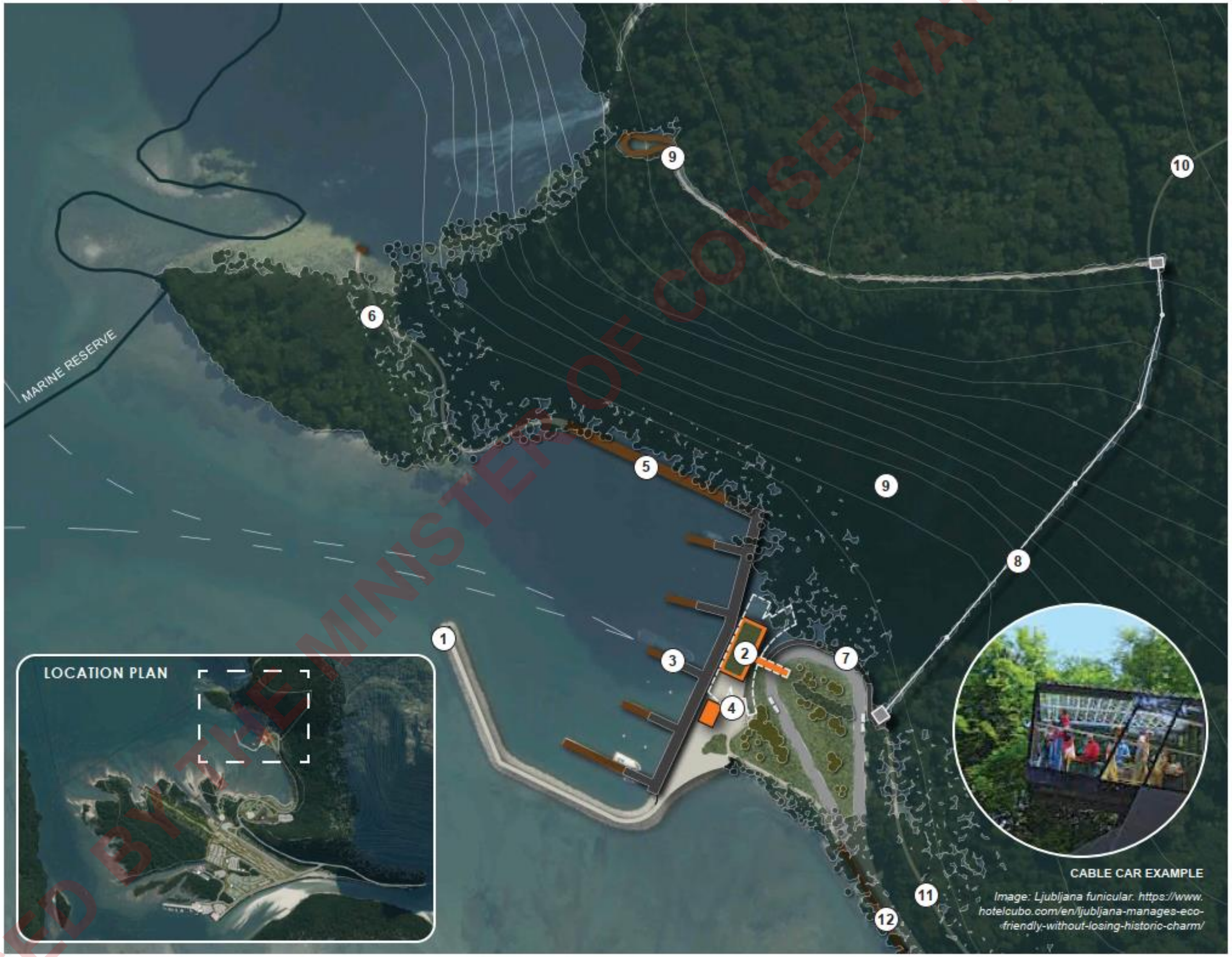


Figure 52: Masterplan Freshwater Basin Layout Concept

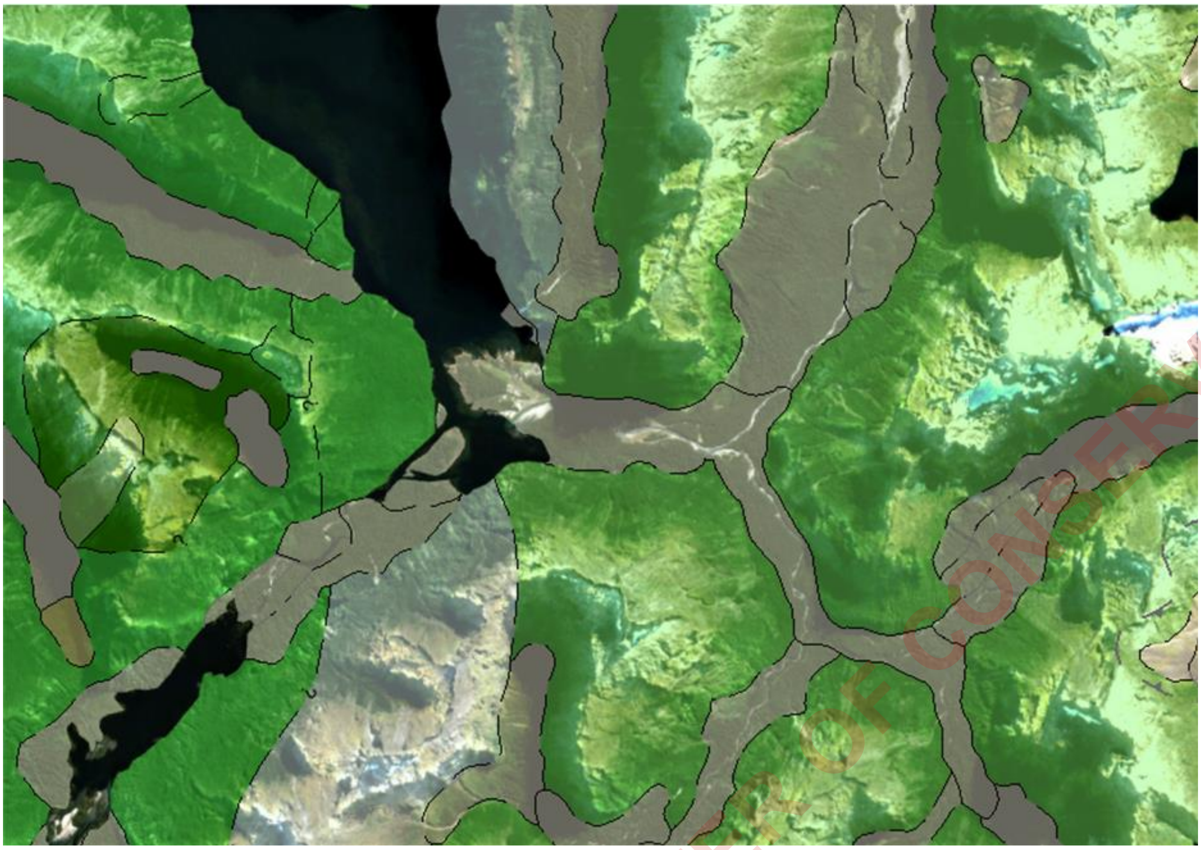


Figure 53: Freshwater Basin – Published Geology

Figure 54: Freshwater Basin looking northwest from the existing carpark and visitor terminal.

Foreshore areas of the site likely consist of deltaic sediments interbedded with organics over bedrock at depth. It is also assumed that water will be encountered at shallow depths below the site. It is likely that the site will have potential for liquefaction and that lateral spreading may occur if located near to the foreshore. Ground conditions on the hills above the foreshore are likely to be bedrock, overlain by a thin layer of organic matter. At this stage the quality of the rock (strength, fractures etc) is unknown.

Proposed upgrades to this site include a cable car (to access the upper Hine-Te-Awa Bowen Falls), Bowen Falls/Valley walk, Bowen Falls viewing platforms, Bowen Falls pontoon walkway, an iconic natural hazard refuge, and redevelopment of the existing boat terminal.

As with the structures, all significant (IL2 or above) structures proposed in this area will require site specific investigation and design.

It is possible that if individual geotechnical investigations of the various sites are completed in conjunction with each other, the amount of investigation can be optimized and will likely lead to efficiencies in investigation costs.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures.

HINE-TE-AWA BOWEN FALLS CABLE CAR

A new cable car (or other transport system) is proposed to provide access to the top of Hine-Te-Awa Bowen Falls and will include a nature walk. The concept alignment would follow an existing hydro pipeline up a steep incline. The final alignment or transportation system may change due to site limitations (such as slope gradients).

At this stage until further details are available, general comments for a transport system are as follows:

- The base building will potentially be located on deep soft soils. It should be anticipated that foundation design will need to account for settlement. The site may also experience liquefaction and lateral spreading during a seismic event.
- The slope up to the top of Hine-Te-Awa Bowen Falls is assumed to be Gneissic bedrock. Construction will likely include rock anchors as part of the foundations. Anchors into the rock will need to account for the quality of the rock. Based on WSP experience of designing and installing anchors in similar environments, drilling rates will likely be slow given the assumed quality of rock and long anchor lengths may be required due to wide discontinuity spacings within the rock mass. However, development of rock anchor design will require site specific investigation and inspection.
- The top building will need to account for founding into bedrock with similar issues as noted for the anchors.

Foundation recommendations will be highly dependent on the final type of transportation system and the alignment which will determine the slope gradient. In addition, geotechnical investigation of the slope is unlikely to be feasible or cost effective. Geotechnical investigation of the top building will be used to inform the design of the foundations on the slope. This will mean that confirmation of assumptions during construction will be required, and provision for additional work (additional anchors, redrilling, and lengthening) should be allowed for. A system that avoids construction on the slope more efficient and avoid construction uncertainties. An example would be the Lone Peak

Tram at Big Sky Resort, Montana, United States. The tram utilizes a system consisting of only a base and top building to access steep terrain where infrastructure such as towers could not easily be built. Considerable cost is expected to be incurred in the investigation, design, and construction of this structure. The Masterplan notes that there is an opportunity to combine the provision of a cable car as part of a planned upgrade to the hydro scheme penstock infrastructure needed to service growing electricity demand in Milford Sound Piopiotahi.

BOWEN FALLS / VALLEY WALK AND VIEWING PLATFORMS

The proposed falls and valley walks include a cantilevered viewing platform to provide views of the top of Hine-Te-Awa Bowen Falls. This assessment will be like the Barren Peak Spur lookout due to limited access for a geotechnical investigation. The investigation of the site will consist of visual inspections and hand investigation. It is likely that bedrock will be encountered at shallow depths. It is anticipated that rock will be of sufficient quality that the foundation can be anchored into the rock. Assumptions of the rock quality will need to be confirmed during construction.

It is WSP's understanding that the valley walk is not expected to have any structures associated with it and will therefore not require any specific geotechnical investigation. However, design may be needed if any steps and railings need to be built along the alignment.

HINE-TE-AWA BOWEN FALLS PONTOON WALKWAY

A floating pontoon walkway is proposed to provide access from the existing boat terminal to a boardwalk and lookout structure at the base of Hine-Te-Awa Bowen Falls. The proposed offshore pontoon walkway is to replace an old walkway that was closed due to the rockfall hazard posed by the steep slopes above the walkway.

The anchor point located at the southeast end of the walkway is likely to have similar river deposits as those expected at the cable car base location. The proximity to the foreshore may increase the site's liquefaction and lateral spread potential in these softer soils. The northwest anchor point is not well understood currently, but there are some indications that bedrock is present at or near surface. Geotechnical investigation of both anchor points should be undertaken to gain a better understanding of the area to inform foundation selection.

ICONIC REFUGE

A shelter and viewing area that doubles as a natural hazard refuge is proposed on the waterfront alongside the boat terminal to provide protection for visitors and staff during a natural disaster (e.g. rockfall and tsunami). The structure will need to be designed as an Importance Level 4 building to allow it to perform as required both during and post-disaster.

Given the likely ground conditions at the location (liquefiable deltaic sediments with interbedded organic layers and bedrock at depth) suitable foundations are likely to be deep piles. Ground improvements may also be required (such as deep soil mixing, stone columns). A site-specific geotechnical investigation and seismic assessment would be required as with the case of the Visitor Accommodations and other refuges in Milford Sound Piopiotahi.

While technically feasible from a geotechnical point, the ground conditions are not favourable for a structure to function as a refuge. The foundations required for a refuge will likely be prohibitively expensive at this location and it may not financially viable.

REDEVELOP BOAT TERMINAL

The existing boat terminal is proposed for either downsizing, to act as a covered gateway to boat services, or repurposing for other activities. The scope of geotechnical investigation will be determined by what re-development of the boat terminal will entail.

It is assumed that the site will have similar ground conditions as those expected for the pontoon walkway and be subject to the same challenges to be mitigated.

11.7 CONTAMINATED SITES

The Freshwater Basin Node is in a sheltered basin between the (Lady) Hine-te-awa Bowen Falls and Cleddau Deltas. The Node will be based around the existing boat terminal and jetties and will primarily be used as an experience Node for visitors with a short road link and separated boardwalk along the foreshore from the Visitor's Hub.

11.7.1 IDENTIFIED HAIL ACTIVITIES

A PSI has been undertaken by e3Scientific for the Ferry Terminal which is part of the Freshwater Basin Node in the Masterplan. The information provided in the sections below has been obtained after review of the abovementioned e3S PSI (e3Scientific, 2022d).

As Hazardous Activities and Industries List (HAIL) activities have been identified on the site, the Freshwater Basin Node has been classified as RED requiring further assessment to the risks to human health and the environment prior to development. A summary of the identified HAIL activities and their locations has been provided in Table 58 and Figure 55 respectively. RED – HAIL indicates that activities (current or past) are likely or known.

Table 58: Identified HAIL activities at Freshwater Basin Node

HAIL ID	Location	HAIL activity	Dates	Comment	Likelihood
FT1	Hydro scheme shed	A17. Storage tanks or drums for fuel, chemicals, or liquid waste. B2. Electrical transformers including the manufacturing, repairing, or disposing of electrical transformers or other heavy electrical equipment. B4. Power stations, substations, or switchyards.	1960s – present	400L diesel supplied backup generator for hydro scheme shed. Hydro scheme shed contains a generator, transformer, and other equipment for the generation of hydroelectric power.	Certain
		I. Any other land that has been subject to the intentional release of a hazardous substance in sufficient quantity that it could be a risk to human health or the environment.	1960s – present	Potential discharge of degraded hazardous building materials (e.g. asbestos/lead-based paint) to soil; 3m halo around all long-term structures in Milford Township.	Unverified
FT2/SLUS-000000099	Allied Petroleum Marinestop	F7. Service stations including retail or commercial refuelling facilities.	1990s – ongoing	1x40,000L diesel tank with bowser and underground fuel supply to the jetties.	Registered site (ES)
FT3	Former above ground fuel supply facility.	F7. Service stations including retail or commercial refuelling facilities.	1960s – 1990s	Several large above ground storage tanks with a pump on the north side of the passenger terminal.	Certain
FT4	Ferry Terminal	A17. Storage tanks or drums for fuel, chemicals or liquid waste.	1990s – ongoing	Diesel fired boiler with 400L AST. Records show an underground fuel system, but this has not been sighted.	Certain
FT5				Records also indicate the presence of a former underground fuel compound. References in two documents of an underground fuel supply, potentially connected to the boiler (FT4). However, not verified by site workers. Further information required.	Possible

Figure 55: Site Location Plan Freshwater Basin with identified HAIL sites.

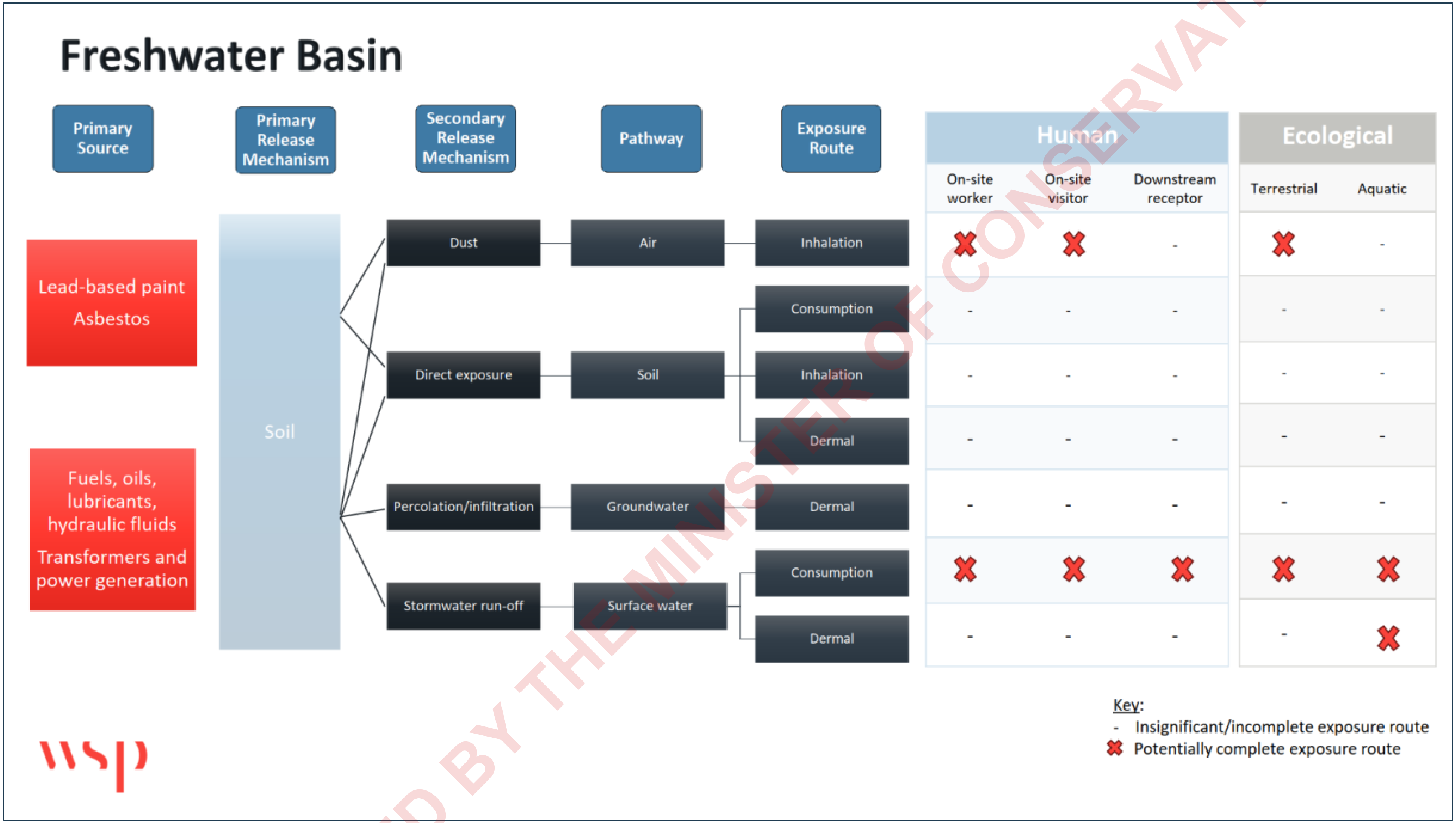


Figure 56: Conceptual Site Model: Freshwater Basin Node

11.7.1.1 CONSENTING CONSIDERATIONS

NES-CS REGULATIONS

Investigation results revealed that HAIL activities are occurring or have occurred on the site. As such, the NES-CS Regulations apply to the site (Ministry for the Environment, 2011).

LAND USE CHANGE AND SUBDIVISION

The PSI has concluded that it is highly unlikely for there to be a risk to human health associated with the ongoing use of the site as commercial/industrial (e3Scientific, 2022d). As such, according to Regulation 8(4) of the NES-CS, subdividing the piece of land is a permitted activity. Should a more sensitive land use be proposed, based on the findings there are potential risks associated with soil contaminants and as such a Detailed Site Investigation (DSI) would be necessary to further quantify these risks. In the absence of a DSI, future land use changes would be a discretionary activity under Regulation 11 of the NES-CS.

SOIL DISTURBANCE

Any soil disturbance or removal that does not meet the permitted activity criteria outlined in Regulation 8(3) (refer to Section 3.2 of the Contaminated Land summary report) would be a discretionary activity under Regulation 11 unless a DSI to quantify contaminant concentrations is completed. The PSI concluded that for pieces of land within the site, any activity requiring soil disturbance should be managed under a contaminated site management plan or if a site management plan already exists, it should be updated to include any additional information from this report (e3Scientific, 2022a).

PROPOSED SOUTHLAND WATER AND LAND PLAN

The PSI concluded that the piece of land most likely to generate a passive discharge is FT2, Allied Marine stop fuel facility. Based on the results of previous investigations, the passive discharge of residual hydrocarbons in soil and groundwater is expected to meet the guidelines adopted in the pSWLP, and therefore in the absence of any information to the contrary, the discharge is a permitted activity (e3Scientific, 2022d).

11.7.2 FURTHER ASSESSMENT

HUB	DSI SCOPE OUTLINE	CONTAMINANTS OF CONCERN	DSI COST ESTIMATE
Freshwater Basin	DSI's likely to involve the excavation of test pits or window sample holes for soil sampling to depths up to 3.0m bgl along with surface sampling of halos around buildings for asbestos/ lead -based paint assessment.	Heavy Metals, TPH, PAH, BTEX, PCB's Asbestos	$35,000 - $40,000

11.8 VERTICAL INFRASTRUCTURE

HINE – TE – AWA UPPER BOWEN FALLS LIFT ACCESS

- Gondola Lift > 1000/hr , Funicular Railway 300 – 400/hr , Incline Elevator 300 – 400/hr, Cable Car 250 – 500/hr
- Provision of easy access for visitors to viewing platform(s)
- Car/ Cabin size can be selected to match the required capacity. Increasing car/cabin size requires greater supporting infrastructure.
- IL3 – crowd activity. No Post disaster function.
- Emergency access/egress to/from upper terminal.
- Constructability while protecting natural features.
- There are numerous examples of similar lifts around the world, and construction is considered structurally feasible. Significant further investigations are necessary to confirm the scope, alignment, ground conditions, emergency provisions, and resilience to natural hazards for the lift and terminal buildings before confirming if a lift is viable, when all inputs to the design are fully understood.

PIOPIOTAHI FERRY TERMINAL RENOVATION.

- 6,000 visitors per day and 1,000 per hour estimated. No post disaster function.
- Single Level. IL3 – Designed for crowd activities – AS/NZS 1170.0, Table 3.2, requires airport terminals, principal railway station with a capacity greater than 250 to have an Importance Level of IL3. No post – disaster function.
- Further investigation is required into ground conditions to confirm the feasibility of an IL3 structure at this location. The site ranges from shallow to deep soils with the potential for liquefaction under seismic loading.

12 CLEDDAU DELTA NODE

CLEDDAU DELTA NODE			
Proposal	Removal of the aerodrome runway, helipads relocation, Cleddau Delta bush tracks, iconic refuges.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	High	Should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures
	Three Waters Infrastructure	NA	Covered in Piopiotahi Visitors Hub
	Contaminated Sites	High	DSIs to assess the risk to human health and the environment for any ground disturbance
Overall Feasibility of the proposal	Notes – Primary Masterplan proposal may need review owing to lack of feasibility owing to High risk levels for Natural Hazards, Geotechnical Engineering and Contaminated Sites.		
Next Best Option	Description - Further assessment of the natural hazard risks is necessary to determine the location and alignment of the proposed structures and walkway.		Feasibility: Low (High risk factors identified)

12.1 NODE SUMMARY

The Cleddau Delta node is located between Freshwater and Deepwater Basins and was formed at the mouth of the Cleddau River prior to the channel being managed by the existing stop bank and the ground level of some areas raised.

Figure 45: Cleddau Delta Cluster Plan

12.1.1 REGENERATIVE LANDSCAPE SPINE

Removal of the aerodrome runway for fixed wing flights will allow for spatial optimisation of Milford Sound Piopiotahi. Its removal will improve the visitor experience, reduce environmental impacts, and avoid costly runway maintenance and upgrades, while having only a minor impact on visitation. This will free up additional space for other uses, such as a realigned road entry, bus terminal, publicly accessible view shafts/observation points and greater walking track connectivity across the Cleddau Delta. The use of helicopters would remain, with helipads being relocated to the southeast along Pembroke Drive. Helicopter approach will be designed to minimise noise and disruption to ground visitors.

Redeveloping the runway is the biggest opportunity in Milford Sound Piopiotahi, seeking to re-inhabit large areas of lowland delta landscape and improve public access to a host of new experiences. A large-scale regenerative landscape approach is proposed, reminiscent of the former braids of the Cleddau River that originally ran through the existing runway alignment. It is intended to reconnect those visiting Milford Sound Piopiotahi back to the past – as it was.

A key part of the landscape approach seeks to reduce the total area of impervious surfaces and expand areas of open, boulder habitat that are of importance for rare species, such as the threatened and nationally critical, Milford Boulder Butterfly. Revegetation elsewhere will restore indigenous shrubland with the aim to heal the edges of the mature Cleddau Bush, whilst being mindful of retaining views to the wider landscape setting.

To diversify the visitor's experience, an access route will be maintained to enable views along the Rahotu Mitre Peak viewpoint while incorporating pause points and interpretation stations as visitors transition between river and estuary. A unique water-based observation point, via a board walk extension at the end of the spine, will offer views across Freshwater Basin toward the distinctive features of Hine-te-awa Bowen Falls.

12.1.2 CLEDDAU BUSH TRACKS

The Cleddau Bush is an existing mature lowland Beech Forest ecosystem that has survived the braided movements of the Cleddau River across the Delta. With the potential for improved access from the visitor's hub, there are new opportunities for some high quality, accessible loop tracks into the Bush that will enable wheelchair access in most locations. One track primarily links between observation points along the foreshore, focusing on the estuarine margins and longer views to the surrounding landscape features that include those most important for mana whenua. The other track will provide a nature trail through the Bush. Both are intended to be sensitively integrated utilising existing trap lines where possible.

12.1.3 ICONIC REFUGES

As part of a series of iconic designed, natural hazard refuges throughout Milford Sound Piopiotahi, two will be provided at key locations in the low-lying coastal zones of the Delta. These will be positioned near areas of higher visitor activity to inform visitors about risks and protect them in the event of a natural disaster, in this case tsunami. As day-to-day landmarks, they would also function as general-purpose shelters with facilities for rest and weather protection, accompanied by interpretive displays.

12.1.4 MILFORD AERODROME

Prior to Covid-19, the approximately five percent of visitors who arrived by air to the Milford Aerodrome were split roughly 75 percent on fixed wing and 25 percent on rotary wing aircraft. The Masterplan recommends that fixed wing aviation should be discontinued, and the runway removed.

Helicopter access would be retained and relocated closer to other operational areas nearer to Deepwater Basin. This recommendation is based on a combination of issues, including:

1. Several operational and safety challenges due to its location in a mountainous area. In addition, there are highly changeable meteorological conditions, which means it currently operates on only about 150 days of the year.
2. It is in an environmentally sensitive area with the presence of threatened fauna, a high proportion of impermeable surfacing and is flood prone. The latter is an issue that will only get worse over time with climate change induced sea level rise.
3. The runway is slowly sinking and needs major reconstruction work to strengthen its foundations, which will be a costly exercise.
4. There is a poor landside visitor experience without normal airport terminal facilities.
5. There is a large area of restricted public access for runway and airside facilities that splits Milford Sound Piopiotahi into two, severing direct access between Freshwater and Deepwater Basins.

The retention of helicopter access should more than adequately accommodate high-value, time-poor visitors, and address resilience issues, including the ability to evacuate people in the event of a natural disaster. The Masterplan proposes to retain the ability to have scenic overflights over Milford Sound Piopiotahi, noting that the flights themselves are a highlight of the current visitor experience.

The aerodrome is close to its limits in passenger numbers and constrained by the number of days when it cannot operate. Land access will more than cover the loss of air access. Fixed wing aviation provides around 3.5 percent of current access with very limited scope for growth, while the ground-based access options through a combination of tour coach and hop on/hop off buses recommended in the Masterplan will provide for up to 185 percent of current demand. Parts of the existing aerodrome infrastructure could be repurposed for bus access to enhance the existing arrival experience at Milford Sound Piopiotahi, providing a direct viewpoint to Mitre Peak.

The currently under-utilised Te Anau Airport has ample capacity to accommodate growth without the significant safety, cost, and operational challenges of the Milford Aerodrome, which means there are additional options available to existing fixed wing aircraft operators to develop their business in the absence of landing at Milford Sound Piopiotahi.

This would provide the opportunity for a different model of scenic flights and increase the utilisation of Te Anau Airport, including making it a more attractive proposition for some form of scheduled air service from Queenstown or elsewhere, and would drive significant economic benefits to Te Anau and the wider Te Rua-o-Te-Moko Fiordland National Park and Southland regions.

12.2 PRIMARY OPTION FOR CONSIDERATION

Cleddau Delta Node - The node is a Class 2 site for Landslide, Avalanche and Flooding risk, but is a Class 3 site for Tsunami Risk. The risk to the workers and visitors is assessed to be substantial, the proposed plan for the node should only be progressed after a high-level review of the natural hazards.

The Masterplan structures listed at this site are water viewing decks and a Delta link bridge, and a refuge. The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict design requirements and complex construction will be required for these structures.

Heliport is feasible at Deep Water Basin but has some restrictions at the Little Tahiti Site. Further investigations are necessary to finalise the design and capacity of the heliport.

12.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

12.4 NATURAL HAZARD RISK ASSESSMENT

PART A: ASSESSMENT:

For the purposes of this report, Milford Sound Piopiotahi area is defined as the area west of the Tūtoko and Cleddau River confluence. This area includes the following key sites: Little Tahiti, Milford Sound Lodge, Deepwater Basin, Cleddau Delta, and Freshwater Basin (Figure 57).

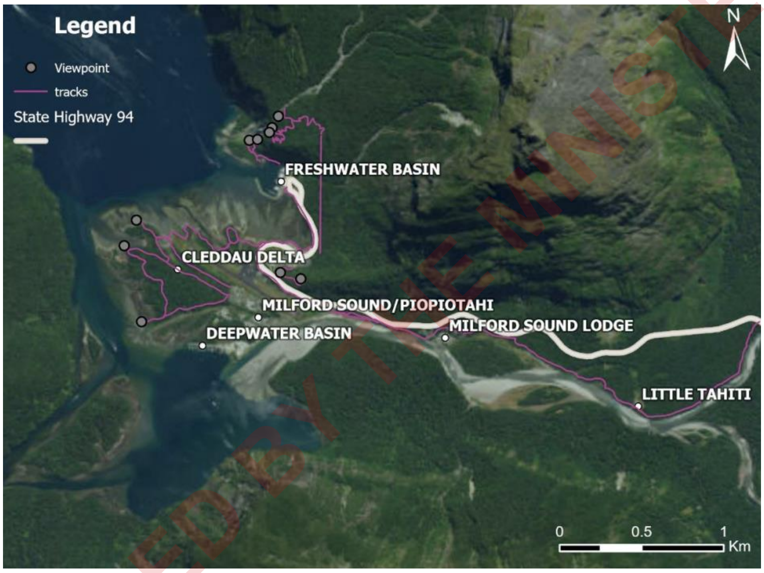


Figure 57: Aerial of Milford Sound Piopiotahi.

Figure 58: Milford Sound Piopiotahi sites under the MOP Master Plan (source: Stantec and Boffa Miskell)

12.4.1 LANDSLIDE, FLOOD AND AVALANCHE RISK

12.4.1.1 CLASS 2 SITES

As per the GNS methodology, a Class 2 site indicates that a basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

The Deepwater Basin and the Milford Sound visitor areas are situated on the Cleddau River delta which forms a reasonably flat peninsula surrounded by Milford Sound Piopiotahi.

The surrounding terrain is typically described as being steep heavily vegetated mountainous terrain. Previous studies and reports detail the extent of flood risk at Deepwater Basin and across the Cleddau Delta associated with the Cleddau River. There is extensive stop bank and rock armouring mitigation and control measures in place along the banks of the Cleddau at this site as a direct result of previous investigations and assessments of flood risk. Flood mitigation is based on existing data and reports, estimated to reduce the identified flood hazard to a low probability of occurrence, although exposure time remains high currently at these sites due to the presence of staff accommodation. If the proposal in the Masterplan to relocate staff accommodation from this area is implemented, then exposure times will significantly reduce.

The Deepwater basin and Cleddau Delta are assessed as Class 2 sites for flood risk associated with the Cleddau River. Visitors also use the constructed walkway between the Milford Sound visitor centre and the ferry terminal in Freshwater Basin. This area is typically low-lying and at the bottom of steep to very steep mountain side with near vertical faces such as that at the Bowen Falls areas north of Freshwater Basin. This area is prone to landslides, tree slides, and occasional rockfall which have occurred in recent years. Notably a tree slide and rockfall event caused significant damage to a storage building in 2016.

Landslide and rockfall hazard probability at the Freshwater Basin is assessed qualitatively as medium. Rockfall and landslide hazard footprints in this area are mostly restricted to narrow chutes within existing gullies and on failed slopes while tree slides can occur in areas with mature vegetation outside of gullies.

Based on current usage of these areas site visitors and workers are expected to pass through hazard footprints in relatively short spaces of time and are unlikely to spend any significant time directly within the hazard footprint. Typical exposure windows of between 30 and 180 minutes have been determined in discussion with current site workers and operatives and future visitor use. The Freshwater Basin is assessed as a Class 2 site for landslides, tree slides, and rockfall.

On the Milford Sound Piopiotahi side of the Homer Tunnel, there are two sites on the Cleddau River assessed as being Class 2: Little Tahiti and Milford Sound Lodge. These sites are assessed as being exposed to flooding from the Cleddau River with a low probability of occurrence. However, the hazard at these sites is now somewhat mitigated due to the elevation of the sites above the existing river level and recent additional rock armouring placed along the riverbank at Little Tahiti and the Milford Sound Lodge. These sites were impacted by flood related scour and resulted in loss of the riverbank during the February 2020 storm events that impacted the Milford region. However, neither the Little Tahiti or Milford Sound Lodge site were flooded or inundated during the event.

Figure 59: The flood mitigation stop bank on the northern margin of the Cleddau River looking out towards Milford Sound.

Figure 60: Freshwater Basin with an old tree slide scarp to the right of the image.

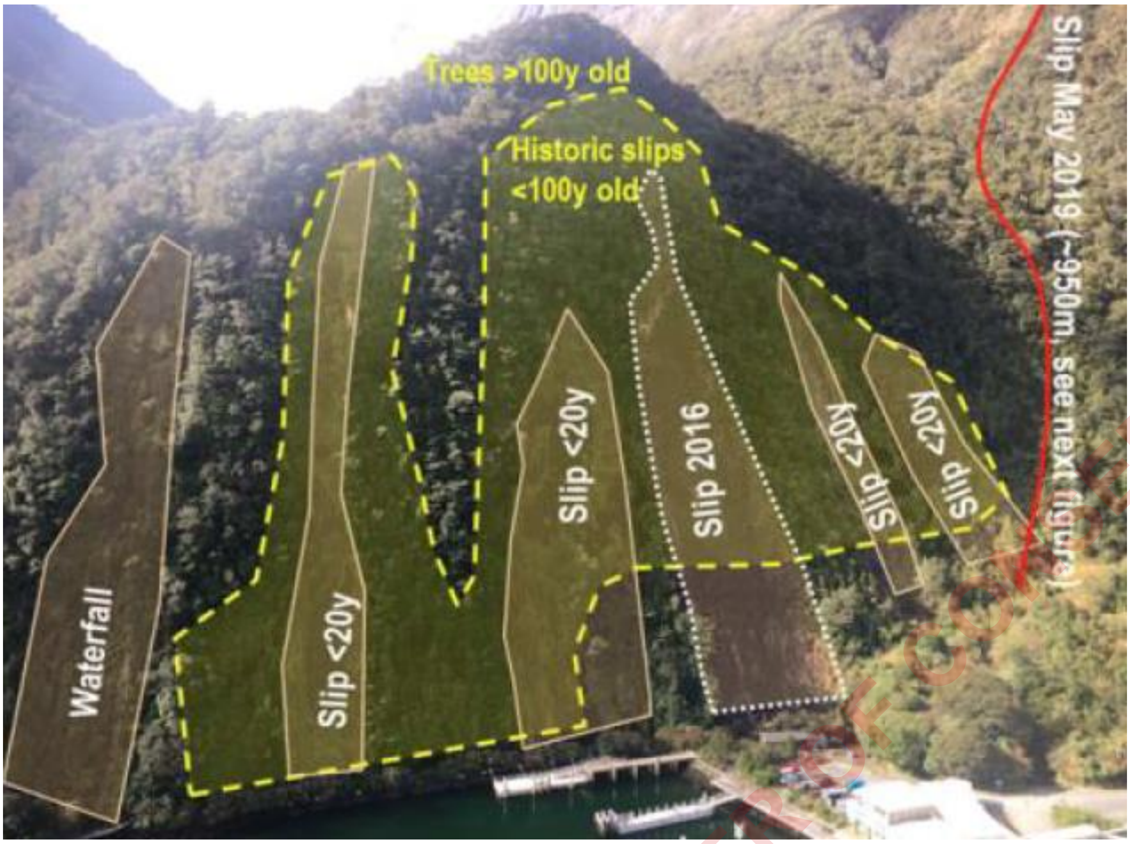


Figure 61: Tree slides and landslides in the hillslope next to Freshwater basin in Milford Sound (source: Stantec 2021)

Figure 62: Damage to a storage building in Milford Sound from a rockfall in 2016 (source: Tim Holland)

12.4.1.2 TSUNAMI RISK (CLASS 3A)

Defined by the GNS methodology, a Class 3A risk level indicates a "High to extreme" Significance level and falls under an "intolerable" DOC evaluation category. Risk Management Actions indicate that Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required. Class 3A represents the highest priority for further risk analysis and risk management actions.

The previous Stage 2 reporting identified the extent of tsunami risk in the Milford Sound area. Extensive studies and assessments of the occurrence of tsunamis within the sound or affecting the Milford Sound basin area have already concluded that there is a proven record of events having occurred over geological time.

As noted above there are typically two distinct sources of tsunami:

1. Landslide (rock avalanche) induced.
2. Earthquake induced sea floor rupture.

These are discussed and differentiated further in the Part B report, however for the purpose of the screening analysis a review of the data presented in the Stage 2 works concluded that for the Milford Sound Piopiotahi area, the wave amplitude of a 100-year return interval tsunami (H50/100) was of the order of 1.3 – 1.9 m. This is based on the NTHM and only incorporates fault-induced tsunami.

For the Alpine Fault triggered landslide tsunami event, there is 150-year return interval for tsunami amplitudes ranging between 0.3 and 10 m at Freshwater Basin. For the Visitor Hub, Freshwater Basin, Deepwater Basin, and Cleddau Delta $S_{overland}$ (tsunami wave amplitudes required to impact the site) has been calculated as being 1.52 m, 1 m, and 0.5 m which are tsunami events all estimated to occur at least once every 100 years. Given the current use of the basin and population distributions around the area exposure times across the three sites in Milford Sound Piopiotahi have been determined as being greater than 180 minutes. Adopting the GNS methodology the Preliminary Analysis of tsunami risk as detailed in the tables presented in the Natural Hazards Part A assessment report, determines the site as being Class 3A for tsunami risk.

Due to the elevation and distance from the coast of the Milford Sound Lodge (~ 11 m above sea level and 1200 m away) and Little Tahiti (~19 m above sea level and 2400 m away), it is anticipated that a much larger tsunami wave at the Cleddau River Mouth would be needed before an actual impact at either site would occur.

For the Milford Sound Lodge $S_{overriver}$ has been calculated as 7.03 m which is equivalent to a tsunami with a return interval of 150 years (AF8 event). This hazard is qualitatively assessed as having a medium probability of occurrence. Exposure time at this site is also anticipated to be greater than 180 minutes. On this basis the Milford Sound Lodge is categorised as a Class 3A site for tsunami risk.

For the Little Tahiti site, Soverriver has been calculated as 12.5 m. This is outside of the range of potential amplitudes from an AF8 event. A 12.5 m amplitude tsunami wave at Milford has been assessed as having a return interval of 555 years according to Dykstra (2012), > 2500 years according to Taig & McSaveney (2015), and >2500 years using theNTHM. This is assessed as a hazard with a low probability of occurrence and as such Little Tahiti is categorised as a Class 2 site for tsunami risk.

12.4.2 PART B ASSESSMENT

Table 59: Natural Hazard Risk

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Low to Moderate	Visitors/Workers	Based on the flood works completed on the Cleddau river. Further assessment is recommended
Landslide	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable- Continue with the proposal only after high level review.
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable – Close the site
Tsunami	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable – Continue with the proposal only after high level review
Tsunami	Substantial	Workers	Continue with the proposal only after a high-level review.

12.4.2.1 SOCIETAL RISK – TSUNAMI

LANDSLIDE INDUCED TSUNAMI

For the most likely event:

— When the population at risk is 1, we estimate there to be 1 fatality.

— When the population at risk is 50, we estimate there to be 28 fatalities.

— When the population at risk is 2000, we estimate there to be 1120 fatalities.

— When the population at risk is 3000, we estimate there to be 1680 fatalities.

For the maximum credible event:

— When the population at risk is 1, we estimate there to be 1 fatality.

— When the population at risk is 50, we estimate there to be 45 fatalities.

— When the population at risk is 2000, we estimate there to be 1800 fatalities.

— When the population at risk is 3000, we estimate there to be 2700 fatalities.

AF8 INDUCED TSUNAMI

— When the population at risk is 1, we estimate there to be no fatalities.

— When the population at risk is 50, we estimate there to be 21 fatalities.

— When the population at risk is 2000, we estimate there to be 840 fatalities.

— When the population at risk is 3000, we estimate there to be 1260 fatalities.

12.4.2.2 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

- When the population at risk is 1 at each site, we estimate there to be no fatalities at any site.
- When the population at risk is 5 at each site, we estimate there to be 1 fatality at Freshwater Basin.
- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Visitor Hub.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

12.5 LONG TERM CLIMATE CHANGE ASSESSMENT

The Milford Sound Piopiotahi Hub is the only location within the Milford Corridor to be exposed to Sea Level Rise. Given historical records of flooding at high spring tides at the Cleddau delta and current existing conditions, risk is moderate. Sea rise projections (including vertical land movement) towards the end of the century will raise risk up to extreme levels.

Extreme weather (high winds and storms) currently has moderate risk at this location; however, this is expected to reach extreme levels by late century. Similarly, flooding risk levels from extreme precipitation events are moderate, however future projections suggest that elements-at-risk will be more exposed to flooding from the Cleddau River over time, reaching extreme levels towards the end of the century.

It is important to note that extreme weather and heavy rainfall events may also contribute to increase the risk of slopes instability and given the evidence of rockfall and landslides at Freshwater and Deepwater basins, an increase in the frequency and intensity of climate events could potentially increase the risk of slope instability too.

Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher (hot days), the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise however, that, given the natural variability of rainfall, occasional dry periods will occur, over which drought and wildfire risk will be higher.

The number of hot days (temperature >25°C) will increase towards the end of the century, changing the risk from low currently to moderate, increasing the cooling requirements in buildings (i.e.: HVAC Systems).

Given the existing conditions around this location, avalanche risk is not applicable.

Table 60: Climate change risk summary – Milford Sound Hub

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Milford Sound Piopiotahi HUB	BUILDINGS	Curre t Yea	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	BUILDINGS	Mid- centur	High	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid- centur	High	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid- centur	High	High	High	Low	Moderate	Low	High
	BUILDINGS	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme

12.6 GEOTECHNICAL ASSESSMENT

CLEDDAU DELTA NODE:

The following is noted for Cleddau Delta Node:

- The Masterplan structures listed at this site are water viewing decks and a Delta link bridge, and a refuge.
- Elevation: The site is approximately 0 m – 5 m ASL
- Closest Active Fault: Anita Shear Zone #8756 located approximately 12 km west of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene River deposits (Unweathered, loose, bouldery gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded.
- Environment Southland Liquefaction Risk Map: High Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Existing geotechnical investigation information indicates that the site is likely to be underlain by uncontrolled fill of varying thickness with deltaic sediment and interbedded organic swap deposit below, and gabbro bedrock at unknown depth. Groundwater level is assumed to be <2 m.

The site likely consists of river sediments interbedded with organics over bedrock at depth. It is anticipated that the soils are likely to have layers of finer sediments throughout, and shallow ground water. It is likely that the site will have a potential for liquefaction and that lateral spreading may occur if located near to the foreshore.

The water viewing deck and bridge are not assumed to be required to contain or protect people during earthquakes or other natural hazards.

It is possible that if individual geotechnical investigations of the various sites are completed in conjunction with each other, the amount of investigation can be optimised and will likely lead to efficiencies in investigation costs.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict design requirements and complex construction will be required for these structures.

WATER VIEWING DECK AND DELTA LINK BRIDGE

Given the type of structures, anticipated subsoil conditions, and the potential high volume of pedestrian traffic, a geotechnical investigation and specific design will be required. The scope of the investigation required will be clearer once the loading conditions are better understood.

TWO ICONIC REFUGES

Given the likely ground conditions at the location (liquefiable deltaic sediments with interbedded organic layers and bedrock at depth) suitable foundations are likely to be deep piles. Ground improvements may also be required (such as deep soil mixing, stone columns). A site-specific geotechnical investigation and seismic assessment would be required as with the case of the visitor accommodations and other refuges in Milford Sound Piopiotahi.

While technically feasible from a geotechnical point, the ground conditions are not favourable for a structure to function as a refuge. The foundations required for a refuge will likely be prohibitively expensive at this location and it may not financially viable.

LITTLE TAHITI (ALTERNATE NODE)

The following is noted for Little Tahiti:

- The Masterplan structures lists this site as an alternative location for the new staff accommodation and the heliport.
- Elevation: The site is 10 m – 20 m ASL.
- Closest active fault: Unnamed fault #9213, located approximately 11.5 km east of the site.
- Geological Map: The site is located within the mapped geological unit: Holocene River deposits (Unweathered, loose, bouldery gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded).
- Environment Southland Liquefaction Risk Map: Medium Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- A report completed by e3Scientific indicates that the site is the location of an historical landfill and is known to be contaminated with various substances, including asbestos, and has pockets of landfill waste material distributed across the area to depths of up to 2m. It is understood that the site will be remediated by the Department of Conservation, but it is unknown when this will be completed. Any earthworks at this site (including geotechnical investigations) must consider the risk of soil and water contamination in their methodologies. Groundwater level is assumed to be 1 m -2 m bgl as per e3Scientific report. See Figure 63 below.

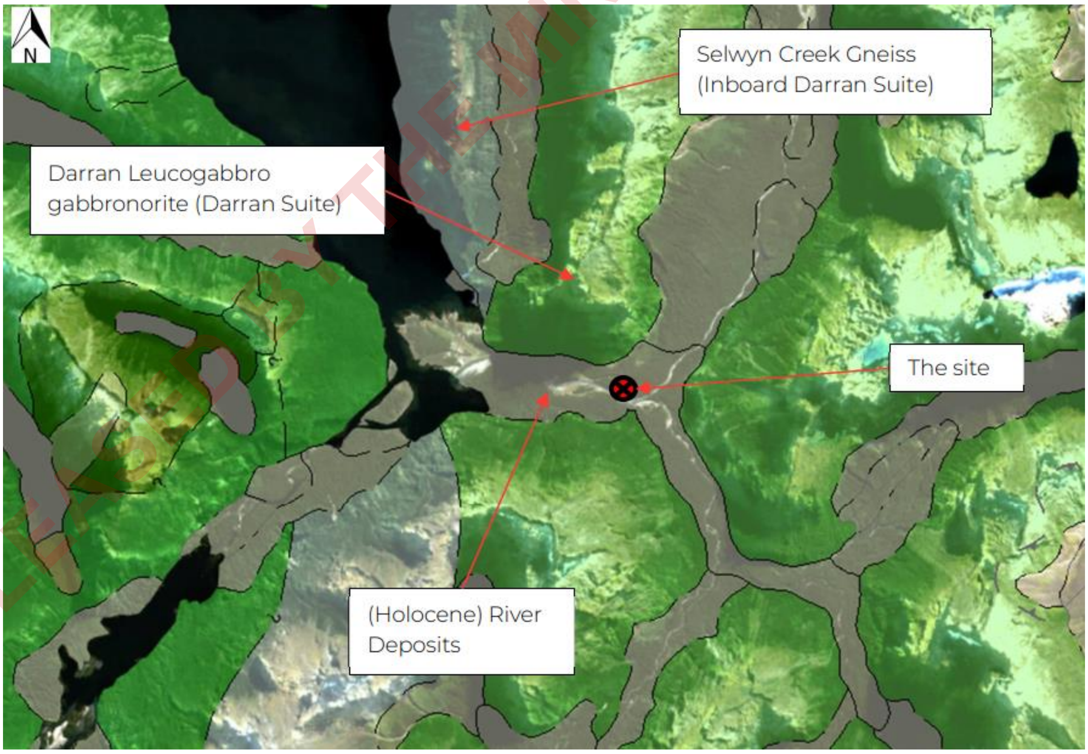


Figure 63 Little Tahiti – Published Geology

Little Tahiti is proposed as an alternative location for the staff accommodation or heliport.

The e3Scientific PSI and DSI report (2022) found the shallow site geology to consist of river sediments with a shallow organic layer above coarse sands and fine gravels at the north of the site, and cobbles and boulders with a coarse sand / fine gravel matrix in the south. Bedrock is expected at depth.

At this stage the site is assumed to have a medium liquefaction potential. Geotechnical investigation of the site will be used confirm the soils onsite, whether groundwater is present at shallow depths and allow determination if further liquefaction assessment of the site is required. Any geotechnical investigation of the site will need to consider contaminated land controls, both for the health and safety of workers and for disposal of any disturbed soils, unless remediation of the site is completed beforehand.

The development as shown in the MOP Masterplan, at this stage, are geotechnically feasible. Due to the proximity of the Alpine Fault, it should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for the staff accommodation building.

STAFF ACCOMODATION (ALTERNATE)

The requirements for site investigation and foundation design are assumed to be similar for this site to those discussed. However, based on the e3Scientific Little Tahiti report, URS completed 12 test pits up to 2.5m bgl of part of the site in 2013. Review of the logs indicate that the shallow subsoil conditions consist of gravels with varying contents of sand with cobbles and boulders present. This may indicate that the site has more favourable ground conditions than those at the primary location for the staff accommodation. However, a site-specific geotechnical investigation will need to be completed to confirm the ground conditions.

HELIPORT (ALTERNATE)

It is assumed that the heliport will include some above-ground infrastructure (e.g. control building, sheds, fuel tanks). The design requirements of the heliport and associated infrastructure (e.g. IL2 or above, specific pavement design), will determine the extent of the geotechnical investigation necessary to inform geotechnical design. As with the staff accommodations, there are indications that the ground conditions are better than the primary location. However, a site-specific geotechnical investigation will need to be completed to confirm the ground conditions.

12.7 CONTAMINATED SITES

The Cleddau Delta Node is located between Freshwater and Deepwater Basins and was formed at the mouth of the Cleddau River prior to the channel being managed by the existing stop bank and the ground level of some areas being raised (MOP, 2021).

The MOP Masterplan proposes to remove the existing aerodrome runway for fixed wing flights to allow for spatial optimisation of Milford Sound Piopiotahi. This will free up additional space for other uses, such as a realigned road entry, bus terminal, publicly accessible view shafts/observation points and greater walking track connectivity across Cleddau Delta.

It is understood that currently three different proposals exist for the taxiway:

- Remove the taxiway to create space for alternative activities,
- Reuse the existing taxiway for bus access with a new taxiway on south side of existing runway,
- Leave the taxiway as is.

From a contaminated land point of view, these options should be assessed depending on the quantities of soil disturbance, as further investigation may be required for soil disturbance more than permitted activity volumes.

12.7.1 IDENTIFIED HAIL ACTIVITIES

A review of two PSIs undertaken by e3Scientific for Cleddau Village (e3Scientific, 2022c) and the Airport (e3Scientific, 2022b) has revealed a historic landfill site and multiple fuel storage areas. Details of the identified HAIL activities are summarised in Table 61 below with a site location plan provided in Figure 64.

As Hazardous Activities and Industries List (HAIL) activities have been identified on the site, the Cleddau Delta Node has been classified as RED requiring further assessment to the risks to human health and the environment prior to development.

RED – indicates that HAIL activities (current or past) are likely or known.

It should be noted that the potential presence of PFAS has been identified as a data gap. Due to the small scale of the airport, no fire station being present on the aerodrome, and no known firefighting incidents or training to have occurred, the presence of PFAS is unlikely. However, as this remains a data gap, consideration of PFAS is recommended during further investigations.

Table 61: Summary of identified HAIL activities.

HAIL ID	Location	HAIL Activity	Dates	Comment	Likelihood
SLUS-00000247	Sinbad Drive Recreation area	G3. Landfill sites	1950s-1970s	Small domestic waste landfill mainly associated with the THC Hotel, received asbestos-containing materials after fire destroyed parts of the hotel.	Registered site (ES)
SLUS-00000319	The whole airport	F1. Airports including fuel storage, workshops, washdown areas, or fire practice areas.	1950s – present	Airport with refuelling compounds.	Registered site (ES)
AP1	Former south side refuelling compound including drums of fuel prior to the storage tanks.		1950s – 1984	A historic refuelling compound on the southside of the runway; included underground tanks and fuel storage in drums. Underground tanks were removed with the installation of the Mobil Aerostop on the northside of the runway.	Certain
AP2	Control tower	I. Any other land that has been subject to the intentional or accidental release of a hazardous substance in sufficient quantity that it could be a risk to human health or the environment.	1970s – present	A 3m halo around the building has been identified as due to the age of the building it is possible that lead paints were used.	Unverified

Figure 64: Site location Cleddau Delta with Identified HAIL Sites

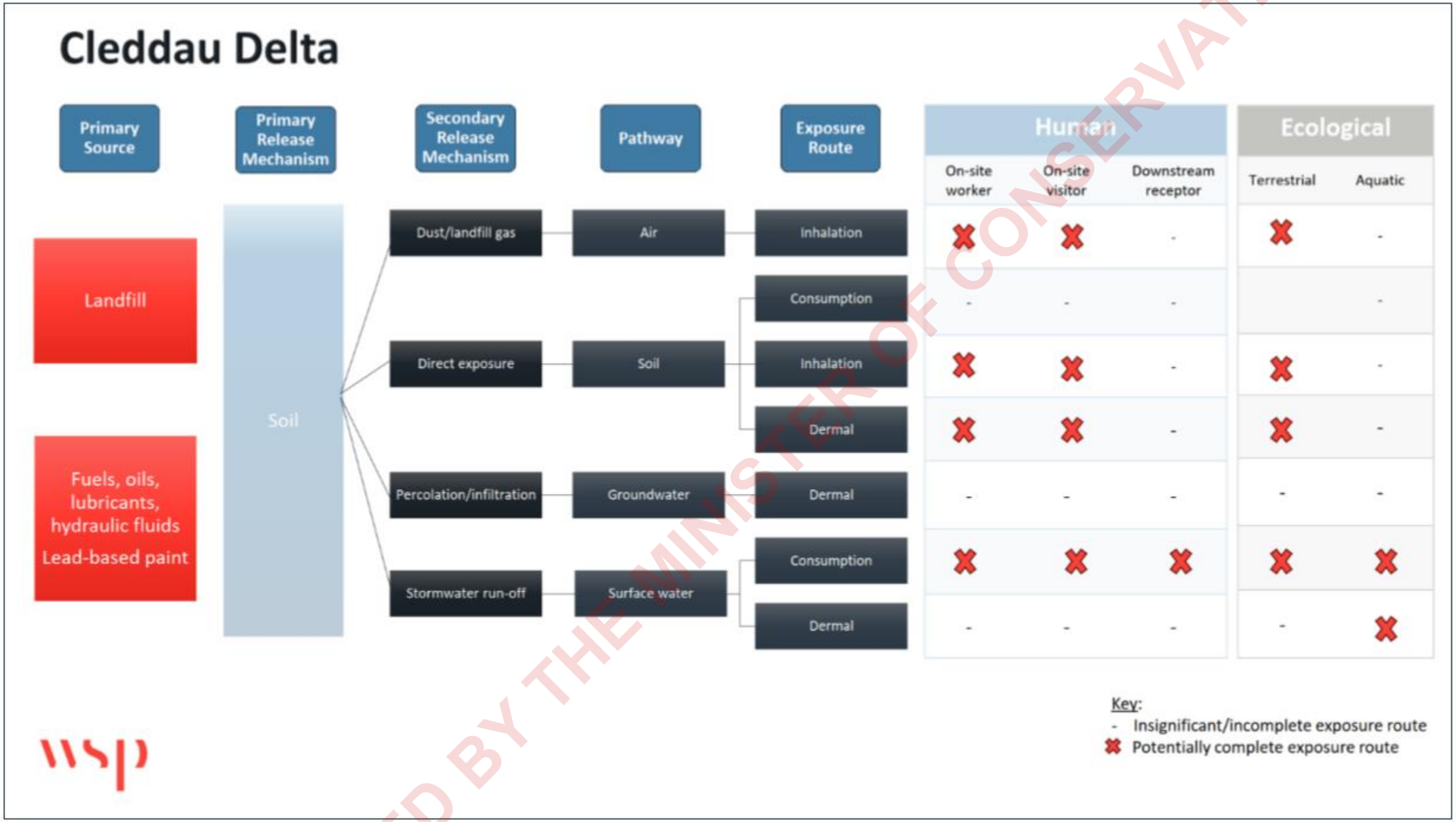


Figure 65: Conceptual Site Model for Cleddau Delta Node – Milford Sound Piopiotahi

12.7.2 CONSENTING CONSIDERATIONS

NES-CS REGULATIONS

Investigation results revealed that HAIL activities are occurring or have occurred on the site. As such, the NES-CS Regulations apply to the site (Ministry for the Environment, 2011).

LAND USE CHANGE AND SUBDIVISION

The PSIs have concluded that it is highly unlikely for there to be a risk to human health associated with the ongoing use of the site as commercial/industrial. As such, according to Regulation 8(4) of the NES-CS, subdividing the piece of land is a permitted activity.

Should a more sensitive land use be proposed, based on the findings there are potential risks associated with soil contaminants and as such a Detailed Site Investigation (DSI) would be necessary to further quantify these risks. In the absence of a DSI, future land use changes would be a discretionary activity under Regulation 11 of the NES-CS.

SOIL DISTURBANCE

Any soil disturbance or removal that does not meet the permitted activity criteria outlined in Regulation 8(3) (refer to Section 3.2 of this report) would be a discretionary activity under Regulation 11 unless a DSI to quantify contaminant concentrations is completed.

The PSIs concluded that for pieces of land where HAIL has been identified within the site, any activity requiring soil disturbance should be managed under a contaminated site management plan or if a site management plan already exists, it should be updated to include any additional information from this report.

PROPOSED SOUTHLAND WATER AND LAND PLAN

The Cleddau Village PSI concluded that the piece of land most likely to generate a passive discharge is SLUS-00000247, the ex-THC Hotel closed landfill. Because the landfill is likely to contain less than 15,000m^3 of waste and closed before 1970, it does not meet the definition of a *closed landfill* in the pSWLP.

A first investigation was conducted when the landfill was rediscovered and remediated. The first round of groundwater quality sampling reported contaminant concentrations exceeding the relevant guidelines, however follow-up sampling showed lower concentrations below the same guidelines. As such, it was concluded that a minor amount of leachate was being generated by the closed landfill, the permitted activity conditions were met, and no consent was required.

The PSI undertaken by e3Scientific re-evaluated the water quality data. The report concluded that current conditions of rule 46 of the pSWLP would be exceeded for both monitoring rounds and therefore further investigation is required to confirm the permitted activity status of the current discharge (e3Scientific, 2022c).

The PSI undertaken for the Airport concluded that the piece of land most likely to generate a passive discharge is the former Mobil Aerostop. However, this area has been investigated and tested against rule 46 by PDP in 2013 and was found to be a permitted activity under the conditions of the rule. In the absence of any information to the contrary, the discharge is a permitted activity.

12.8 VERTICAL INFRASTRUCTURE

PIOPIOTAHI TRACKS AND OBSERVATION – CLEDDAU DELTA/ DEEPWATER BASIN

- Visitor protection refuges. Stage2 report includes refuges from hazards.
- Visitor protection / shelters at Fresh water Basin. Long Stay Parking, Deepwater Basin and Cleddau Delta.
- Single level. Basic Shelters from wet weather.
- This area is located on the Waipàteke Cleddau River delta. The Stage 2 Report includes four refuges from hazards located at Deepwater Basin, Freshwater Basin and two in the Delta area.
- Alpine Fault earthquakes are considered to be the dominant trigger for landslide-induced tsunami in Milford Sound. Tsunami amplitudes are estimated to range between 1 to 9m at Freshwater Basin. The delta area is low lying, and it is considered that providing refuges in this area will not provide protection to visitors from flooding or a tsunami wave. The shelters on the delta should be to provide protection from inclement weather only.
- It is not considered practical to provide post-disaster function, or protection from hazards (tsunamis), at these locations.
- Structurally feasible to provide standard weather protection shelter structures. IL2

PIOPIOTAHI TRANSPORT TERMINAL FOR SHUTTLES

- Operation and maintenance of shuttles. Facilities for bus driver resting, shuttle maintenance, charging and overnight housing. No Post disaster function.
- Single Level. Standard structure. IL2
- The construction of the Transport Terminal structure is feasible but further investigations are necessary to confirm how the loading from natural hazards are mitigated. With the Transport Terminal not having post-disaster functionality the structure can be designed to resist the design earthquake loads but may be able to justify a reduction in the resilience of the structure to withstand tsunami loading. Refer also; Milford Opportunities Project, Milford Sound Park and Ride Design Report, Feasibility Study - Draft. Beca 23 February 2024.

13 DEEPWATER BASIN NODE

DEEPWATER BASIN NODE			
Proposal	Visitor viewing area, food cart, recreational boat ramp with trailer parking, dedicated sea kayak area, iconic refuge, car parking and bus layover areas, Heliport.		
Engineering assessment	Major Risk	Risk Assessment	Mitigation Measures
	Natural Hazards	High	Interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required.
	Long term Climate Change	Medium	No mitigation measures proposed.
	Geotechnical Engineering	High	It should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures.
	Three Waters Infrastructure	N/A	Covered in the Piopiotahi Visitor Hub
	Contaminated Sites	High	Additional boreholes for groundwater monitoring may be warranted based on development proposals along with the findings of the soil sampling and analysis and/ or initial groundwater assessment.
	Heliport Assessment	Medium	Study the applicability of existing flight circuit with the proposed approach/take-off orientation of the helipads (FATO), Specific research, Noise monitoring, further computational noise modelling

DEEPWATER BASIN NODE		
Overall Feasibility of the proposal	Notes - Primary Masterplan proposal may need review owing to lack of feasibility owing to High risk levels for Natural Hazards, Geotechnical Engineering and Contaminated Sites.	
Next Best Option	Description - Further assessment of the natural hazard risks is necessary to determine the location and alignment of the proposed structures and walkway.	Feasibility: Low (High risk factors identified)

13.1 NODE SUMMARY

Adjacent to the existing outlet of the Cleddau River, the Deepwater Basin node accommodates an existing marina for commercial fishing, kayak operations and a boat ramp/boat trailer park for recreationalists. It is proposed that a new visitor viewing area and refuge are incorporated with these activities and that the heliport is relocated.

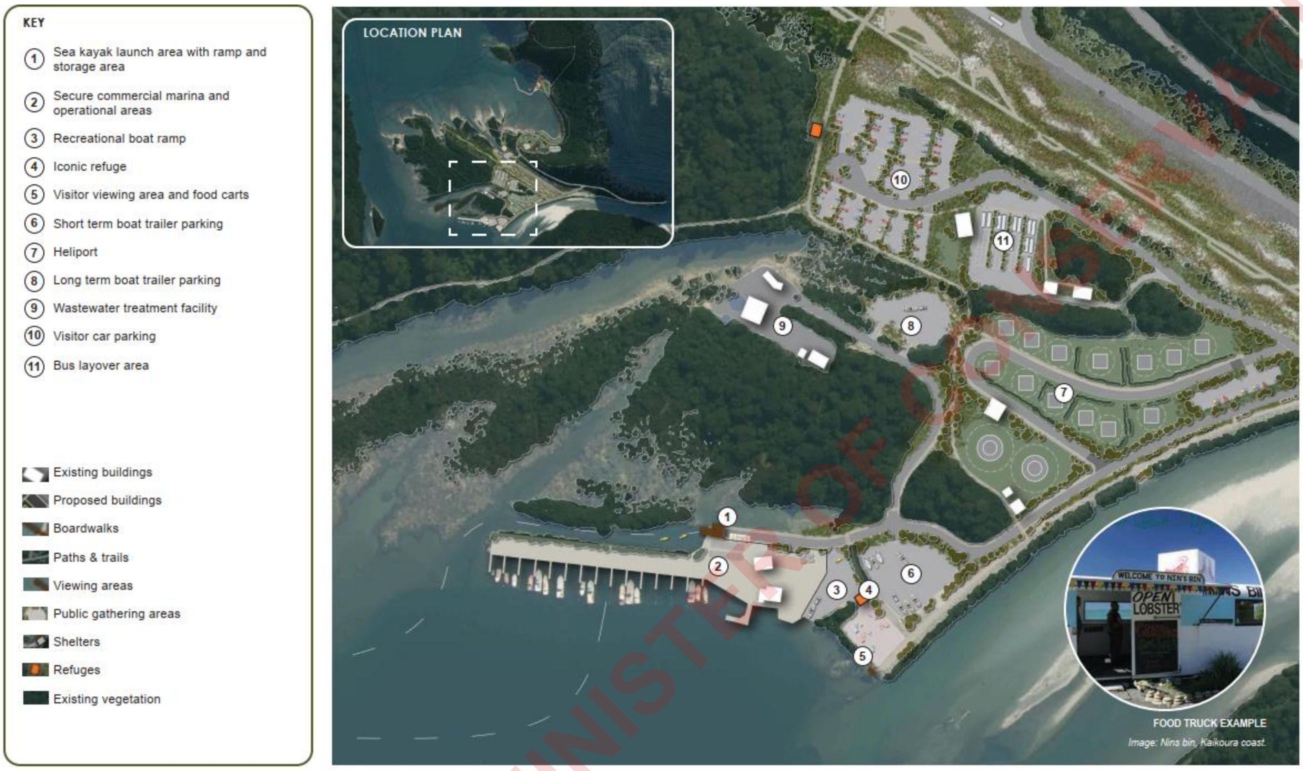


Figure 66: Deep water basin node

13.1.1 *VISITOR VIEWING AREA AND FOOD CARTS*

The direct, cross-spine pathway between the visitor's hub and Deepwater Basin node steps up onto the Cleddau River stop bank and terminates at raised viewing areas overlooking its river mouth and Deepwater Basin. Alternatively, hop on/hop off buses accessing the layover area on Sinbad Drive could be used for regular shuttle service to and from the visitor's hub.

A hard stand area would provide opportunities for seasonal food carts and sheltered dining areas set within a revegetated landscape. Its character would be matched to the more operational activities in Deepwater Basin. Visitors could experience the dynamics of a working marina and recreational slipway, and, while sampling its products and having it interpreted, keep safely separated in designated viewing areas.

13.1.2 *RECREATIONAL BOAT RAMP AND TRAILER PARKING*

The location of the concrete dual access boat ramp will be retained and upgraded with access and manoeuvring areas configured to reduce conflicts between activities. Boat trailer parking will be formalised to use the available space more efficiently with a dedicated area for short stay parking nearby and long stay parking along Gravel Pit Lane.

13.1.3 DEDICATED SEA KAYAK AREA

To support existing sea kayaking enterprises, it is proposed to relocate visitor operations to a separate ramp/service area with a dedicated launching ramp and boat storage at a nearby estuarine inlet. This will provide sheltered put ins in a more natural setting and ready access to the Cleddau Delta coastline, while avoiding commercial and other larger recreational boat movements.

13.1.4 ICONIC REFUGE

As part of a series of iconic designed, natural hazard refuges throughout Milford Sound Piopiotahi, a refuge will be placed at the intersection of the four main activities operating out of Deepwater Basin. It will reside within the low-lying coastal zone and inform visitors about risks and protect them in the event of a natural disaster. As a day-to-day landmark, it would also function as a general-purpose shelter with facilities for rest and weather protection, accompanied by interpretive displays.

13.1.5 CAR PARKING AND BUS LAYOVER AREAS

A direct, cross-spine pathway between the visitor's hub and Deepwater Basin Node will enable convenient walking access to a central visitor car park located on raised ground of the existing staff accommodation at Cleddau Village. Vehicles and campervans will be diverted off Milford Road at the Deepwater Basin Road junction and directed up Sinbad Drive to minimise private vehicle traffic at the visitor's hub. Existing and supplementary landscape planting will visually break up potentially large areas of car parking into smaller clusters with spaces that can be individually booked and effectively managed.

Similarly, a bus lay-up area for electric recharging or hydrogen refuelling and driver rest time will be located within an adjacent clearing off Noel Lane.

13.1.6 HELIPORT

A new heliport will be located on raised ground off the existing staff accommodation at Cleddau Village. This responds to an opportunity to reduce the impact of noise on the visitor hub and more closely associate it with other commercial operating environments, such as the commercial marina.

The direct, cross-spine pathway between the visitor's hub and Deepwater Basin Node will also allow more convenient walking access to and from the heliport for visitors taking scenic flights. Pembroke Drive will be kept as a service road with opportunities for clear management between landside bus layby or staff parking and airside operational areas. Existing and supplementary landscape planting will visually break up the continuity of landing pads for a high amenity visitor arrival.

The existing DOC service yard off Deepwater Basin Road will be adapted for emergency evacuation landings with utility sheds that could be reused for maintenance and storage for rotary operations with additional site capacity to relocate lightweight buildings from the existing aerodrome.

13.2 PRIMARY OPTION FOR CONSIDERATION

Deepwater Basin Node - The node is a Class 2 site for Landslide, Avalanche and Flooding risk, but is a Class 3 site for Tsunami Risk. The risk to the workers and visitors is assessed to be substantial, the proposed plan for the node should only be progressed after a high-level review of the natural hazards.

Proposed upgrades to this site include a carpark and bus layover area, a boat ramp, kayaking facilities, an iconic refuge, and a new heliport. The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine Fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures.

13.3 SECONDARY OPTION FOR CONSIDERATION

Further detailed assessments are recommended to assess the Natural hazard (flooding and landslide) risks to determine the locations of the structures and design the mitigation measures to reduce risk.

OPTIONEERING ASSESSMENT BY TECHNICAL DISCIPLINE

13.4 NATURAL HAZARD RISK ASSESSMENT

PART A: ASSESSMENT:

For the purposes of this report, Milford Sound Piopiotahi area is defined as the area west of the Tūtoko and Cleddau River confluence. This area includes the following key sites: Little Tahiti, Milford Sound Lodge, Deepwater Basin, Cleddau Delta, and Freshwater Basin (Figure 67).

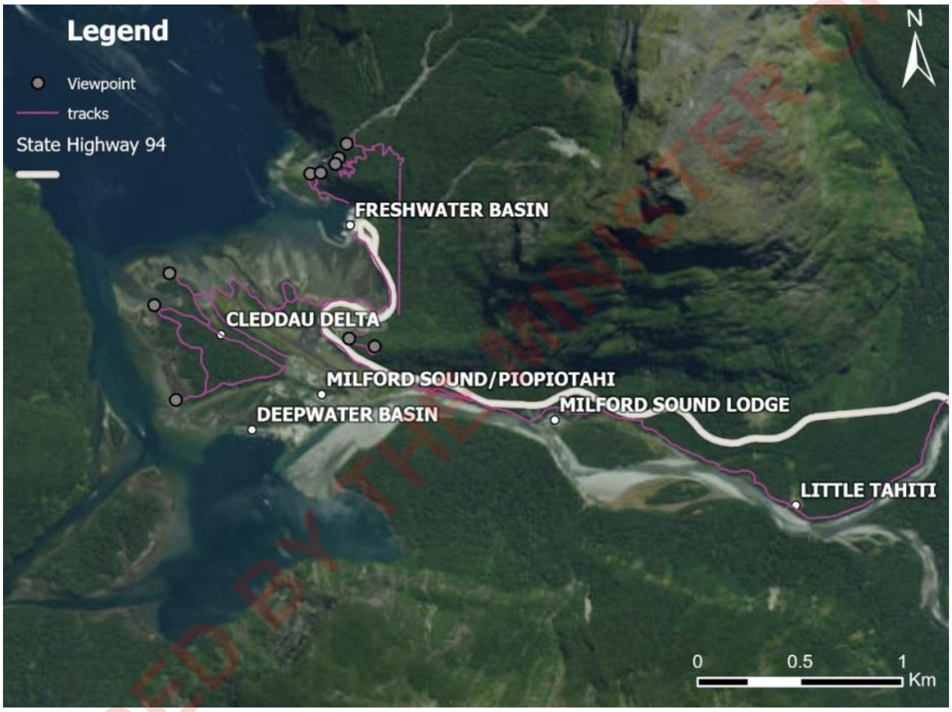


Figure 67: Aerial of Milford Sound Piopiotahi.

Figure 68: Milford Sound Piopiotahi sites under the MOP Master Plan (source: Stantec and Boffa Miskell)

13.4.1 LANDSLIDE, FLOOD AND AVALANCHE RISK

13.4.1.1 CLASS 2 SITES

As per the GNS methodology, a Class 2 site indicates that a basic level of risk analysis is required. The analysis should highlight and identify the potential impacts to persons on the public conservation lands and waters. Identified high-risk sites may require further advanced risk analysis and consideration of mitigation options.

The Deepwater Basin and the Milford Sound visitor areas are situated on the Cleddau River delta which forms a reasonably flat peninsula surrounded by Milford Sound Piopiotahi.

The surrounding terrain is typically described as being steep heavily vegetated mountainous terrain. Previous studies and reports detail the extent of flood risk at Deepwater Basin and across the Cleddau Delta associated with the Cleddau River. There is extensive stop bank and rock armouring mitigation and control measures in place along the banks of the Cleddau at this site as a direct result of previous investigations and assessments of flood risk. Flood mitigation is based on existing data and reports, estimated to reduce the identified flood hazard to a low probability of occurrence, although exposure time remains high currently at these sites due to the presence of staff accommodation. If the proposal in the Masterplan to relocate staff accommodation from this area is implemented, then exposure times will significantly reduce.

The Deepwater basin and Cleddau Delta are assessed as Class 2 sites for flood risk associated with the Cleddau River. Visitors also use the constructed walkway between the Milford Sound visitor centre and the ferry terminal in Freshwater Basin. This area is typically low-lying and at the bottom of steep to very steep mountain side with near vertical faces such as that at the Bowen Falls areas north of Freshwater Basin. This area is prone to landslides, tree slides, and occasional rockfall which have occurred in recent years. Notably a tree slide and rockfall event caused significant damage to a storage building in 2016.

Landslide and rockfall hazard probability at the Freshwater Basin is assessed qualitatively as medium. Rockfall and landslide hazard footprints in this area are mostly restricted to narrow chutes within existing gullies and on failed slopes while tree slides can occur in areas with mature vegetation outside of gullies.

Based on current usage of these areas site visitors and workers are expected to pass through hazard footprints in relatively short spaces of time and are unlikely to spend any significant time directly within the hazard footprint. Typical exposure windows of between 30 and 180 minutes have been determined in discussion with current site workers and operatives and future visitor use. The Freshwater Basin is assessed as a Class 2 site for landslides, tree slides, and rockfall.

On the Milford Sound Piopiotahi side of the Homer Tunnel, there are two sites on the Cleddau River assessed as being Class 2: Little Tahiti and Milford Sound Lodge. These sites are assessed as being exposed to flooding from the Cleddau River with a low probability of occurrence. However, the hazard at these sites is now somewhat mitigated due to the elevation of the sites above the existing river level and recent additional rock armouring placed along the riverbank at Little Tahiti and the Milford Sound Lodge. These sites were impacted by flood related scour and resulted in loss of the riverbank during the February 2020 storm events that impacted the Milford region. However, neither the Little Tahiti or Milford Sound Lodge site were flooded or inundated during the event.

Figure 69: The flood mitigation stop bank on the northern margin of the Cleddau River looking out towards Milford Sound.

Figure 70: Freshwater Basin with an old tree slide scarp to the right of the image.

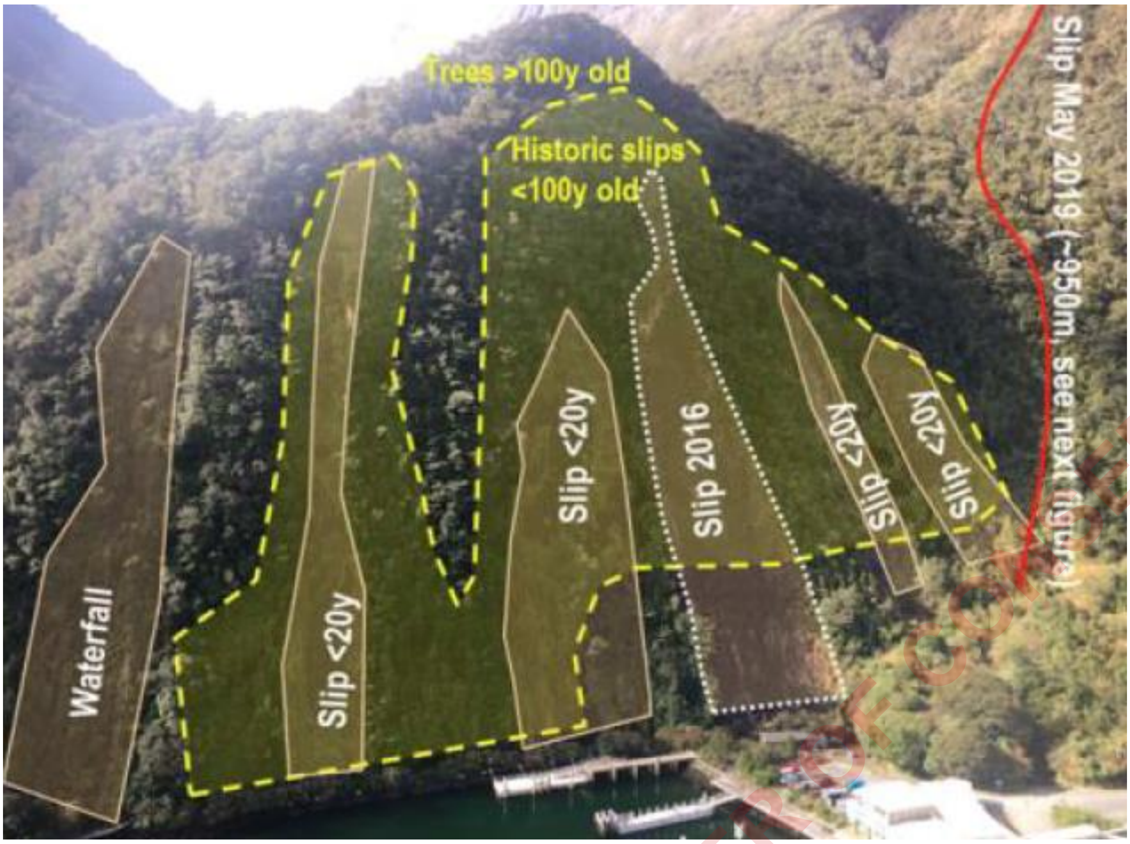


Figure 71: Tree slides and landslides in the hillslope next to Freshwater basin in Milford Sound (source: Stantec 2021)

Figure 72: Damage to a storage building in Milford Sound from a rockfall in 2016 (source: Tim Holland)

13.4.1.2 TSUNAMI RISK (CLASS 3A)

Defined by the GNS methodology, a Class 3A risk level indicates a “High to extreme” Significance level and falls under an “intolerable” DOC evaluation category. Risk Management Actions indicate that Urgent action is required. This may involve interim risk management solutions (e.g. Closures) while solutions are developed. Basic-level risk analysis must be undertaken, and an advanced-level risk analysis may be required. Class 3A represents the highest priority for further risk analysis and risk management actions.

The previous Stage 2 reporting identified the extent of tsunami risk in the Milford Sound area. Extensive studies and assessments of the occurrence of tsunamis within the sound or affecting the Milford Sound basin area have already concluded that there is a proven record of events having occurred over geological time.

As noted above there are typically two distinct sources of tsunami:

1. Landslide (rock avalanche) induced.
2. Earthquake induced sea floor rupture.

These are discussed and differentiated further in the Part B report, however for the purpose of the screening analysis a review of the data presented in the Stage 2 works concluded that for the Milford Sound Piopiotahi area, the wave amplitude of a 100-year return interval tsunami (H50/100) was of the order of 1.3 – 1.9 m. This is based on the NTHM and only incorporates fault-induced tsunami.

For the Alpine Fault triggered landslide tsunami event, there is 150-year return interval for tsunami amplitudes ranging between 0.3 and 10 m at Freshwater Basin. For the Visitor Hub, Freshwater Basin, Deepwater Basin, and Cleddau Delta $S_{overland}$ (tsunami wave amplitudes required to impact the site) has been calculated as being 1.52 m, 1 m, and 0.5 m which are tsunami events all estimated to occur at least once every 100 years. Given the current use of the basin and population distributions around the area exposure times across the three sites in Milford Sound Piopiotahi have been determined as being greater than 180 minutes. Adopting the GNS methodology the Preliminary Analysis of tsunami risk as detailed in the Natural Hazards Part A assessment report, determines the site as being Class 3A for tsunami risk.

Due to the elevation and distance from the coast of the Milford Sound Lodge (~ 11 m above sea level and 1200 m away) and Little Tahiti (~19 m above sea level and 2400 m away), it is anticipated that a much larger tsunami wave at the Cleddau River Mouth would be needed before an actual impact at either site would occur.

For the Milford Sound Lodge $S_{overriver}$ has been calculated as 7.03 m which is equivalent to a tsunami with a return interval of 150 years (AF8 event). This hazard is qualitatively assessed as having a medium probability of occurrence. Exposure time at this site is also anticipated to be greater than 180 minutes. On this basis the Milford Sound Lodge is categorised as a Class 3A site for tsunami risk.

For the Little Tahiti site, Soverriver has been calculated as 12.5 m. This is outside of the range of potential amplitudes from an AF8 event. A 12.5 m amplitude tsunami wave at Milford has been assessed as having a return interval of 555 years according to Dykstra (2012), > 2500 years according to Taig & McSaveney (2015), and >2500 years using theNTHM. This is assessed as a hazard with a low probability of occurrence and as such Little Tahiti is categorised as a Class 2 site for tsunami risk.

13.4.2 *PART B ASSESSMENT*

Table 62: Natural Hazards Risk

Natural Hazards	Risk	Category	Mitigation Measures
Flooding	Low to Moderate	Visitors/Workers	Based on the flood works completed on the Cleddau river. Further assessment is recommended
Landslide	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable- Continue with the proposal only after high level review.
Landslide	Moderate to High	Workers	Reduce to as low as reasonably practicable – Close the site
Tsunami	Moderate to Substantial	Visitors	Reduce to as low as reasonably practicable – Continue with the proposal only after high level review
Tsunami	Substantial	Workers	Continue with the proposal only after a high-level review.

13.4.2.1 SOCIETAL RISK – TSUNAMI

LANDSLIDE INDUCED TSUNAMI

For the most likely event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 28 fatalities.
- When the population at risk is 2000, we estimate there to be 1120 fatalities.
- When the population at risk is 3000, we estimate there to be 1680 fatalities.

For the maximum credible event:

- When the population at risk is 1, we estimate there to be 1 fatality.
- When the population at risk is 50, we estimate there to be 45 fatalities.
- When the population at risk is 2000, we estimate there to be 1800 fatalities.
- When the population at risk is 3000, we estimate there to be 2700 fatalities.

AF8 INDUCED TSUNAMI

- When the population at risk is 1, we estimate there to be no fatalities.
- When the population at risk is 50, we estimate there to be 21 fatalities.
- When the population at risk is 2000, we estimate there to be 840 fatalities.
- When the population at risk is 3000, we estimate there to be 1260 fatalities.

13.4.2.2 SOCIETAL RISK FOR LANDSLIDE

For the most likely event:

- When the population at risk is 1 at each site, we estimate there to be no fatalities at any site.
- When the population at risk is 5 at each site, we estimate there to be 1 fatality at Freshwater Basin.
- When the population at risk is 40 at each site, we estimate there to be some fatalities (2-7) at Visitor Hub.

For the maximum credible event:

- When the population at risk is 1 at each site, we estimate there to be 1 fatality at every site except Little Tahiti. This is due to the distance of the Little Tahiti site from a potential maximum credible source.
- When the population at risk is 5 at each site, we estimate there to be some fatalities (2-7) at every site except Little Tahiti.
- When the population at risk is 40 at each site, we estimate there to be multiple fatalities (10-40) at all sites.

13.5 LONG TERM CLIMATE CHANGE ASSESSMENT

The Milford Sound Piopiotahi Hub is the only location within the Milford Corridor to be exposed to Sea Level Rise. Given historical records of flooding at high spring tides at the Cleddau delta and current existing conditions, risk is moderate. Sea rise projections (including vertical land movement) towards the end of the century will raise risk up to extreme levels.

Extreme weather (high winds and storms) currently has moderate risk at this location; however, this is expected to reach extreme levels by late century. Similarly, flooding risk levels from extreme precipitation events are moderate, however future projections suggest that elements-at-risk will be more exposed to flooding from the Cleddau River over time, reaching extreme levels towards the end of the century.

It is important to note that extreme weather and heavy rainfall events may also contribute to increase the risk of slopes instability and given the evidence of rockfall and landslides at Freshwater and Deepwater basins, an increase in the frequency and intensity of climate events could potentially increase the risk of slope instability too.

Risk from higher temperatures is expected to be lower than those of extreme weather and rainfall. Although temperature will be higher (hot days), the expected increase in rainfall will reduce the number of dry days, reducing the risk of drought and wildfires. It is important to recognise however, that, given the natural variability of rainfall, occasional dry periods will occur, over which drought and wildfire risk will be higher.

The number of hot days (temperature >25°C) will increase towards the end of the century, changing the risk from low currently to moderate, increasing the cooling requirements in buildings (i.e.: HVAC Systems).

Given the existing conditions around this location, avalanche risk is not applicable.

Table 63: Climate change risk summary – Milford Sound Hub

			SEA LEVEL RISE	RAIN		TEMPERATURE		Lower Temperature	Extreme Weather
LOCATION	Element at Risk		Coastal Inundation	Heavy Rain/Flooding	Heavy Rain /Slope instability	Dry days/Drought	Hot days	Frost Nights – Avalanche	High winds / Storms
Milford Sound Piopiotahi HUB	BUILDINGS	Curre t Yea	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	TRANSPORT INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	GENERAL INFRASTRUCTURE	Curren t Year	Moderate	Moderate	Moderate	Low	Low	Low	Moderate
	BUILDINGS	Mid- centur	High	High	High	Low	Moderate	Low	High
	TRANSPORT INFRASTRUCTURE	Mid- centur	High	High	High	Low	Moderate	Low	High
	GENERAL INFRASTRUCTURE	Mid- centur	High	High	High	Low	Moderate	Low	High
	BUILDINGS	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	TRANSPORT INFRASTRUCTURE	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme
	GENERAL INFRASTRUCTURE	Late- centur	Extreme	Extreme	Extreme	Low	Moderate	Low	Extreme

13.6 GEOTECHNICAL ASSESSMENT

The following is noted for Deepwater Basin Node: The Masterplan structures listed at this site are carpark upgrades, redevelopment of the boat ramp, new facilities for kayaking, a refuge, and a heliport.

- Elevation: The site is approximately 0 m – 5 m ASL.
- Closest active fault: Anita Shear Zone #8756, located approximately 12 km west of the site.
- Geological Map Information: The site is located within the mapped geological unit: Holocene River deposits (Unweathered, loose, bouldery gravel, sand, and mud in modern floodplains. Peat and carbonaceous mud bands may be interbedded).
- Environment Southland Liquefaction Risk Map: High Risk. Note mapping completed between 2006 and 2012. Data may be outdated under current liquefaction assessment techniques.
- Assessments of the boat ramp, carpark pavement and a shelter were completed between 2017 and 2023.
- 4 August 2017; Holmes Consulting Group (Holmes) and Wyatt + Gray Architects Ltd (Wyatt + Gray) issued a draft design of a shelter for the site. The Holmes design report was not available at the time of this report. It is not clear if the shelter has been designed to act as a refuge.
- August 2017; RDAgritech Ltd (now RDA Consulting) issued a bearing capacity assessment report for a proposed shelter for the site. The report is limited to a bearing assessment for a Timber Framed Building as per NZS 3604:2011. The RDA report does not provide any seismic, liquefaction or lateral spread analysis for the structure at the site.
- 1 November 2017; GeoSolve issued a pavement design report to upgrade the current carpark. The carpark upgrade proposed by the Masterplan is in a different part of the site to the current carpark that this report covers.
- 18 January 2018; Opus International Consultants Ltd (now WSP) issued a condition assessment report for the Deepwater Basin Boat ramp. On 11 July 2023 WSP issued drawings for a replacement boat ramp.
- RDA Consulting completed 5 Scala penetrometers for their bearing assessment report of the proposed 2017 shelter site. The Scalas were advanced between 0.25 m and 2.10 m bgl. The location for the 2017 proposed shelter is approximately the same as that proposed by the Masterplan for refuge to be located at site.
- GeoSolve completed 57 Falling Weight Deflectometer (FWD) test points along 4 runs for the pavement design report. The location of the 2017 proposed carpark site has been proposed for short term boat trailer storage based on the Masterplan.
- Based on the proximity of the Cleddau River and the likely soils, groundwater is assumed to be relatively shallow at approximately 2 m bgl. See Figure 73 below.

Figure 73: Deepwater basin looking southwest from the northern bank of the Cleddau River

13.6.1.1 COMMENTARY ON FEASIBILITY OF PROPOSED STRUCTURES

The site likely consists of river sediments interbedded with organics over bedrock at depth. It is anticipated that the soils are likely to have layers of finer sediments throughout, and shallow ground water. It is likely that the site will have a potential for liquefaction and that lateral spreading may occur if located near to the foreshore.

RDAgritechs report notes that the proposed shelter site is on reclaimed land and that no fill placement records were available at the time of their report. The GeoSolve report also notes that parts of the site for the 2017 carpark upgrade is located on reclaimed land with fill material likely sourced from the Cleddau River. Some of the fill placed at site was likely placed as part of the Cleddau Flood Protection Scheme. As noted previously, it has been indicated that DOC possesses fill placement and compaction records, but they were not currently available at the time of this report.

Proposed upgrades to this site include a carpark and bus layover area, a boat ramp, kayaking facilities, an iconic refuge, and a new heliport.

It is assumed that the only structures at this node requiring design to an Importance Level above 2 are the iconic refuge and heliport associated infrastructure. The carpark, bus layover area, boat ramp and kayaking facilities are assumed to be simple lightly loaded structures and will not be required to contain or protect people during a seismic event or other natural hazards.

It is possible that if individual geotechnical investigations of the various sites are completed in conjunction with each other, the amount of investigation can be optimized and will likely lead to efficiencies in investigation costs.

The development as shown in the MOP Masterplan, at this stage, is feasible from a geotechnical point. Due to the proximity of the Alpine Fault and refuges status of some structures, it should be expected that more detailed geotechnical investigations, strict designs requirements and complex construction will be required for these structures.

CARPARK AND BUS LAYOVER AREA

A new carparking area and bus layover is proposed to be constructed at the Deepwater Basin Node. It is WSP's understanding that both carpark and bus layover will consist of an open air at grade carpark with associated facilities. This area is currently raised above the surrounding area and ground conditions are assumed to include varying thicknesses of fill, underlain by river sediments and bedrock at depth.

The assumed fill at this location was placed during construction of the Cleddau Flood Protection Scheme. As noted previously, records for this fill placement were not available at the time of this report to determine the fill extents or specifications. DOC have indicated that records do exist, and these could be obtained to inform future phases. It is likely that review of the records and a basic geotechnical investigation should be able to determine the subgrades stability for a single-storey carpark. More detailed investigation will be required if the carpark is to be a multi-storey structure.

It should be noted that the proposed carpark area is near the existing aerodrome runway. Investigations completed where settlement has occurred, were found to be likely caused due to decomposing organic matter. If areas of soft or organic ground are encountered on site, they will likely require over-excavation and backfilling with controlled fill to improve the subgrade.

BOAT RAMP

The existing boat ramp is proposed to be upgraded to dual lane, with work to optimise the access, manoeuvring and boat parking areas. Depending on the final upgrades, a basic geotechnical investigation consisting of shallow hand investigations (e.g. Scala penetrometer tests and hand augers) may be necessary to support design for the boat ramp upgrade.

KAYAKING FACILITIES

Existing kayaking facilities, comprising a temporary shelter and storage area, are proposed to be relocated to a separate service area at a nearby estuarine inlet. The new facility includes additional boat storage and a dedicated launching ramp. It is assumed that that all new structures are simple, lightly loaded, uninhabited, and single storey.

Basic hand geotechnical investigations are likely sufficient to determine appropriate foundations. This would comprise Scala penetrometer tests and hand augers. The final structure loadings and subsurface conditions will inform the most effective foundation solution.

ICONIC REFUGE

A natural hazard refuge is proposed in the low-lying coastal area near the boat ramp to provide protection for visitors and staff during a natural disaster (e.g. rockfall and tsunami). The structure will need to be designed as an Importance Level 4 building to allow it to perform as required both during and post-disaster.

Given the likely ground conditions at the location (liquefiable deltaic sediments with interbedded organic layers and bedrock at depth) suitable foundations are likely to be deep piles. Ground improvements may also be required (such as deep soil mixing, stone columns). A site-specific geotechnical investigation and seismic assessment would be required as with the case of the Visitor Accommodations and other refuges in Milford Sound Piopiotahi.

While technically feasible from a geotechnical point, the ground conditions are not favourable for a structure to function as a refuge. The foundations required for a refuge will likely be prohibitively expensive at this location and it may not financially viable.

HELIPORT

A new heliport is proposed to be located on raised ground off the existing staff accommodation. It is assumed that the heliport will include some above-ground infrastructure (e.g. control building, sheds, etc). The design requirements of the heliport and associated infrastructure (e.g. IL2 or above, specific pavement design), will determine the extent of the geotechnical investigation necessary to inform design.

13.7 CONTAMINATED SITES

The Deepwater Basin Node is located adjacent to the existing outlet of the Cleddau River. The area currently comprises a marina for commercial fishing, kayak operations, a boat ramp with trailer park for recreational visitors and a wastewater treatment plant.

13.7.1.1 IDENTIFIED HAIL ACTIVITIES

As Hazardous Activities and Investigations List (HAIL) activities have been identified on the site, the Deepwater Basin Node has been classified as RED requiring further assessment to the risks to human health and the environment prior to development. A summary of the identified HAIL activities has been provided in Table 64 with a location plan in Figure 74. RED – indicates that HAIL activities (current or past) are likely or known.

Table 64: Identified HAIL activities at Deepwater Basin Node

HAIL ID	Location	HAIL Activity	Dates	Comment	Likelihood
DWB1	Gravel Pit Lane (RealNZ)	A17. Storage tanks or drums for fuel, chemicals or liquid waste.	2012 – present	Two HAZCHEM stores, one with caustic cleaning chemicals, the other small volumes of petrol.	Certain
SLUS-20173159	Gravel Pit Lane (MSI)	A17. Storage tanks or drums for fuel, chemicals, or liquid waste. B2. Electrical transformers including the manufacturing, repairing, or disposing of electrical transformers or other heavy electrical equipment.	2012 – present	500L diesel tank and transformer 'T4'	Registered Site (ES)
DWB2	Gravel Pit Lane (MSTL)	A17. Storage tanks or drums for fuel, chemicals, or liquid waste.	2010 – present	Minor quantities or various chemicals including diesel (200L) and backup generator, weed control sprays, minor mechanical work and waste oil.	Certain
DWB3	Gravel Pit Lane (MSDA)	G6. Waste recycling or waste or wastewater treatment.	1990s – present	Wastewater treatment facility including minor storage of HAZCHEM including fuel storage (small mobile tank) for backup generator.	Certain
SLUS-00000806	Fisherman's Wharf, Deepwater Basin	F7. Service stations including retail or commercial refuelling facilities.	1980s – present	Bulk diesel storage in two 40,000L AGSTs with bowsers for land and marine vessel refuelling.	Registered site (ES)
DWB4	The White House	I. Any other land that has been subject to the intentional or accidental release of a hazardous substance in sufficient quantity that it could be a risk to human health or the environment.	1970s – present	Potential discharge of degraded hazardous building materials (e.g. asbestos/lead paint) to soil; 3m halo around all long-term structures in Milford Township.	Unverified

Figure 74: Site location plan Deepwater Basin with identified HAIL sites

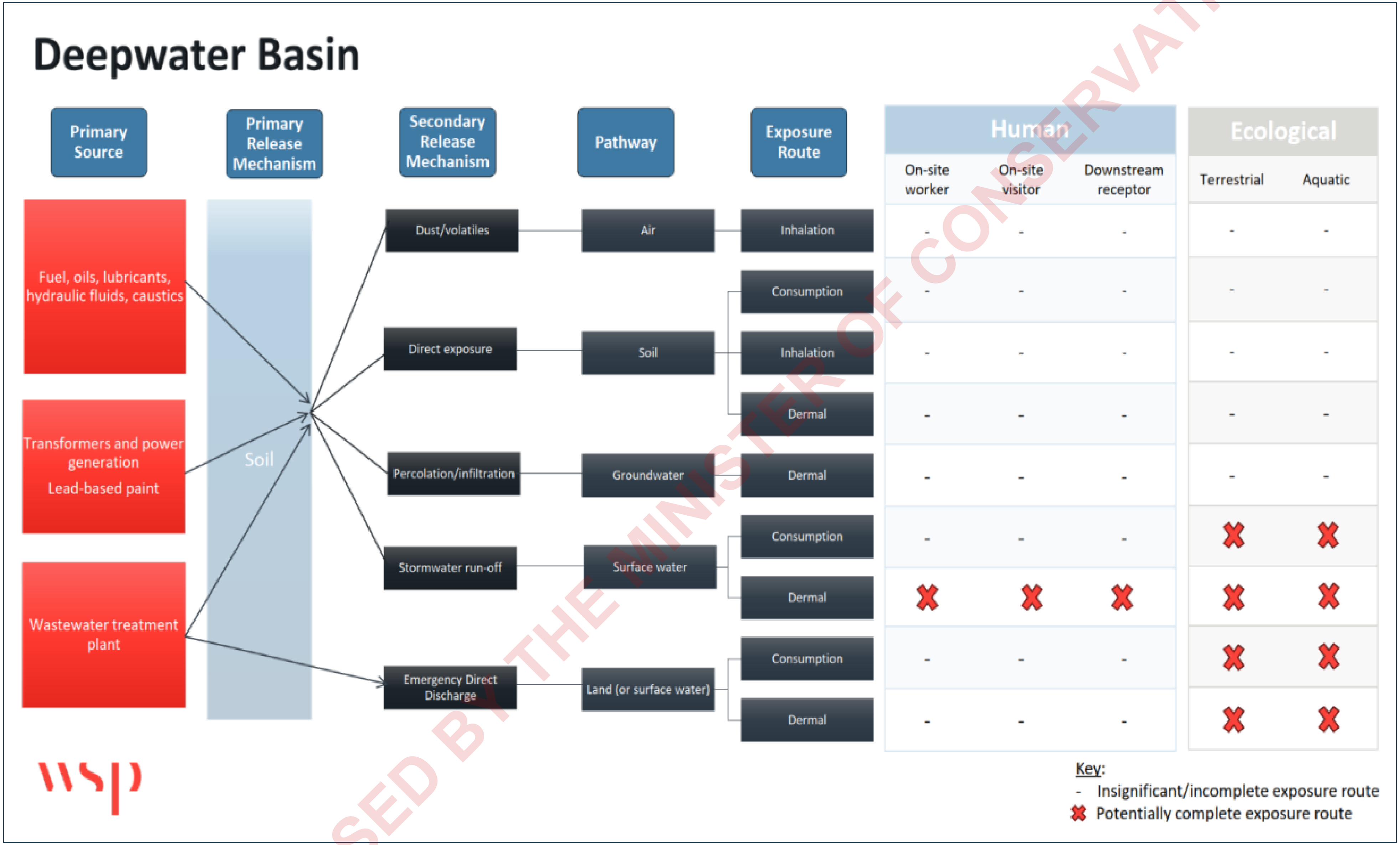


Figure 75: Conceptual Site model for Deepwater Basin Node – Milford Sound Piopiotahi

13.7.2 CONSENTING CONSIDERATIONS

NES-CS REGULATIONS

Investigation results revealed that HAIL activities are occurring or have occurred on the site. As such, the NES-CS Regulations apply to the site (Ministry for the Environment, 2011).

LAND USE CHANGE AND SUBDIVISION

The PSI has concluded that it is highly unlikely for there to be a risk to human health associated with the ongoing use of the site as commercial/industrial (e3Scientific, 2022a). As such, according to Regulation 8(4) of the NES-CS, subdividing the piece of land is a permitted activity. Should a more sensitive land use be proposed, based on the findings there are potential risks associated with soil contaminants and as such a Detailed Site Investigation (DSI) would be necessary to further quantify these risks. In the absence of a DSI, future land use changes would be a discretionary activity under Regulation 11 of the NES-CS.

SOIL DISTURBANCE

Any soil disturbance or removal that does not meet the permitted activity criteria outlined in Regulation 8(3) would be a discretionary activity under Regulation 11 unless a DSI to quantify contaminant concentrations is completed.

The PSI concluded that for pieces of land within the site, any activity requiring soil disturbance should be managed under a contaminated site management plan or if a site management plan already exists, it should be updated to include any additional information from this report (e3Scientific, 2022a).

PROPOSED SOUTHLAND WATER AND LAND PLAN

The PSI concluded that there are no pieces of land which could be considered contaminated and causing a possible discharge that does not meet the permitted activity condition (e3Scientific, 2022).

13.7.2.1 FURTHER ASSESSMENTS

Table 65: Further Testing requirements for contamination

HUB	DSI SCOPE OUTLINE	CONTAMINANTS OF CONCERN	DSI COST ESTIMATE
Deepwater Basin	Additional boreholes for groundwater monitoring may be warranted based on development proposals along with the findings of the soil sampling and analysis and/ or initial groundwater assessment.	Heavy Metals, TPH, PAH, BTEX, PCB's Asbestos	$35,000 - $40,000

13.8 HELIPORT ASSESSMENT

Purpose of this Study: Feasibility assessment to operate helicopters from the proposed Masterplan (2021) Deep water basin site1 and an alternate location in the area known locally as "Little Tahiti".

13.8.1 SITE CHARACTERISTICS

The existing airfield is surrounded by mountainous terrain. The alpine environment can create very challenging flying conditions to and from the airport including wind conditions which can cause excessive turbulence, up and downdrafts, and unpredictable shear areas.

13.8.2 DESIGN HELICOPTER

The Airbus H125 is the most common helicopter type used by commercial operators to service Milford Sound Piopiotahi.

13.8.3 PLANNING PARAMETERS AND ASSUMPTIONS

- The site boundaries currently shown are tentative and driven by the heliport concepts proposed in this study.
- Design Helicopter H125 (previously designated AS350) is used for this study purposes. The H125 is the most common helicopter used by commercial operators to service Milford Sound Piopiotahi.
- This Helicopter (H125) is expected to operate under performance Class 3, per international guidance single engine rotorcraft are required to be operated in PC3. Hence the guidance on PC 3 (Category C) was used in the concept/study to develop FATO and approach/take-off surfaces.
- Physical dimension guidance for type "Surface Level Heliports" was used for study purpose. It assumes the FATO will be sited on ground.
- The heliport is expected to cater to daytime operations only or under VMC conditions. This eliminates the requirement for a transitional surface for FATO.
- Helicopters at this heliport are expected to hover or air taxi to the stands after landing in the FATO. Same for take-off (Air taxi from the stand to FATO and take-off).
- The elevation model for OLS assessment was created using a combination of the Southland LINZ Lidar data, captured between December 2020 and April 2023, supplemented with the NZ 8m Elevation Model, 2012 to fill the wider area not covered by the lidar.
- The elevation model includes existing ground, buildings, and tree information.
- The landing pad level considered for the OLS assessment – 5m for Site 1 Helipad and 20m for Site 2 Helipad (matches the underneath ground level)
- Noise modelling has been undertaken in FAA's AEDT noise modelling software in line with New Zealand Standard NZS 6807 Noise Management and Land Use Planning for Helicopter Landing Areas. This is referenced in the National Planning Standards and provides a suitable assessment tool to determine reasonable noise under the RMA 1991.
- A total of 256 movements would occur on an average day, all occurring within the 0700 – 2200-hour period, defined as "daytime".
- A single helipad has been assumed for this modelling, where multiple helipads (for take-off/landings) are adopted, this may change the location of the noise contours.
- 80% of aircraft movements would occur to the west/northwest, with 20% occurring to the east/southeast.

- Noise has been assessed until helicopters reach 500 ft (152 metres) above the ground, in line with the High Court Dome Valley decision. This takes approximately 1220 horizontal metres to occur along the flight paths. Helicopters operating over this height contribute little noise and so rarely impact the overall noise contours.
- Standard operating ascent/decent procedures, aircraft weights, and fuel consumption have been assumed.
- The analysis does not account for the effects of existing noise within Milford Sound (from aircraft, road traffic, birdlife, etc.)

13.8.4 WIND ANALYSIS

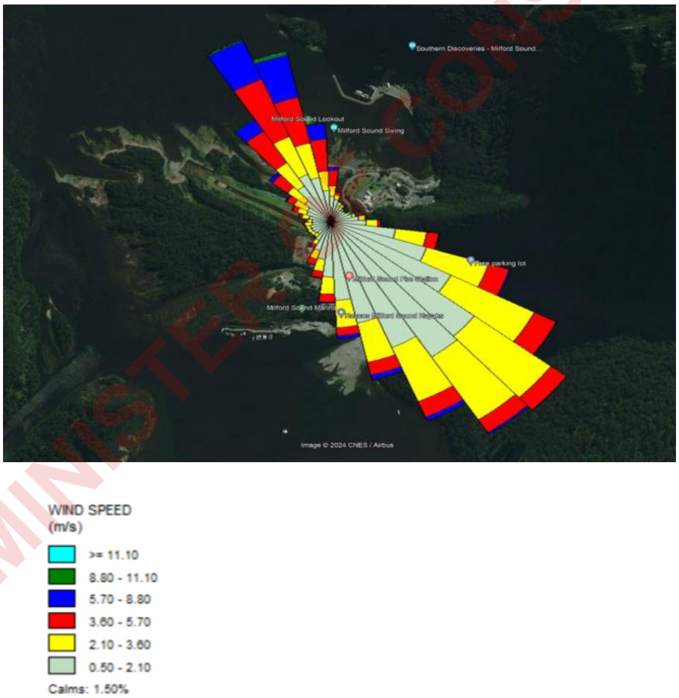
13.8.4.1 WIND ROSE – MILFORD SOUND

The following tools were used to analyse the wind data obtained from NIWA:

- WRPLOT
- Windrose Pro 3
- FAA Wind Rose Tool

The prevailing wind direction is North Westerly (NNW) and Southeasterly (SE).

The image to the right represents wind direction and speed over 3 years at the existing runway at Milford Sound Aerodrome.

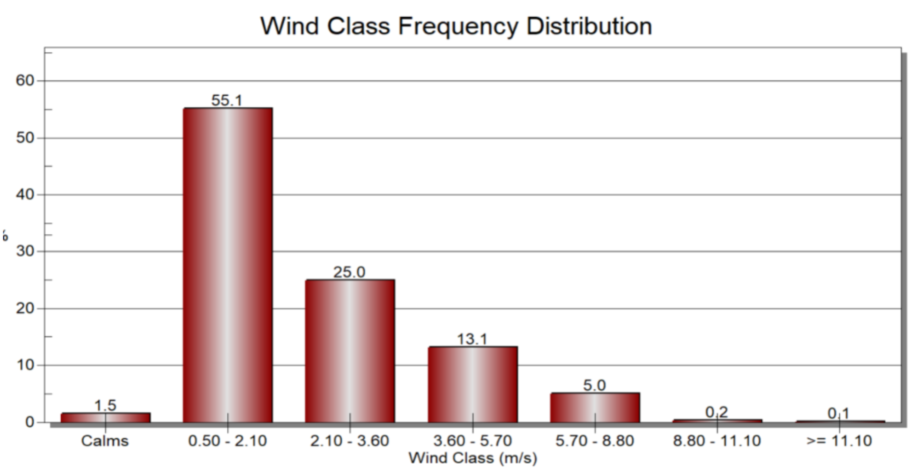


13.8.4.2 WIND DATA DISTRIBUTION

The percentage of occurrence of wind speed from the hourly wind data is represented as a bar graph.

Milford Sound is surrounded by mountainous terrain, which typically shelters the area from strong winds.

The occurrence of winds stronger than 5 m/s (10 kts, which could affect helicopter operations) from the overall data is <5% of the time overall.



13.8.5 HELIPORT CONCEPT

13.8.5.1 HELIPORT CONCEPT 1

The area shown for maintenance and the terminal facility is tentative and not measured to scale.

The location of the FATO requires further optimisation based on the planned boundary fence height, it is possible that the location may be moved slightly to the south from the current location to allow sufficient separation from the FATO to the boundary fence, so that the fence does not infringe the approach/take-off surface.

13.8.5.2 HELIPORT CONCEPT 2

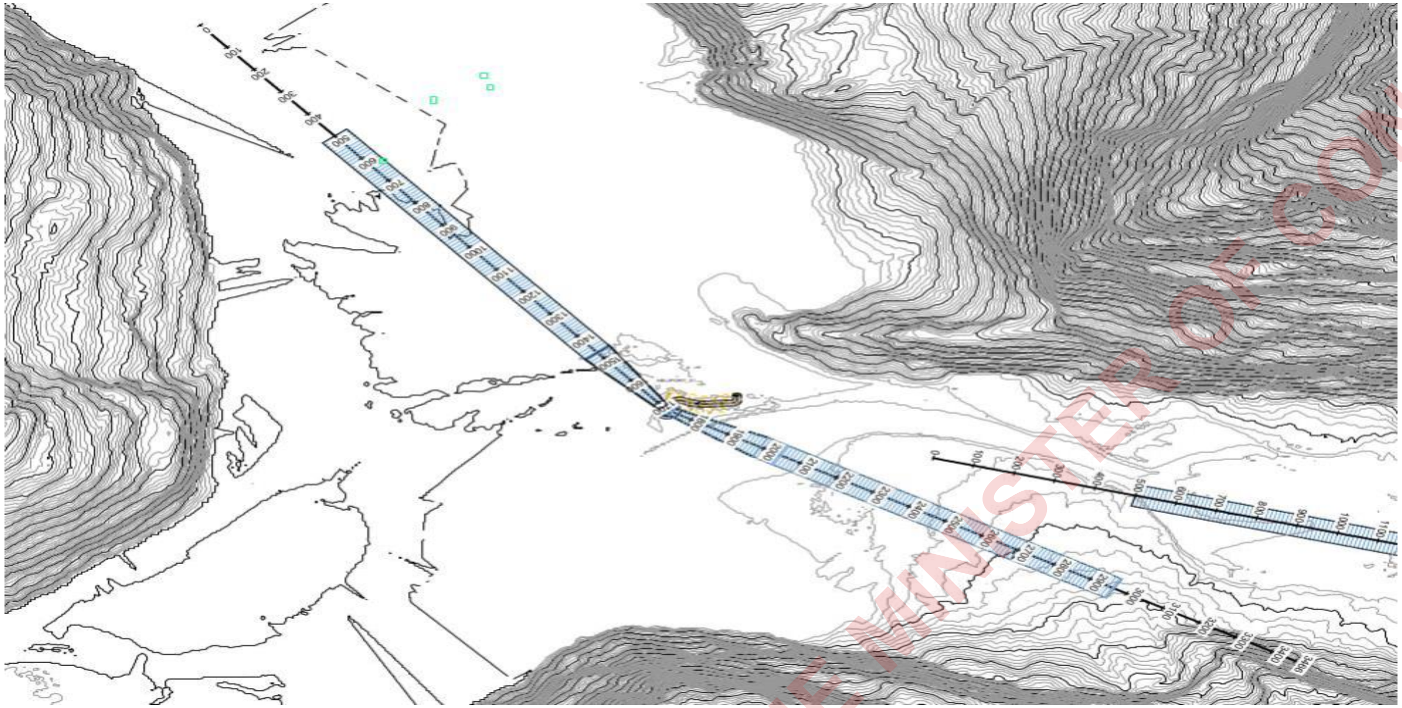
This concept/configuration can accommodate 8 parking stands and 2 FATOs.

This concept follows a pier topology, and a resilient design with two FATO's. Even if one of the FATO become unusable due to an incident the system can still operate safely using the other.

The taxi time is substantially reduced compared to the previous concept, as the helicopters are not restricted to land or take off from a single FATO.

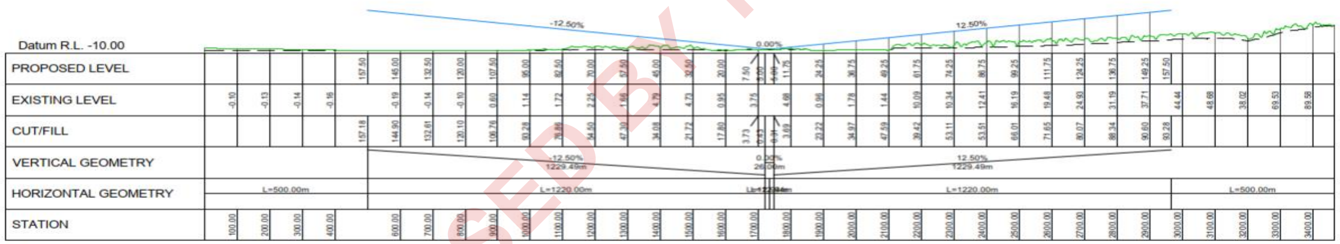
13.8.6 *SITE 1 - DEEP WATER BASIN FINDINGS*

13.8.6.1 OBSTACLE LIMITATION SURFACES (OLS) ASSESSMENT



12/32 was identified to be a suitable orientation for the approach/take-off path for Site 1.

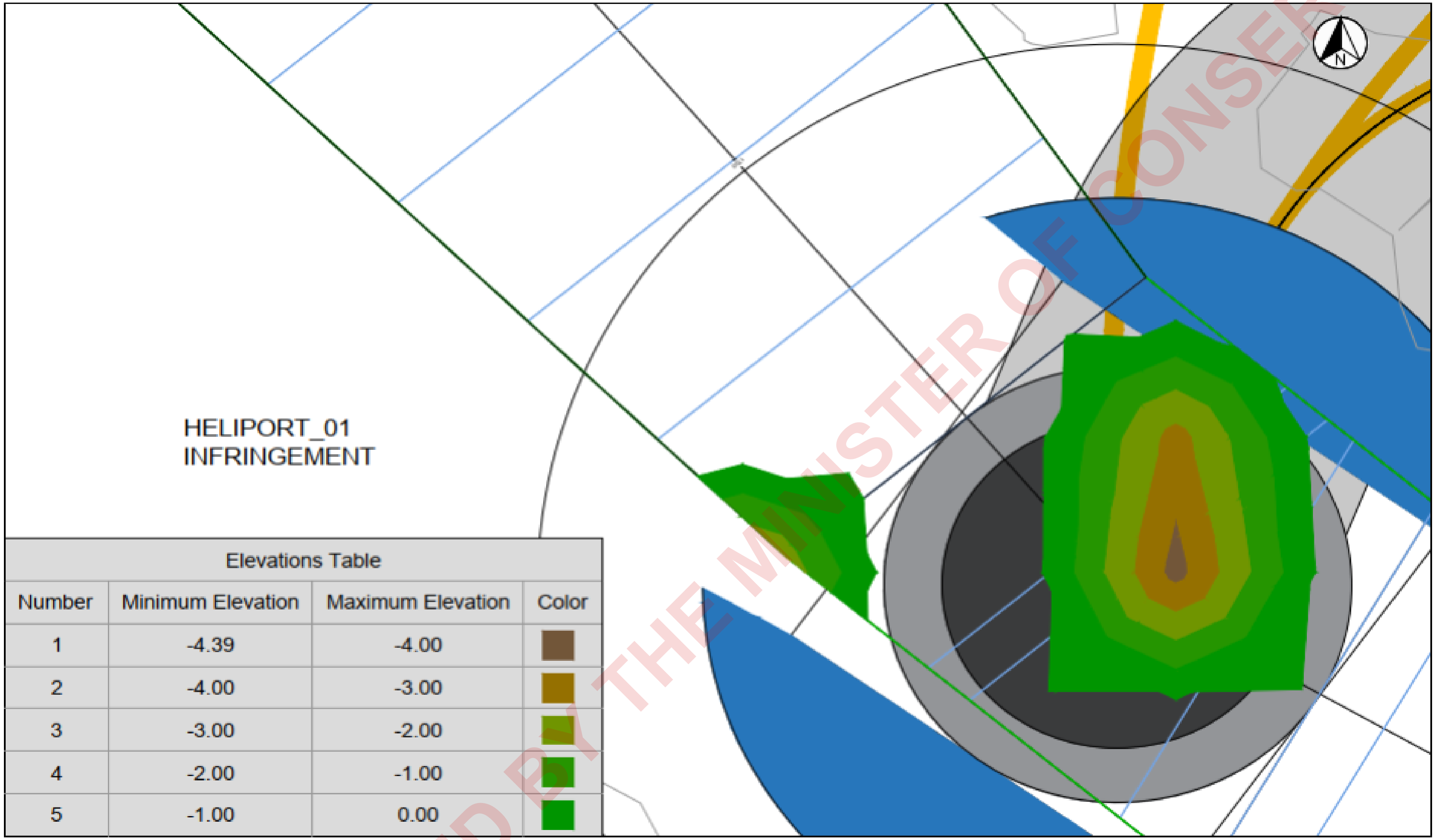
- The OLS assessment was limited to concept 1 (one FATO) only.
- A Snip of the OLS surface modelled is placed over the contours containing existing ground level and trees/building information.
- The corresponding profile view (NW – SE) is shown below. The blue line is the modelled surface, and the dashed line is the existing ground.
- No infringements were identified in the flight path due to the terrain, and the terrain for the modelled section (1.2+0.5 km) in each direction seems to be flat.



Heliport_01
SECTION BETWEEN CH: 0.00 AND 3465.88

Approach/Take-off Surface
Trees/Buildings
Ground Profile

Infringements to the OLS by buildings observed for Site 1 heliport. However, it is noted in the Masterplan that all staff accommodations and buildings in the deepwater basin node (site 1) will be cleared to enable the heliport proposal.



Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	-4.39	-4.00	
2	-4.00	-3.00	
3	-3.00	-2.00	
4	-2.00	-1.00	
5	-1.00	0.00	

13.8.6.2 ENVIRONMENTAL ASSESSMENT

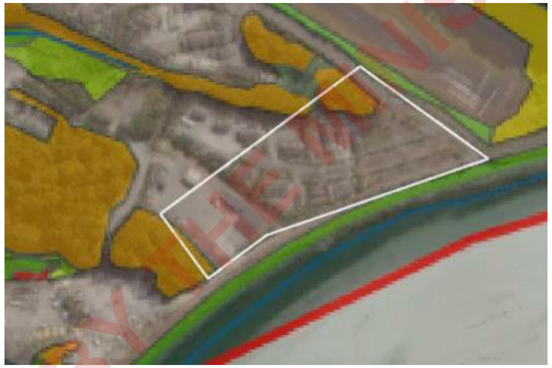
Site 1 (in Deepwater Basin Node) is a brownfield, and the proposed heliport concept would be constructed by clearing the existing development at the site including carpark and accommodation.

Images below represent the site boundary in relation to the environmentally sensitive areas at Site 1.

Based on preliminary review, the environmental impacts are likely to be manageable for the proposed concepts. Environmentally sensitive areas are not found to be significantly impacted by this proposal.

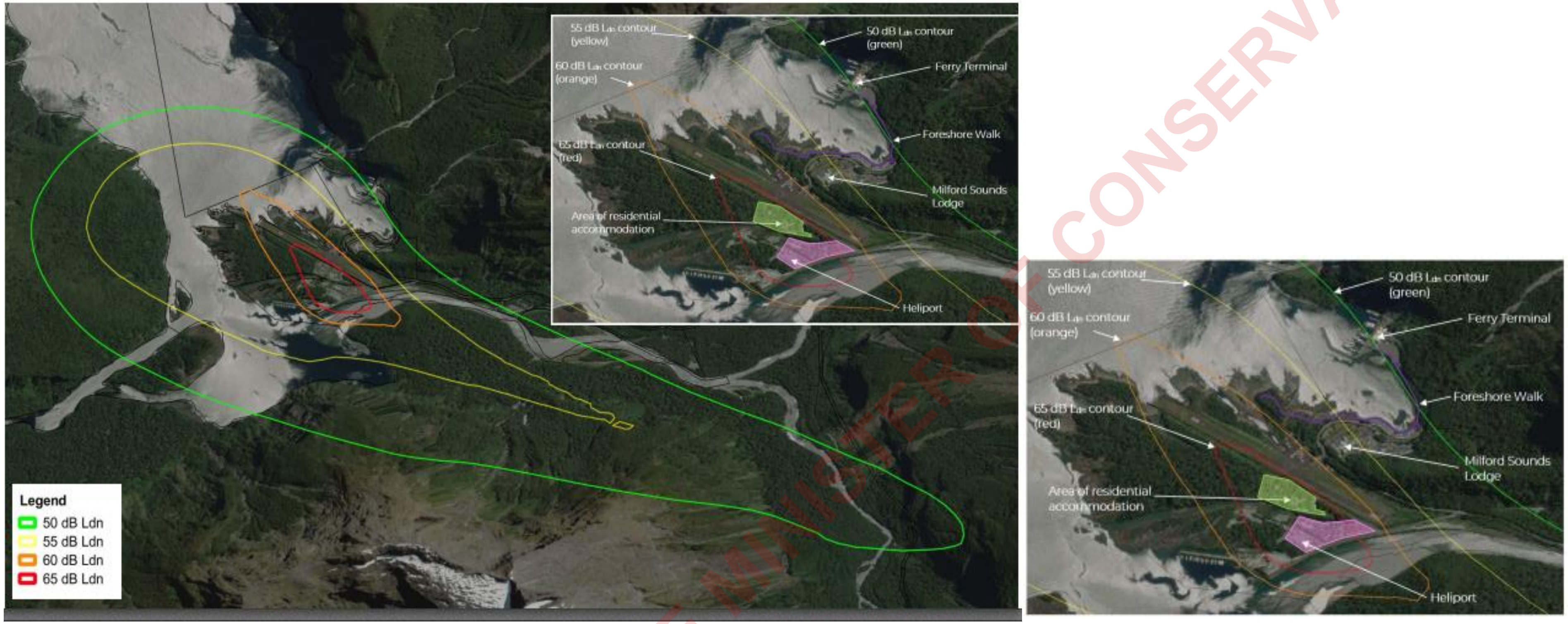
If the topology/concept of the heliport changes or a new location identified, further environmental assessment will be required.

Concept 1



Concept 2

13.8.6.3 NOISE ASSESSMENT (SITE 1 - DEEPWATER BASIN FINDINGS)



DAY-NIGHT-AVERAGE

The hotel and associated buildings are predicted to receive noise levels between 53 – 58 dB Ldn. When helicopters arrive and depart, raised voice effort will be required to be audible over helicopter noise when outdoors. Noise may also be distracting for some indoor activity.

WHO research outlines that 22 to 32% of people would be highly annoyed when exposed to aircraft noise between 53 – 58 dB Ldn. Levels of 50 dB Ldn or less are predicted at the ferry terminal. Normal speech effort is unlikely to be disrupted by helicopter flights at this location.

The Milford Sound Foreshore Walk is predicted to receive noise levels between 58 dB Ldn and 50 dB Ldn. Raised voices may be required at times at the lookout area at times, especially when helicopters fly overhead.

MAXIMUM NOISE LEVEL

Noise levels at the hotel and the ferry terminal are predicted to be at or below 45 dB LAFmax from helicopter arrivals or departures. At this level, there is no risk of conversation being disturbed or sleep disturbance.

Noise levels on the point of the Milford Sound Foreshore Walk (near the lookout point) are predicted to be up to 55 dB LAFmax. During helicopter departures/arrivals from the west, raised voice effort will be required to converse.

Based on international surveys, visitors to national parks are likely to view aircraft noise as intolerable when levels are greater than 54 dBA. This only impacts the lookout point area of the Milford Sound Foreshore Walk.

TRANQUILITY

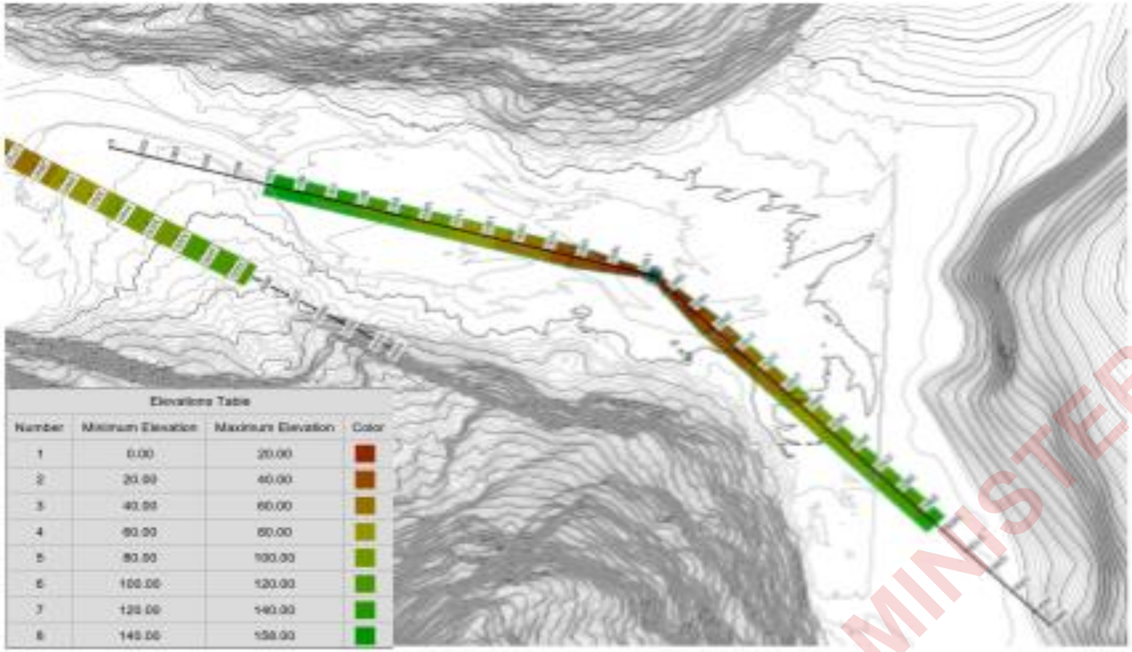
The time-above noise level has been set to 32 dBA. Based on NZ research, this is when the tranquillity level is likely to fall below 8. No area within Milford Sound will have a Tranquillity Rating of 8 or higher for a full day.

All areas of Milford Sound township are predicted experience tranquillity levels below 8 for a minimum 1 minute of each helicopter flight (arrival and departure).

Specifically, Bowen Falls is predicted to have a tranquillity rating below 8 for approximately 4 hours a day, or 40% of a 10-hour day. Milford Track Trailhead/Sandfly Point is predicted to experience a tranquillity rating of less than 8 for 2 hours (or 20%) of the day with Milford Foreshore Walk and ferry terminal are predicted to have a tranquillity rating of less than 8 for 4 – 8 hours of each day.

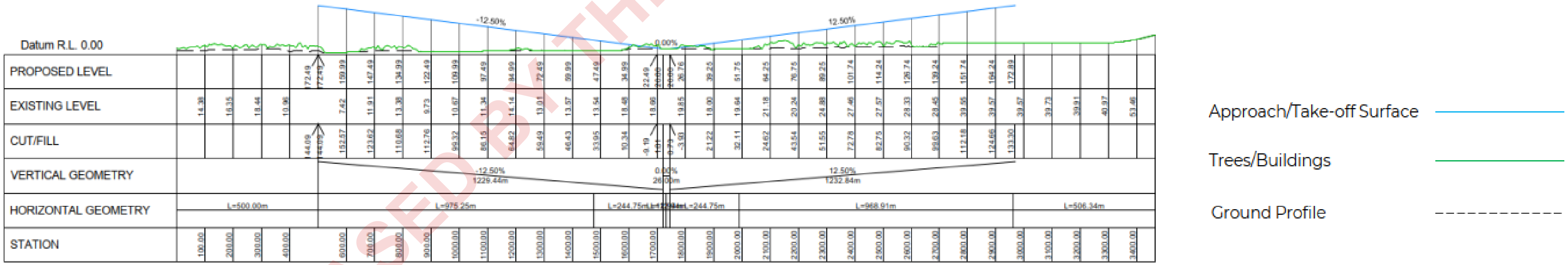
13.8.7 SITE 2 LITTLE TAHITI FINDINGS

13.8.7.1 OBSTACLES LIMITATIONS SURFACES ASSESSMENT

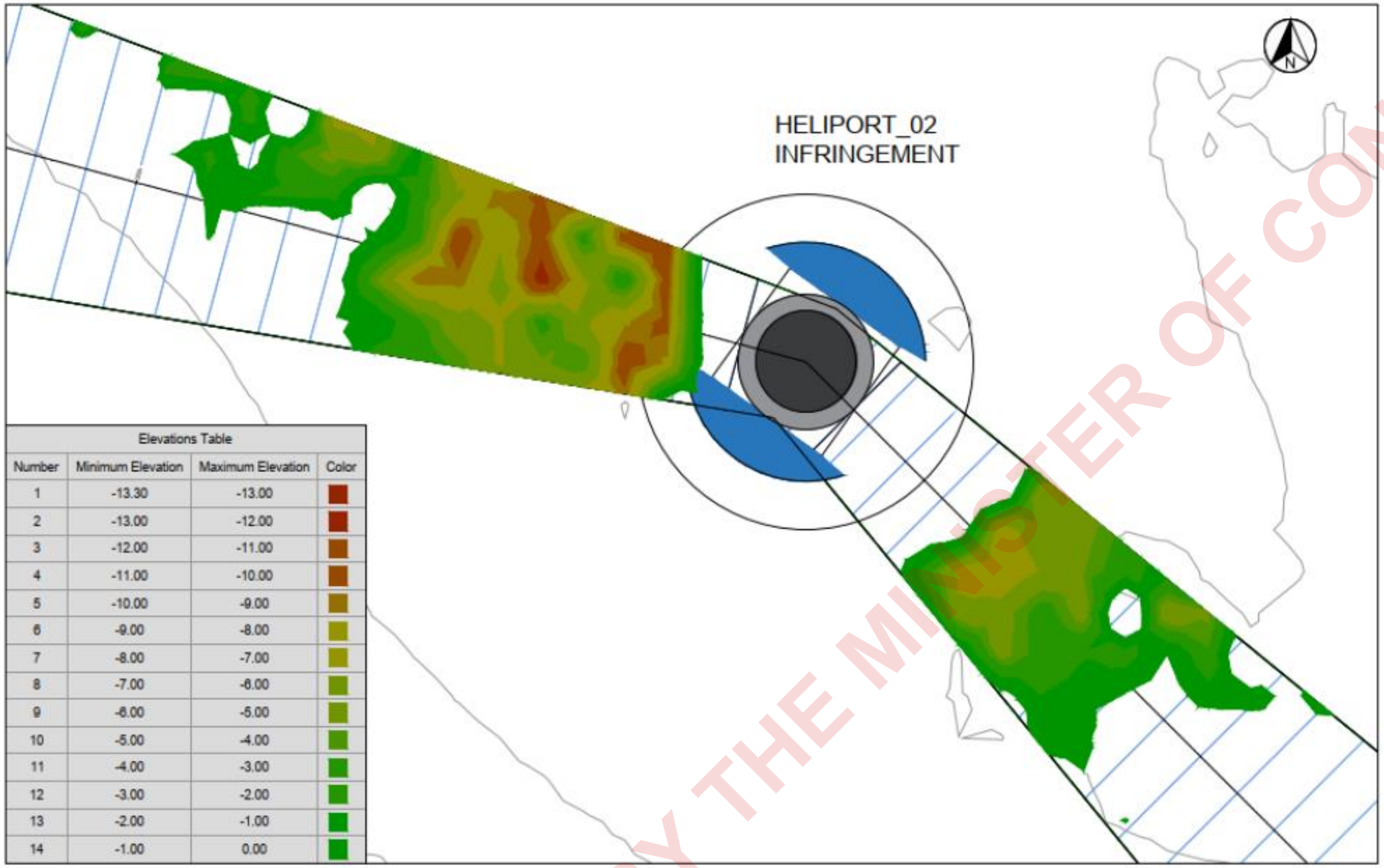


14/29 was identified as a suitable orientation for the approach/take-off path for Site 2.

- The OLS assessment was limited to concept 1 (one FATO) only.
- Illustration of the OLS surface modelled is placed over the contours containing existing ground-level information
- The corresponding profile view (NW – SE) is shown below. The blue line is the modelled surface, and the dashed line is the existing ground.
- No infringements were identified in the flight path due to the terrain, and the terrain for the modelled section (1.2+0.5 km) in each direction is flat.



The infringements due to trees/buildings are quite significant (as seen in the illustration below),which is due to dense forest surrounding the Little Tahiti site. The level of infringement by the trees into the OLS surface is up to 13m.



Number	Minimum Elevation	Maximum Elevation	Color
1	-13.30	-13.00	
2	-13.00	-12.00	
3	-12.00	-11.00	
4	-11.00	-10.00	
5	-10.00	-9.00	
6	-9.00	-8.00	
7	-8.00	-7.00	
8	-7.00	-6.00	
9	-6.00	-5.00	
10	-5.00	-4.00	
11	-4.00	-3.00	
12	-3.00	-2.00	
13	-2.00	-1.00	
14	-1.00	0.00	

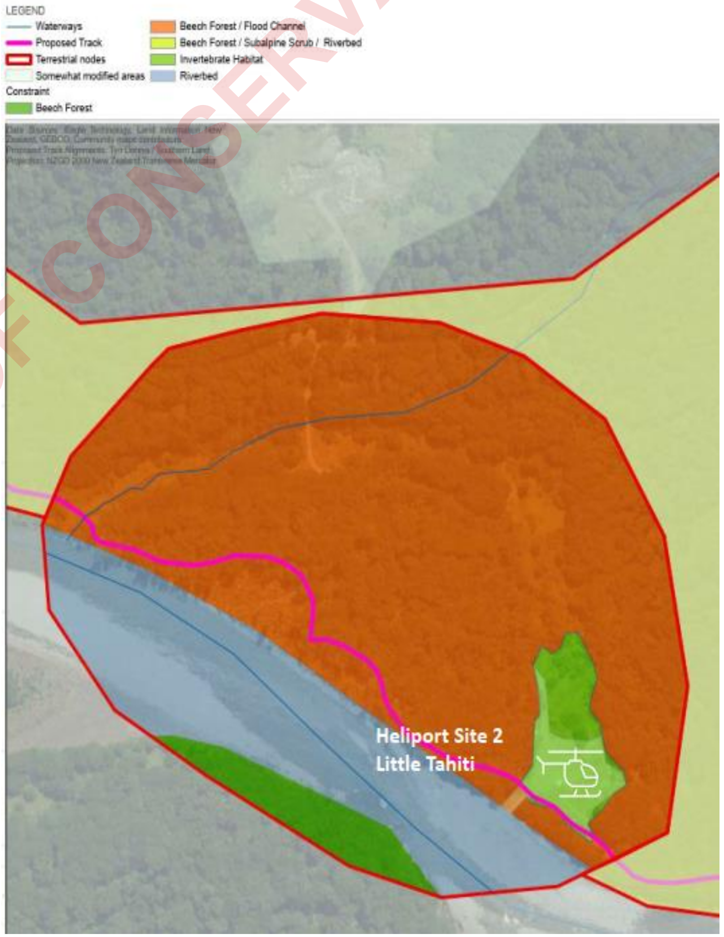
13.8.7.2 ENVIRONMENTAL ASSESSMENT

Site 2 is largely undeveloped, is located close to a riverbed and sits over the areas designated as environmentally sensitive (i.e. Invertebrate Habitat, Beech Forest).

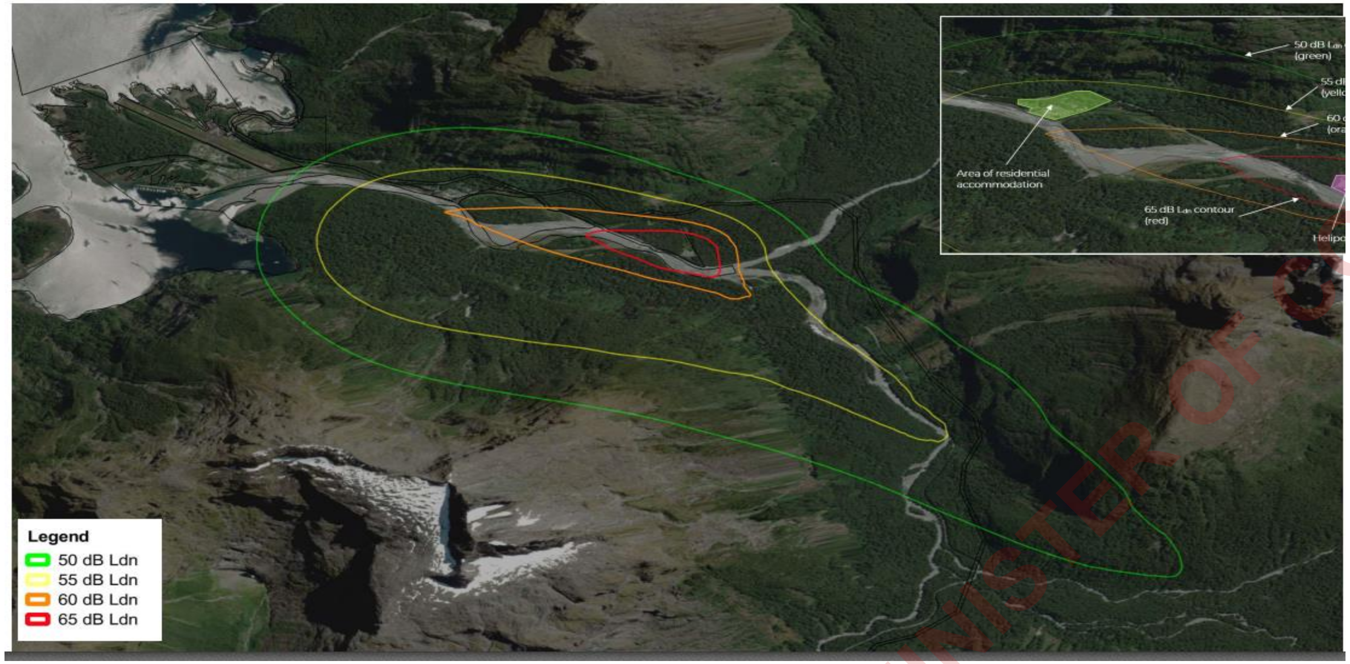
Below are the images showing the heliport concepts overlayed on Site 2 (Little Tahiti).

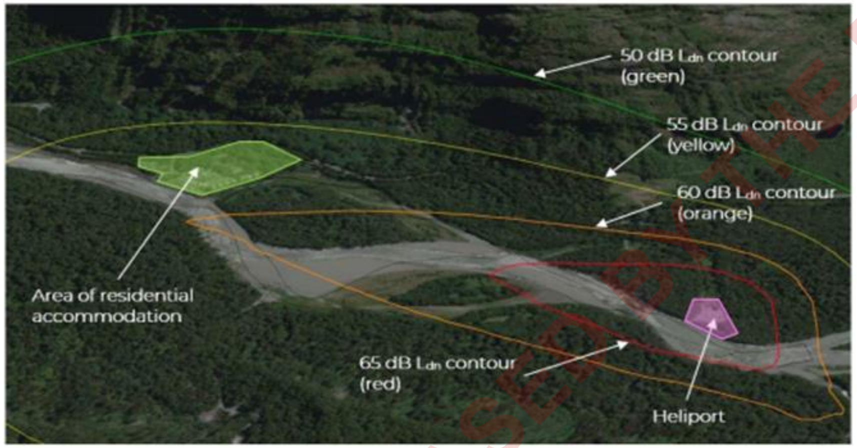
Approximately 1.5 – 1.7 Ha of vegetation is required to be cleared at Little Tahiti to have an operational heliport as proposed in this study. Please note - this does not include the cut/trim quantity of trees outside the site.

Approximately 22,396 cubic meters volume of cut is required to the tree surface (outside the site) to enable obstruction free approach/take-off in direction 14/29 for one FATO (measured from the model shown in previous slide). Please note - the cut volume captured is estimated, the actual cut volume may vary



13.8.7.3 NOISE ASSESSMENT (SITE 2 – LITTLE TAHITI FINDINGS)





DAY-NIGHT-AVERAGE

Milford Sound Lodge and campervan park to the west of the proposed Little Tahiti heliport are the only developed locations which are predicted to receive noise levels greater than 50 dB Ldn. Noise at other locations is either roads or are undeveloped areas.

Milford Sound Lodge is predicted to receive noise levels up to 58 dB Ldn. Based on WHO research, noise from aircraft at this level would result in 32% of people being highly annoyed.

This location is likely to receive lower noise from existing aviation activities and as such the change in aviation noise at this site is likely to be high.

As there are no night flights, there is no risk of sleep disturbance from the operation of the heliport.

MAXIMUM NOISE LEVEL

Due to the flight paths, the noise levels for helicopter movements from the Little Tahiti site are predicted to be like those at the Deepwater Site, and as such the same comments apply.

Milford Sound Lodge and Campervan Park are predicted to receive noise levels of 50 dB LAFmax. Maximum noise levels of 50 dB LAFmax are unlikely to impact normal voice effort conversations outdoors.

TRANQUILITY

The time-above noise level has been set to 32 dBA, which is when the tranquillity level is likely to fall below 8 based on national research.

No area within Milford Sound will have a Tranquillity Rating of 8 or higher for a full day.

All areas of Milford Sound township are predicted experience tranquillity levels below 8 for a minimum 1 minute of each helicopter flight (arrival and departure). This equates to 2 – 3 hours a day that any area of Milford Sound township would experience tranquillity rating of lower than 8.

Bowen Falls is predicted to have a tranquillity rating of less than 8 for 2 hours a day. Milford Track Trailhead/Sandfly Point are predicted to experience less than 1 minute of tranquillity degradation for each helicopter movement.

13.8.7.4 CAPACITY ASSESSMENT

Analytical models are developed for estimating the theoretical capacity of the airside subsystems.

- FATO
- Helicopter Parking Stands

The heliport capacity is determined by the minimum capacity among the capacities of the subsystems.

13.8.7.5 FATO CAPACITY

The ground capacity of the FATO can be estimated based on the FATO occupancy time of each helicopter and the separation (headway) minima required between two landings.

Occupancy Time - Ideally at airports, a fixed wing aircraft takes about 50-60 seconds to touch down and clear the runway for next movement. So, it is reasonable to assume 40 seconds for helicopters to clear the FATO and move to the respective stands.

Landing/Approach Separation Minima - for study purposes minimum separation between two landings is considered as 3 nautical miles. And this can be translated into time using an approach speed of 100 knots. 3X (3600 sec./90 knots) = 120 seconds

Number of landings that can be accommodated in a single FATO per hour will be = 3600/ (40+120) = 22 landings/hr.

However, the FATO capacity can be increased operation by inserting a take-off between any two landings without affecting landing intervals. Hence, the number of operations per FATO might be doubled during periods with similar numbers of take-offs and landings by alternating such operations on one FATO.

For this study, it is reasonable to assume 22 landings/hr. per FATO to be conservative. And for a day (10-hr. window period 8 AM – 6 PM) is approx. 220 landings.

13.8.7.6 STAND CAPACITY

The stands capacity is mainly determined by stand occupancy time. Steven Mackie (Safety Manager, Glacier Southern Lakes Helicopters) operating flights to tourist traveling from ZQN to MFN, provided helicopter shutdown time at MFN for different tourist packages as below.

- Milford Sound, Flight 201 (scenic flight) – approx. 30 minutes
- Milford Sound, Flight 203 (one of their most popular flights) – approx. 30 minutes

For the (Heli- Cruise – Heli) package from ZQN to MFN, Steven confirmed that the helicopter shutdown and stay in Milford when they have clients completing the cruise. And confirmed the shutdown time is approx. 2 hours 20 minutes when on Milford Sound + Cruise trips.

In addition to the above, a stand utilisation factor is considered in the calculation. This utilisation factor accounts for demand variability and for the time required to manoeuvre helicopter in and out of stands. Typically, the gate utilisation factor at conventional airports varies between 0.5 and 0.8 (source: FAA)

For Concept 1, a utilisation factor of 0.6 is considered due to constrains such as single FATO for all the 11 stands and dependent hover taxi movement. Whereas for Concept 2, a utilisation factor of 0.8

is considered because of the efficient pier type configuration of parking stands and helicopters being able to land/take-off from two FATO's.

We have proposed deterministic models to estimate the theoretical capacity of each of the subsystem: FATO and stands. The lowest capacity value among these subsystems is assumed to be the total system capacity.

The FATO capacity per day (10 hr period) is 220 landings per FATO. This number can be increased by inserting a take-off between any two landings without affecting the landing intervals.

The stand capacity results based on concept 2 (assuming worst case – A total of 8 number of stands)

- With a shutdown time of 0.5 hr the heliport can accommodate 128 flights/day, for every additional stand the system can accommodate 12-16 more flights.
- With a shutdown time of 2.5 hr the heliport can accommodate 25 flights/ day, for every additional stand the system can accommodate 2 more flights.

Preliminary results show the stand capacity is more likely to be critical than FATO capacity. Based on concept 2 with 8 parking stands the heliport can accommodate anywhere between 25-128 flights/day depending on the shutdown time of each operation/flight.

13.8.7.7 SUMMARY

CATEGORY	SITE 1 (DEEPWATER BASIN)	SITE 2 (LITTLE TAHITI)
OLS Obstacles	The proposed FATO orientation is free of obstacles. The terrain does not infringe the approach or take off surface	The OLS in the proposed direction for the FATO in site 2 is not infringed by the terrain. However, there are dense trees/ vegetation around this site which infringes the OLS and must be trimmed or removed to enable heliport operations at Little Tahiti.
Environmental	The environmentally sensitive areas are not found to be significantly impacted due to this proposal and likely to be manageable.	The Little Tahiti site is situated in a location surrounded by dense vegetation and requiring much work to have an operational heliport. Also, there are some portions in the site designated as environmentally sensitive. This requires further study/investigation to confirm impacts as part of the heliport proposal.
Noise	The tranquillity rating in Milford Sound township will be below 8 for 4 - 8 hours a day, depending on the proximity to the heliport. Noise levels, particularly on the Milford Sound Foreshore Walk point lookout and swing will require raised voice effort during helicopter take-offs and/or landings.	The tranquillity rating in Milford Sound township will be below 8 for 2 - 3 hours a day. While average and maximum noise level impacts from aircraft are like Site 1, the Milford Sound Lodge and campervan parking area are likely to require raised voice effort to communicate during helicopter take-offs and/or landings, which is not experienced for Site 1.

13.8.7.8 NEXT STEPS

Key assumptions have been developed for this feasibility assessment. During the next stage of the project, it is recommended that the following works are undertaken:

- Study the applicability of existing flight circuit with the proposed approach/take-off orientation of the helipads (FATO).
- Undertaking specific research for using/modifying the TRAPT for Milford Sound based on the research undertaken at Aoraki Mt Cook.
- Noise monitoring to quantify the existing noise environment with and without aircraft.
- Undertake further computational noise modelling to include detailed flight paths of both scenic flights and transfers (such as between Queenstown and Milford Sound), different makes/models of aircraft used, taxiing of aircraft, non-helicopter operational noise.
- Noise modelling/monitoring of the existing helicopter/fixed wing noise generated by the existing airport to compare to the proposed future heliport(s).

13.8.8 TRANQUILITY ASSESSMENT

Based on discussions with the Department of Conservation (DoC), the metric to assess noise impacts within National Parks in New Zealand (to determine whether the outcomes of the National Parks Act and Conservation Act are being met) is the tranquillity rating. The tranquillity rating is a single number on a scale of 1 – 10 where 0 is a non-tranquil environment (no natural features, loud anthropogenic noise, and high levels of litter/graffiti), and 10 is a highly tranquil space (low anthropogenic noise and all-natural features, such as a bush walk).

The Tranquillity Rating and Prediction Tool (TRAPT) developed in the UK.

2 provides an objective tool to assess tranquillity by determining the level of natural features in a landscape, the anthropogenic noise level, and any moderating factors (such as litter, graffiti, etc.) based on subjective responses of people. While other tools (particularly in soundscape) have been developed, this tool is preferred by DoC as it allows quantification of the tranquillity of the environment.

A pilot study to determine a New Zealand National Park-specific TRAPT was developed in 2020.

3. This study concluded that a Tranquillity Rating of 8 or higher meant that “tranquillity levels are considered excellent” which meant anthropogenic noise was required to be at or lower than 32 dB LAeq, T.

A Tranquillity Level of 8 has been adopted for this assessment.

The noise modelling parameters for undertaking the tranquillity assessed at both the Deepwater Basin and Little Tahiti heliports are presented in Table 66. This data was sourced from DoC.

Table 66: Tranquillity rating aircraft noise modelling parameters

PARAMETER	DESCRIPTION
Aircraft Movement	1 movement
Flight path	Given in Figure 3
Breakdown of aircraft	Airbus H125 (formally AS350 Squirrel)
Helipad location	Deepwater Basin: -44.6763467, 167.92567 Little Tahiti: -44.6814415, 167.95277
Natural and Contextual Features	100%
Moderating Factor	0

The typical route of tourism helicopters was used in the noise modelling. 3D GPS coordinates were provided by the helicopter operators using a GNSS receiver which had a 10-second sampling rate with an accuracy of 2-5 metres. These arrival and departure tracks for each heliport location are provided in Figure 76.

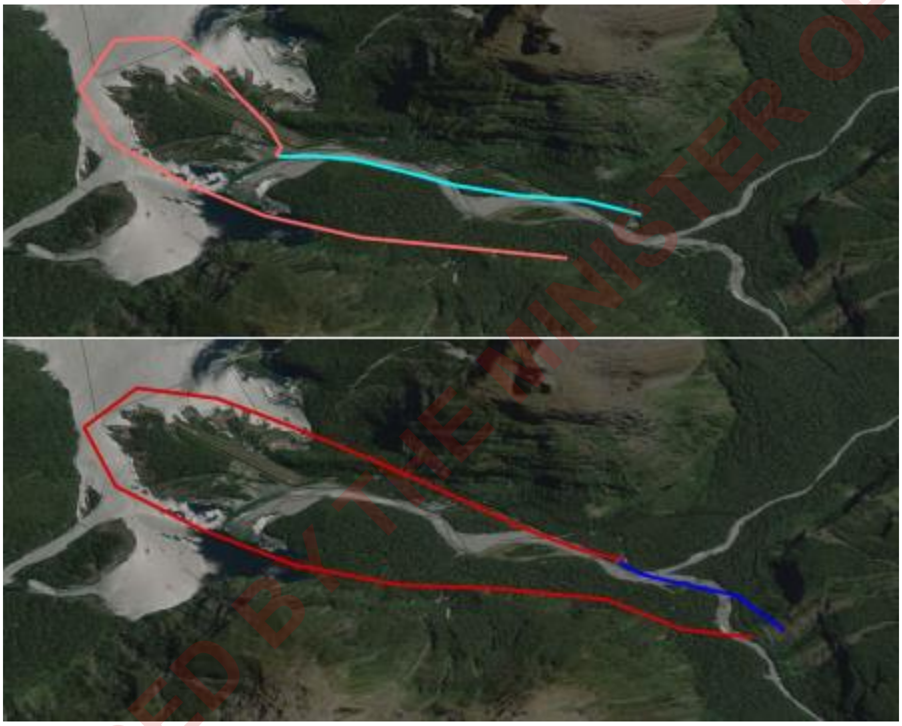


Figure 76: Deepwater basin (top) and Little Tahiti (bottom) flight paths for Tranquillity rating assessment

The time above contours provided by DoC are presented in Appendix D for Deepwater Basin and Little Tahiti of the Heliport assessment report. The time-above contours show the time (in minutes) the area of land is exposed to noise levels above 32 dB LAFmax (determined to be the highest level of noise before the Tranquillity Rating is reduced below 8) for a helicopter flight (arrival and departure). Therefore, any land within the contours presented in Appendix D will experience parts of the day where tranquillity is less than 8.

Based on the noise contours provided by DoC:

— At the marina to the south and the hotel to the north of the proposed Deepwater heliport, a tranquillity rating of less than 8 is predicted for 2 minutes of each helicopter flight. Based on a total of 128 flights per day, this location will experience over 4 hours of Tranquillity less than 8 (40% of a 10-hour day).

- The point of the Milford Sound Waterfront Walk (near the swing and lookout) is expected to have a tranquillity rating of less than 8 for 3 minutes of each helicopter flight. This equates to over 6 hours where the tranquillity will be less than 8.
- The two lookout areas adjacent to the main waterfront carpark are predicted to experience noise levels above 32 dB LAFmax for less than 2 minutes of each helicopter flight. For the 128 helicopter movements, this equates to approximately 3 hours and 50 minutes where the tranquillity rating will be less than 8.
- The tranquillity rating at Bowen Falls is predicted to be degraded below 8 for 2 minutes for each helicopter flight. Assuming 128 flights a day, Bowen Falls will have a tranquillity rating of less than 8 for 4 hours a day.
- Milford Track Trailhead/Sandfly Point including the building in this location is predicted to receive noise levels greater than 32 dB LAFmax for 1 minute for each helicopter flight. Therefore, for over 2 hours a day, this area will have a Tranquillity rating of less than 8.
- No area within Milford Sound will have a Tranquillity Rating of 8 or higher for a full day. • This analysis assumes that there are 100% natural features in the landscape. The landscape element of the TRAPT equation may already result in lower Tranquillity Rating levels over parts of Milford Sound due to the current buildings, carparks, structures, boats, and aircraft in the environment. The quantification of this reduction is outside the current scope of this assessment.

13.8.8.1 LIMITATIONS OF STUDY

Where flight numbers, distribution of day/night flights, different approach/departure tracks and profiles, and/or types of helicopters change from that used, the noise contours will change.

Noise has been assessed from aircraft arriving and departing the site only. No analysis has been undertaken on noise from the wider side (idling aircraft at gates, noise from vehicles on internal roads, etc.), or the construction of the site.

The impacts on the environment also depend on the change in noise level from the existing noise environment. No noise modelling has been undertaken of the existing airport at this stage. To provide a better indication of the effects, noise from the selected heliport option should be compared against the existing noise of the airport.

The day-night average noise level is an average 24-hour noise level, and the tranquillity assessment is averaged over a 10-hour operating window. Consideration will need to be given to any likely future operating rhythm to test the effect of 'pulsing' due to aircraft arrivals and departures synching with boat movements. The maximum noise levels and tranquillity analysis are based on the noise contours produced by DoC. No verification of these contours and/or noise levels have been undertaken.

The assessment of tranquillity is based on research undertaken in Aoraki Mt Cook National Park. This study is a pilot study with a limited dataset. It was also undertaken in a different National Park which may not produce the same dose-response as Milford Sound or Fiordland National Park. It is recommended that the Aoraki Mt Cook work is reproduced in Milford Sound.

The tranquillity rating assessment assumes 100% natural and contextual features and no moderating factors. Milford Sound includes tourism development, and therefore in some areas, the tranquillity rating may be lower.

This study assesses the potential noise impacts from two separate heliport options proposed when the existing Aerodrome is removed. A single option will be developed further in later design stages, and therefore each heliport has been assessed individually.

13.8.8.2 FURTHER WORK

This analysis has been undertaken to inform the feasibility of a heliport in Milford Sound and site selection if a heliport is considered. When a site is selected, the following works will need to be undertaken during developed design and consenting:

- Updating the New Zealand TRAPT for Milford Sound. This will build on the research within and determine the appropriate noise level which would result in a tranquillity rating of less than 8. This will require a site visit to undertake noise measurements and recordings, and public survey and laboratory listening room surveys.
- Noise monitoring to quantify the existing environmental noise with and without aircraft operating.
- Undertaking detailed computational noise calculations of the proposed activity including:
- Detailed flight paths of tourism operators for scenic flights and transfers (such as between Queenstown and Milford Sound). • Different helicopters make/models used.
- Taxiing of helicopters.
- Comparison of the proposed helicopter noise to the existing helicopter and/or fixed-wing noise generated by the existing airport.

13.9 VERTICAL INFRASTRUCTURE

PIOPIOTAHI COMMERCIAL FISHING PORT DEEPWATER BASIN EXPERIENCE HUB.

- No Post disaster function. Single level 300m2.
- Standard Structure. IL2. Construction is feasible.

14 STAGE 3 – COST ESTIMATES

14.1 BACKGROUND

The Milford Opportunities Project launched an ambitious and innovative masterplan for Milford Sound Piopiotahi, the Milford corridor and the region surrounding it, in July 2021.

Masterplan concepts and recommendations were developed through research and engagement with the community, key stakeholders, national interests, and the New Zealand public. (Milford Opportunities Project: Masterplan, 2023).

WSP ENGINEERING WORK STREAM (STAGE 3)

The current engineering work stream phase (Stage 3) of work follows the Stage 2 works completed by others. The objective of this Stage 3 work is intended to build on the technical assessments carried out in Stage 2 and take them to the next level to establish a higher degree of certainty and the technical feasibility of the infrastructure proposals in the Masterplan. The stage 3 engineering workstream included deliverables from the following WSP NZ Ltd (WSP) disciplines: Statutory Planning, Natural Hazards, Environmental (land contamination), Sustainability, Climate Change, Geotechnical, Three Waters, Structural and Aviation (Heliport).

STAGE 1 REVIEW OF COST ESTIMATES

The Stage 1 review of cost estimates was delivered by WSP NZ Ltd (WSP) at the commencement of Stage 3 engineering work stream (November 2023). This review entailed updating the previous (May 2021) cost estimates to present day value using adjustment indexes from Waka Kotahi Adjuster website.

The Stage 1 cost estimation was developed from a PDF version of the Stantec, Stage 2 Infrastructure Assessment Report – Appendix 2.

Following acceptance of the WSP Stage 1 Cost Estimation Report, the Client provided a Microsoft Excel version of the previous Consultant's cost estimation, referred to as V5, this provided significantly more detail than was previously known about how the individual estimates were derived, it was also an updated and current version of the previous consultant's cost estimation.

STAGE 2 REVIEW OF COST ESTIMATES

Recommended options at each hub / node / short-stop have been considered throughout the Milford Opportunities Project (MOP) Stage 3 Infrastructure Engineering Feasibility Assessment, this information has informed the cost estimation process contained within this review.

For a detailed assessment, please refer to the "Stage 2 Review of Cost Estimates, Rev 3 – 19th June 2024".

15 SUSTAINABILITY/CARBON ASSESSMENT

The carbon assessment provides an estimation of emissions for proposed project infrastructure within the categories of Transport, Structures, 3 waters and facilities. The main tool used to complete the initial carbon assessment for Transport, Facilities and 3 waters assets is the Projects Emissions Estimation Tool (PEET) version 4.0, developed by Waka Kotahi, Auckland Transport (AT) and Kiwi Rail.

The report outlines infrastructure lifecycle management (LCA) stages from best practice frameworks such as PAS 2080 2023: Carbon Management in Infrastructure. The assessment aligns with the LCA stages where information was available, and provides an estimation of the carbon emissions by material type, and at each LCA stage as summarised below:

Table 67: LCA module stage

Infrastructure Type	LCA Module Stage			
	A: Construction before use	B: Operation and Maintenance	C: End-of-life	D: Beyond building lifecycle
Transport	1,545 tCO2e	2691 tCO2e Across 50-year lifecycle for parking and carriageway rehab and refurb	2,763 tCO2e for parking and carriageway rehab and refurb	-
3 Waters	84 tCO2e Requires further quantification	Requires further quantification	Requires further quantification	-
Facilities	4,419 tCO2e	711 tCO2e Across 50-year lifecycle for track maintenance	366 tCO2e for track maintenance	-

The carbon assessment for the Structures assets was completed using building lifecycle assessment tools LCAquick, One Click LCA, and a WSP building assessment tool. A range of emissions were calculated for different design options detailed in the report. Results for Structures showed Modules A1-A3 (Material emissions), B1 (refrigerant leakage), and B6 (Operational energy) were most carbon intensive.

The material hotspots identified in the carbon assessment include aggregate, asphalt and sealing chip, cut to waste, steel, concrete, fibercement, and construction fuel. These are found across the four infrastructure types and should further assessed in subsequent assessments and included in design and optioneering.

Not all items within the cost estimate were quantified as an estimate of carbon emissions. The items not quantified will add to the emissions profile of this project, and there is potential that some of these items will have material impact on the emissions profile. Examples of these include the proposed cable car, the wastewater treatment facilities and toilets, and the use of helicopters during construction in remote areas. Information on the details required are included within this report and should be quantified in the next update of the carbon assessment.

15.1.1 INFRASTRUCTURE CARBON ASSESSMENT RESULTS

The carbon assessment has been broken down into four different categories related to the proposed infrastructure types. These categories were reviewed during a meeting with the WSP Project Manager and MOP's Senior Project Manager for Infrastructure Engineering and agreed as an appropriate categorisation of the emissions assessment based on the cost estimate data breakdown,

- Transport
- Structures
- 3 waters
- Facilities

15.1.1.1 TRANSPORT

The items quantified for the transport emissions assessment include asphalt (asphaltic concrete, hot mix asphalt, 5% virgin bitumen), aggregate, cut-to-waste (removed material from existing site), and sealing chip. The proposed large areas of pavement and carpark surfacing, and therefore large areas of pavement and carpark surfacing, and therefore large areas of asphalt, result in the highest material emissions for transport related materials. Asphalt has a higher emissions factor (the rate at which an activity releases greenhouse gases) than aggregate.

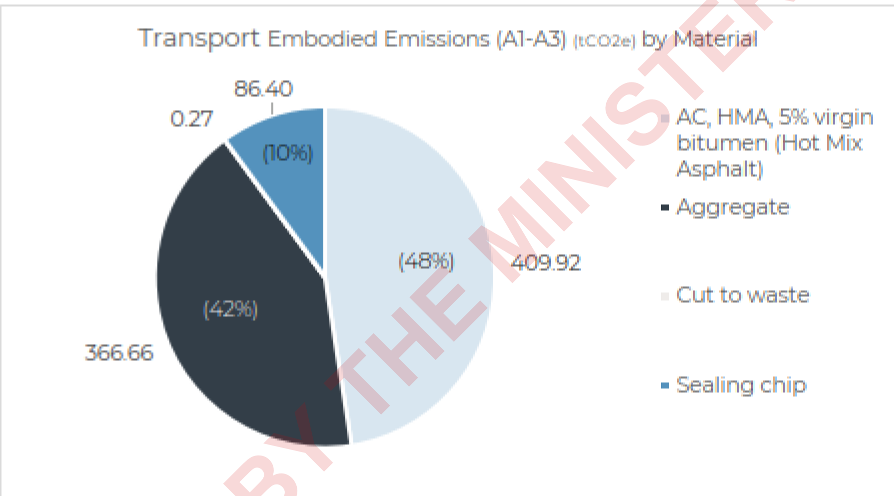


Figure 77: Transport category emissions by material

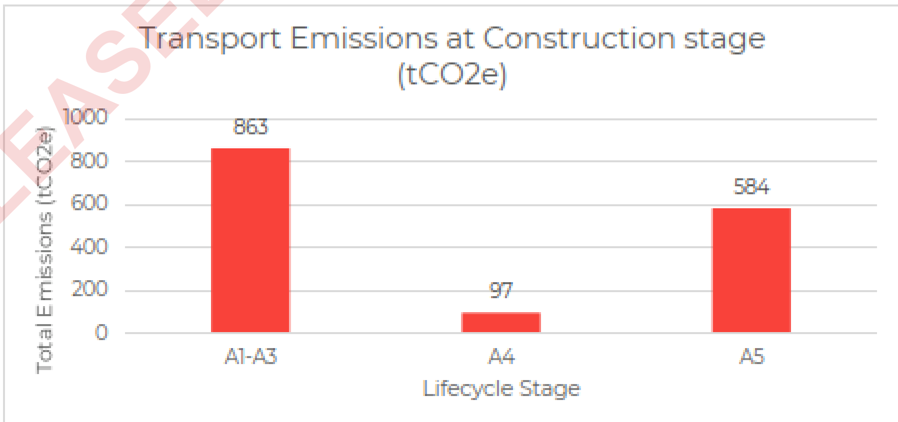


Figure 78: Transport category emissions by LCA stage (A1-A5)

The highest emissions for the materials quantified come from the embodied emissions of the materials themselves (A1-A3). That is, the emissions associated with material extraction, manufacturing, and transport to site. The second highest lifecycle stage is the fuel used on site for construction activities (A5).

15.1.1.2 FACILITIES EMISSIONS

The facilities assessed include walking tracks, boardwalks, viewing platforms, bridges, and pavilions. The estimate of carbon emissions includes the embodied emissions of the associated materials, and the earthworks required for each type of facility.

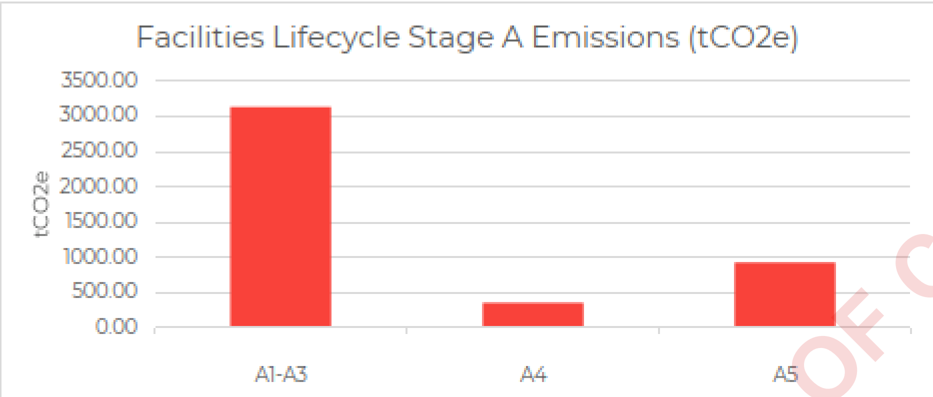


Figure 79: Facilities category emissions by LCA stage (A1-A5)

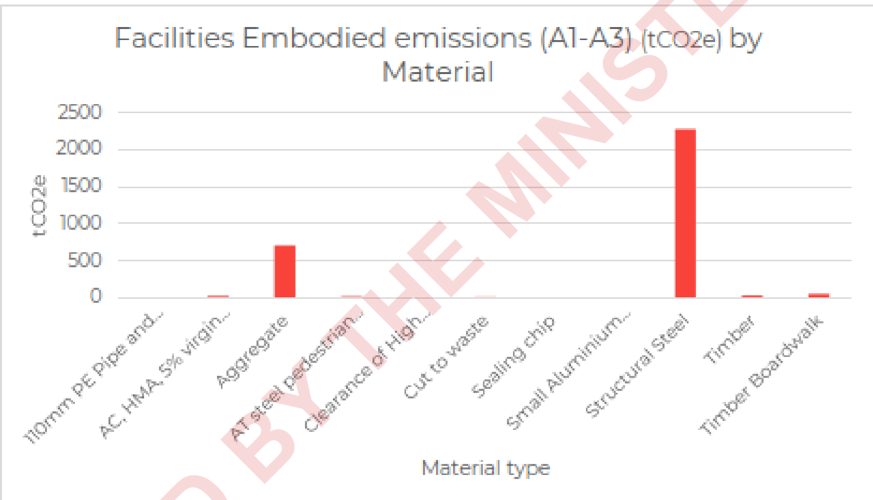


Figure 80: Facilities category embodied emissions by material

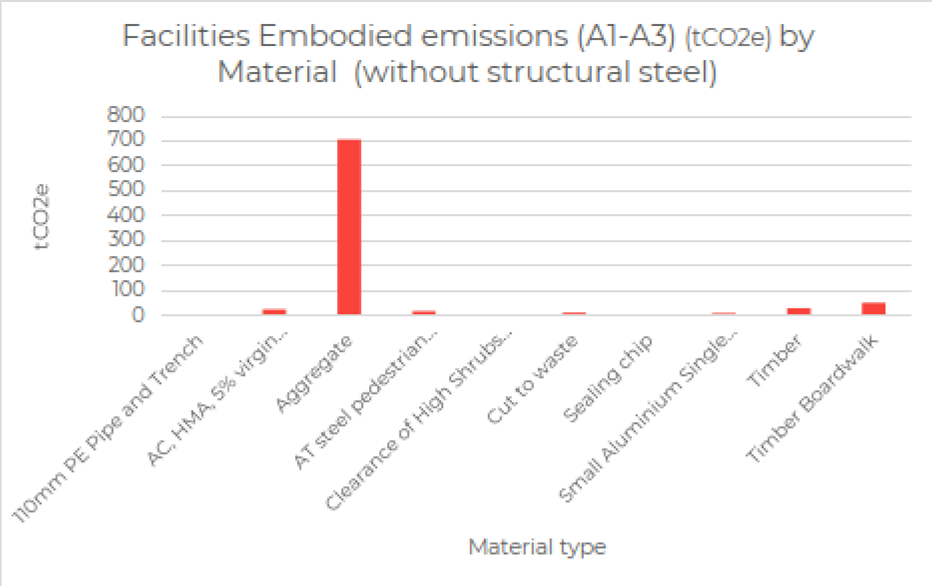


Figure 81: Facilities category embodied emissions by material (without structural steel)

15.1.1.3 THREE WATERS EMISSIONS

The emissions for three waters related activities categorised by lifecycle stages and material breakdown are shown in the figure below. The items quantified for the 3 waters emissions assessment include cover pipelines, manholes and conveyance assets. The results show the highest emissions are from the embodied emissions of the materials themselves. In the PEET 4.0 Tool, the emissions quantification of manholes is based on the following assumption: Concrete manhole with standard 600mm diameter hole, 12m riser and flanged base with cast iron lid and reinforcing.

As identified in the Exclusions section, the wastewater treatment components have not been quantified due to the lack of detail on the asset size, material composition and quantities.

The three waters category items that were quantified in this assessment:

- Piopiotahi wastewater pipelines and manholes
- Knobs Flat experience hub potable water pipelines, wastewater pipelines and manholes
- Knobs Flat and Super Track head toilet blocks (only the slab base estimated)
- Te Anau Visitor Hub wastewater pipelines and manholes, potable water pipelines

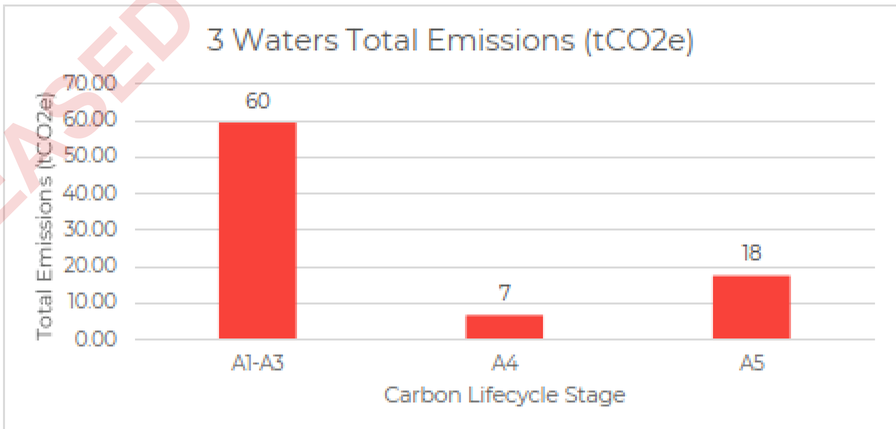


Figure 82: Total lifecycle emissions for Three Waters Infrastructure

Based on the estimated items within the 3 waters category, manholes have the highest emissions across the 3 waters emissions profile. This should be expanded in the next stage of the carbon assessment to include a more comprehensive estimate of the project's proposed wastewater infrastructure emissions.

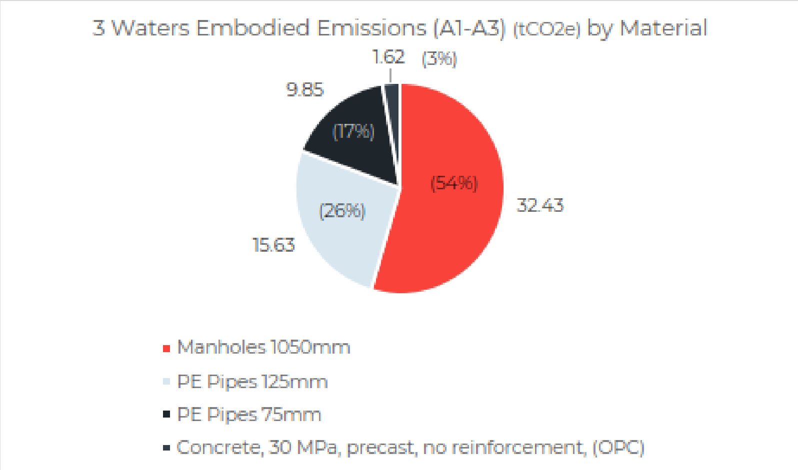


Figure 83: Three waters embodied emissions

15.1.1.4 OPERATION AND MAINTENANCE STAGE – LCA MODULE B

The results of the quantified transport infrastructure and facilities emissions at the operation and maintenance stage show total emissions from resealing and rehabilitation activities for a 50-year asset lifecycle. Transport infrastructure related activities had the highest maintenance emissions due to the estimated resealing and rehabilitation for large parking and pavement areas required across the lifecycle.

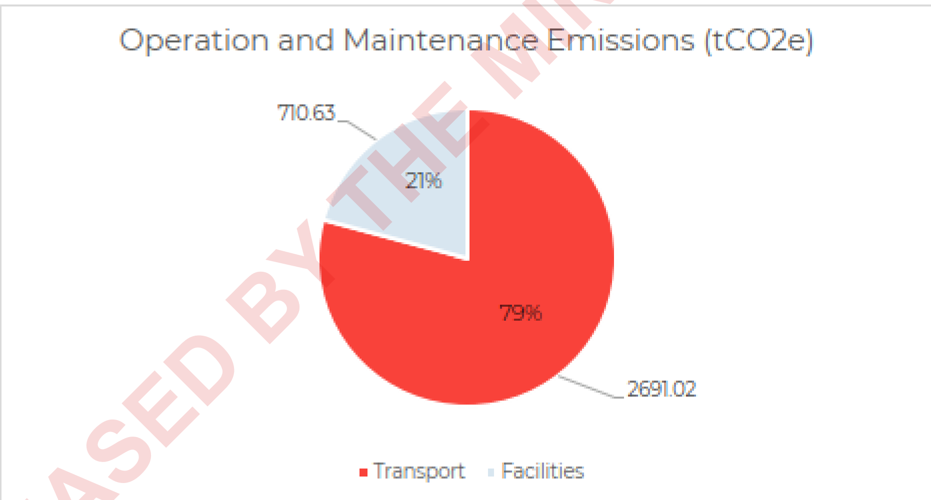


Figure 84: Total emissions for Operation and Maintenance of transport and facilities categories over the 50-year life cycle

15.1.1.5 END OF LIFE STAGE – LCA MODULE C

The results of the quantified transport and facilities emissions at the end-of-life stage show emissions for the end-of-life stage show emissions for the end-of-life material transport of resealing and rehabilitation activities across a 50-year asset lifecycle. Specifically, these emissions result from the transport of waste and materials to the end-of-life facility and represent the fuel used to transport material offsite. The project's activities relating to the transport category have a higher contribution to the overall emissions profile, likely due to the quantity of transport-related material required (as per the cost estimate) being significantly higher than facilities. The number of trips of material requiring offsite disposal will also result in higher end-of-life emissions.

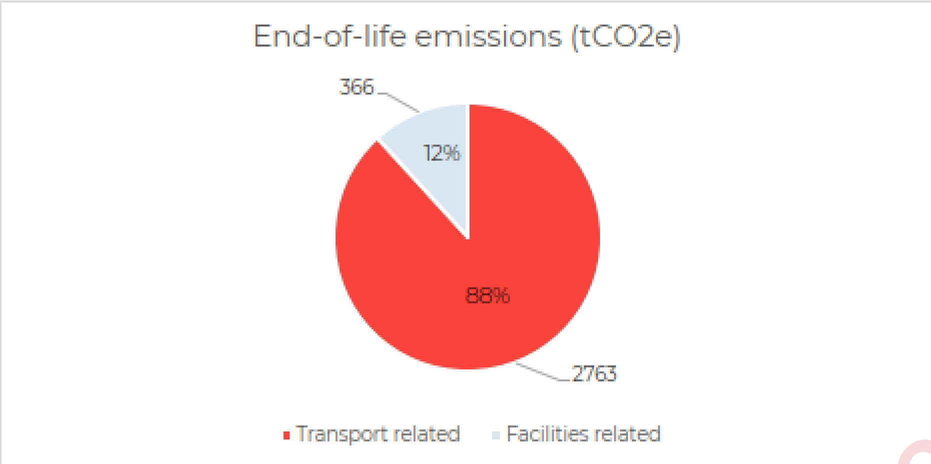


Figure 85: End-of-life emissions for transport and facilities categories

15.1.2 STRUCTURES

15.1.2.1 SUMMARY OF KEY MATERIAL INPUTS

Table 68: Structures key material inputs

Key Inputs Material Category	Concrete	Reinforcement Steel	Structural Steel	Softwood Timber	CLT	LVL	Timber Cladding	Insulation	Plasterboard	Rigid Air Barrier	Fibercement Cladding	Windows	Metal Roof Cladding
Substructure	X	X	X										
Super: EBF, MRF, Steel & Concrete	X	X	X										
Super: Timber & EBF	X	X	X	X	X								
Super: Concrete	X	X	X	X									
Super: Timber	X	X	X		X	X							
Building Envelope: Timber							X	X	X	X		X	X
Building Envelope: Fibercement								X	X	X	X	X	X

15.1.2.2 OPERATIONAL CARBON

The energy consumption is based on the use of heat-pump for both heating and cooling of a typical 3 storey-office building, according to 2023 Clause H1 rules with thermal bridges removed. As such, the operational carbon resulting from the estimated energy demand, would be around 100 kgCO2e/m2. This number can increase significantly for different type of buildings. Evidence obtained from previous projects indicates that these energy demand numbers can increase dependent on the activity within the building, for example to an average of 260 kgCO2e/m2 for educational buildings and 400 kgCO2e/m2 for health centres.

Based on these previous studies, removing the thermal bridges, and using energy efficient systems have the most important roles in reducing operational energy use and consequent emissions. The number (100 kgCO2e/m2) can be increased up to 950 kgCO2e/m2 with thermal bridges and the use of a boiler for heating and air conditioning for cooling.

15.1.2.3 RESULTS AND DISCUSSION

The results of carbon footprint estimations with 10% contingency per GFA of the buildings are presented in the following matrix tables for different design options. The numbers show a rough estimation of kgCO2e/m2 for each scenario. The results cover modules A to D including biogenic carbon. The green colour shows better, and red colour shows the worse options.

Table 69: Building envelope emissions by material – 6 storey

6 Storey	Building Envelope	Timber Cladding		Fibercement Cladding	
	Sub/Super	base isolation	pile and ground beam	base isolation	pile and ground beam
	Steel & Concrete	307	376	317	386
	MRF	337	406	347	416
	EBF	298	367	308	377

Table 70: Building envelope emissions by material – 3 storey

3 Storey	Building Envelope	Timber Cladding			Fibercement Cladding		
	Sub/Super	raft slab	concrete pile	screw pile	raft slab	concrete pile	screw pile
	EBF	529	488	403	541	501	415
	MRF	532	492	406	545	504	418
	Concrete	755	714	628	767	726	640
	timber	218	177	91	230	189	103
	timber & EBF	393	352	266	405	364	278

Table 71: Building envelope emissions by material – 2 storey

2 Storey	Sub & Super	Building Envelope	Timber Cladding	Fibercement Cladding
	EBF & Raft Slab		131	150

Table 72: Building envelope emissions by material – 1 storey

1 Storey		Range	
	Steel & Raft Slab & Metal Cladding	667	800

According to the tables above, EBF superstructure with base isolation and timber cladding in 6 storey building scenarios; and timber superstructure with screw piles and timber cladding in 3 storey building scenarios; and EBF with raft slab and timber cladding in 2 storey buildings have the lowest carbon impact. The lowest carbon emission numbers were expected from scenarios with timber, then timber/steel hybrid designs.

15.1.3 DISCUSSION AND CARBON REDUCTION OPPORTUNITIES

15.1.3.1 MATERIAL HOTSPOTS

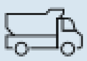
Table 73: Key material hotspots by infrastructure

KEY MATERIAL HOTSPOTS CATEGORY	TRANSPORT	FACILITIES	3 WATERS	STRUCTURES
Aggregate	X	X		
Asphalt and Sealing Chip	X			
Cut to Waste	X	X	X	X
Structural Steel		X		
Superstructural Steel				X
Steel Bridge		X		
Construction Fuel	X	X	X	X
Concrete Manholes			X	
Concrete Piling				X
Fibercement				X

There are several factors that can reduce the emissions in these hotspots, including reusing materials on site, sourcing local materials, efficient design, and construction processes, and exploring material alternatives.

15.1.3.2 CARBON REDUCTION OPPORTUNITIES

Transport



-Reuse aggregate on site and/or source as local as possible

-Reuse bitumen from the existing runway and paved areas that would otherwise be cut to waste. This would also reduce the virgin fill material required for new activities.

-Investigate aggregate substitutions such as glass, rubber crumb and plastics

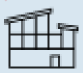
-Increase materials with higher % of SCMs and RAP where feasible

-Use a grid connection where feasible or on-site solar considered for stationary plant

-Assess bio-bitumen processes for circular economy using waste/recovered products

Figure 86: Carbon reduction opportunity for Transport.

Structures



-Use timber where possible, steel/timber hybrid scenarios where timber is not feasible.

-Reduce the use of concrete.

-Specify steel with lower impact manufacturing process where possible.

-Value engineering the super and substructure

-Specify more durable and low maintenance materials

-Increase the operational efficiency and use of low impact refrigerants

- Removing the thermal bridges and using energy efficient systems

Figure 87: Carbon reduction opportunity for Structures.

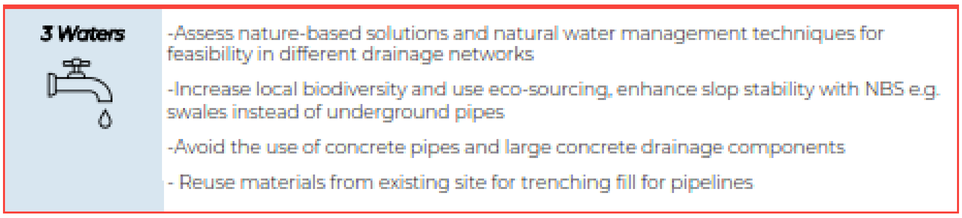


Figure 88: Carbon reduction opportunity for 3waters.

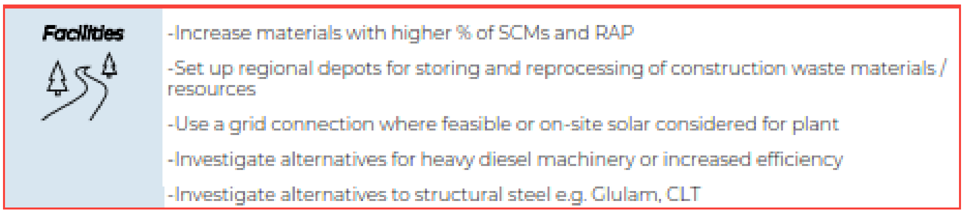


Figure 89: Carbon reduction opportunity for Facilities.

16 WALKING AND CYCLING FEASIBILITY ASSESSMENT

16.1 WALKING AND CYCLING CRITICAL STRUCTURES

Table 74: Walking and cycling proposed structures.

ITEM	SITE NAME	STRUCTURE TYPE	COMMENTS/CONSIDERATIONS
1	Lower Upokororo Eglinton River	Bridge – suspension - 125m span	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 cost and disturbance of 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.

ITEM	SITE NAME	STRUCTURE TYPE	COMMENTS/CONSIDERATIONS
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. 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 Cascade Creek Ō-Tāpara 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.

ITEM	SITE NAME	STRUCTURE TYPE	COMMENTS/CONSIDERATIONS
8	Melita Bluff gantry(s) at Cascade Creek Ō-Tāpara 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 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 is 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 cycleway 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.

ITEM	SITE NAME	STRUCTURE TYPE	COMMENTS/CONSIDERATIONS
12	Sheer down Peak gantry	Bluff bridge – Gantry propped and braced off rock with rock anchors/bolts – 175m.	Technically feasible and is like 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 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.

ITEM	SITE NAME	STRUCTURE TYPE	COMMENTS/CONSIDERATIONS
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.

16.2 NATURAL HAZARDS

16.2.1 PART A ASSESSMENT

CLASS 1: TRACKS

Initial screening and assessment of the identified walking tracks in the lower Eglinton Valley including Lake Mistletoe Track, Eglinton River Trail, and Mirror Lakes Walk have determined that the trails are located on relatively flat terrain at lower elevations with no major changes in slope. Flooding is a concern at these sites but exposure times along river/stream channels is assessed as being relatively low due to short or controlled crossings.

Flooding is also a potential hazard at the Chasm track; however, recurrence probability is assessed as low due to the elevation of the track.

The proposed tracks at the Divide in the upper Eglinton Valley are likely to be susceptible to possible rockfall, landslides, and tree slides, however, the terrain is well forested and previous occurrence of these hazards has not been identified, suggesting a lower hazard recurrence interval.

In Milford Sound Piopiotahi the Barren Peak Spur Track is the only track assessed as Class 1. This is due to its elevation above any flooding or tsunami sources, and lack of identified immediate rockfall/landslide sources.

Class 1 tracks are not considered to present a significant risk to potential trail users and workers and as such no further risk assessment is required for these tracks and trails.

CLASS 2: TRACKS

On the Milford Road, Te Huakaue Knobs Flat Short Walks, Key Summit to Ō-Tāpara Cascade Creek Track, Hinepipiwai Lake Marian Falls Loop Track, the Chasm to Cleddau Horse Bridge Track, and the Milford Sound Lodge to Tūtoko River Bridge Track are all considered to pass through or be located within hazard footprints that pose a risk to track/trail users. These tracks are assessed as having a maximum site hazard Class 2.

Visitors on the Te Huakaue Knobs Flat Short Walks and Key Summit to Ō-Tāpara Cascade Creek Track are likely to be exposed to medium probability flooding, debris flow, and rockfall hazards.

Based on discussions with the MOP team and assessing visitor user types for these areas, the visitor groups are anticipated to spend 30 to 180 minutes in the hazard-prone areas.

Visitors on the Chasm to Cleddau Horse Bridge Track are likely to be exposed to rockfall, debris flow, flooding, and avalanche hazards. Sections of the track traverse through steep undulating terrain prone to rockfall. There are several active stream channel crossings which are prone to flooding and debris flow. Sections of the track are near to or above the tree line where avalanches are known to occur from the southeast facing slopes west of the track. Visitor typology for this trail is likely to be predominately DV. Based on discussions with the MOP team and assessing visitor user types for these areas, the visitor groups are anticipated to spend 30 to 180 minutes in the hazard-prone areas.

Visitors on the Milford Sound Lodge to Tūtoko River Bridge Track are likely to be exposed to medium probability flooding from the Cleddau and Tūtoko Rivers. Visitors are also anticipated to spend 30 to 180 minutes in flooding-prone areas.

In Milford Sound Piopiotahi the Hine-te-awa Bowen Falls – Upper Walking Tracks are Preliminary assessed as Class 2. This is due to the tracks crossing potential rockfall and landslide areas and the area being prone to tree slide. Tsunami risk is assessed as very low for these tracks due to the elevation of the track above the sound.

CLASS 3: TRACKS

Along the Milford Road four tracks are assessed as having a maximum site hazard Class of 3: the Countess Range Track, Gertrude Valley Loop Track, Hinepipiwai Lake Marian Loop Track, and the Cycle Trail.

The hazard and exposure on each of these tracks is detailed below. Exposure to each hazard is defined as the estimated time it takes for a visitor to pass through hazard areas.

In Milford Sound Piopiotahi the Hine-te-awa Bowen Falls – Lower walking tracks, and the Cleddau Delta tracks are also assessed as Class 3A due to tsunami risk, the dominant hazard for this area of the site.

Class 3A sites are considered to present a Significant or Substantial risk rating based on the GNS methodology and warrant further Basic or Advanced Risk Assessment. As such these sites are covered in more detail as part of the Part B Basic Analysis risk assessment reporting that will follow this Part A analysis.

16.2.2 PART B: ASSESSMENT

16.2.2.1 TSUNAMI

For tracks in the Milford Sound near the shoreline (Cleddau Delta walking tracks, Hine-te-awa Lower Bowen Falls Track) visitor and worker exposure to tsunami is likely to be less than at point sites, however, the risk is still considered to be ‘moderate’ to ‘substantial’.

The Milford Sound Lodge to Tūtoko River Suspension Bridge Track is likely to only be impacted by the largest tsunami events and exposure is low. Hence, we consider tsunami risk here to be ‘low’ to ‘moderate’.

16.2.2.2 LANDSLIDE

Visitors and workers on walking and cycling tracks in the MOP are exposed to landslide risk. Table 75 describes landslide hazard at each track in terms of estimated volume, runout potential (P(T:H)), vulnerability (V(D: T)), and probability (P(H)). As we have classified landslide probability as a range in this report, P(H) is given with a lower and upper value.

The 'most likely' landslide event considers smaller failures with less consequence than the 'maximum credible' landslide event at each site.

The findings below do not account for existing mitigation. This is deemed to be conservative, however, risk mitigation options at several of these tracks should be explored and evaluated.

Table 75: Estimated most likely and maximum credible landslide events at each track

Site	Most likely event					Maximum credible event				
	Volume class	$P_{(T:H)}$	$V_{(D:T)}$	$P_{(H)}$		Volume class	$P_{(T:H)}$	$V_{(D:T)}$	$P_{(H)}$	
				Lower	Upper				Lower	Upper
Countess Range Track	2	0.01	0.8	5.0E-02	5.0E-01	6	1	1	1.0E-04	1.0E-03
Gertrude Valley Track	2	0.1	0.8	5.0E-02	5.0E-01	6	1	1	1.0E-04	1.0E-03
Hinepipiwai Lake Marian Loop Track	3	0.1	0.8	1.0E-02	5.0E-02	6	0.75	1	1.0E-04	1.0E-03
Te Anau Downs to the Divide Cycle Trail	3	0.1	0.8	5.0E-02	5.0E-01	6	0.75	1	1.0E-04	1.0E-03
Te Huakaue Knobs Flat Short Walks	3	0.1	0.8	1.0E-02	5.0E-02	6	0.75	1	1.0E-04	1.0E-03
Gunn Nature Trail	3	0.1	0.8	1.0E-02	5.0E-02	6	0.75	1	1.0E-04	1.0E-03
Key Summit to Ōtāpara Cascade Creek Track	3	0.1	0.8	1.0E-02	5.0E-02	6	0.75	1	1.0E-04	1.0E-03
The Chasm to Cleddau Horse Bridge Track	3	0.1	0.8	5.0E-03	2.0E-02	6	0.75	1	1.0E-04	1.0E-03
Milford Sound Lodge to Tutoko River Bridge Track	3	0.02	0.8	1.0E-03	1.0E-02	7	0.5	1	1.0E-04	1.0E-03
Hine-te-awa Lower Bowen Falls pontoon and tracks	3	0.2	0.8	5.0E-02	1.0E-01	7	1	1	1.0E-04	1.0E-03
Hine-te-awa Upper Bowen Falls tracks	3	0.2	0.8	5.0E-02	1.0E-01	7	1	1	1.0E-04	1.0E-03

Table 76: Visitor (IRPD) and worker risk (AIFR) for landslides on tracks in the MOP. *Exposure (P(S:T) to each landslide event has been estimated for each entire track. *Combined includes both the most likely and maximum credible events.

Site	P(S:T) – total*		IRPD – combined*		P(S:T) -total*		AIFR – combined*	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Countess Range Track	5.7E-05	3.4E-04	2.9E-08	1.7E-06	3.0E-03	1.8E-02	1.5E-06	8.9E-05
Gertrude Valley Track	2.3E-06	5.7E-05	9.4E-09	2.3E-06	1.2E-04	3.0E-03	4.9E-07	1.2E-04
Hinepipiwai Lake Marian Loop Track	3.4E-04	3.4E-04	3.0E-07	1.6E-06	1.8E-02	1.8E-02	1.6E-05	8.5E-05
Te Anau Downs to the Divide Cycle Trail	3.4E-04	3.4E-04	1.4E-06	1.4E-05	1.8E-02	1.8E-02	7.3E-05	7.3E-04
Te Huakaue Knobs Flat Short Walks	2.3E-06	5.7E-05	2.0E-09	2.7E-07	1.2E-04	3.0E-03	1.0E-07	1.4E-05
Gunn Nature Trail	2.3E-06	5.7E-05	2.0E-09	2.7E-07	1.2E-04	3.0E-03	1.0E-07	1.4E-05
Key Summit to Ōtāpara Cascade Creek Track	5.7E-05	3.4E-04	5.0E-08	1.6E-06	3.0E-03	1.8E-02	2.6E-06	8.5E-05
The Chasm to Cleddau Horse Bridge Track	5.7E-05	3.4E-04	2.7E-08	8.0E-07	3.0E-03	1.8E-02	1.4E-06	4.2E-05
Milford Sound Lodge to Tutoko River Bridge Track	2.3E-06	5.7E-05	1.5E-10	3.8E-08	1.2E-04	3.0E-03	7.8E-09	2.0E-06
Hine-te-awa Lower Bowen Falls pontoon and tracks	5.7E-05	3.4E-04	4.6E-07	5.8E-06	3.0E-03	1.8E-02	2.4E-05	3.0E-04
Hine-te-awa Upper Bowen Falls tracks	5.7E-05	3.4E-04	4.6E-07	5.8E-06	3.0E-03	1.8E-02	2.4E-05	3.0E-04

Table 76 above presents the estimated IRPD and AIFR for tracks in the MOP.

Visitor risk (IRPD) is assessed as:

- 'moderate' to 'substantial' for the Gertrude Valley Track, Hinepipiwai Lake Marian Loop Track, Te Anau Downs to the Divide cycle trail, and the Hine-te-awa Bowen Falls Tracks,
- 'low' to 'moderate' for the Countess Range Track, Te Huakaue Knobs Flat Short Walks, Gunn Nature Trail, Key Summit to C Ō-Tāpara Cascade Creek Track, and the Chasm to Cleddau Horse Bridge Track,
- 'low' for Milford Sound Lodge to Tutoko River Bridge Track.

Worker risk (AIFR) is assessed as:

- 'moderate' to 'high' for the Te Anau Downs to the Divide cycle trail and the Hine-te-awa Bowen Falls Tracks,
- 'moderate' for Countess Range Track, Key Summit to Ō-Tāpara Cascade Creek Track, and Chasm to Cleddau Horse Bridge Track,
- 'low' to 'moderate' for the Gertrude Valley Track, Te Huakaue Knobs Flat Short Walks, and Gunn Nature Trail.

16.3 VERTICAL INFRASTRUCTURE

COUNTESS RANGE HUT TRAMPING HUT:

- 40 bed and 20 bed option for back country hut
- Location to be confirmed but will be remote.
- No post disaster function.
- Single level – 230 m2
- IL 2 Construction is feasible.
- No access from the road so dispensations from the full requirements of the New Zealand Building Code are likely to be acceptable.
- BCH/AS1 Acceptable solution for Backcountry Huts provides a means of compliance with the New Zealand Building Code.
- The Countess Range Hut (40 and 20 bunk options) tramping hut will fall within this category as it is proposed in a remote location.
- IL2. Construction is feasible.

16.4 THREE WATERS INFRASTRUCTURE

COUNTESS RANGE TRAMPING HUT

The Countess Range hut is proposed as either a 20 or 40 bed development with non-flushable toilets and rainwater supply as per other DOC huts. There will be limited access due to the remote nature of the proposed huts and septage is expected to be flown out via helicopter.

It is proposed to provide rainwater stored in tanks for dish washing.

The cost is assumed to be included in the Hut estimate provided by others (see Walking & Cycling Experiences report - Tim Dennis, 2024).

16.5 GEOTECHNICAL ENGINEERING - WALKING TRACKS

16.5.1 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.

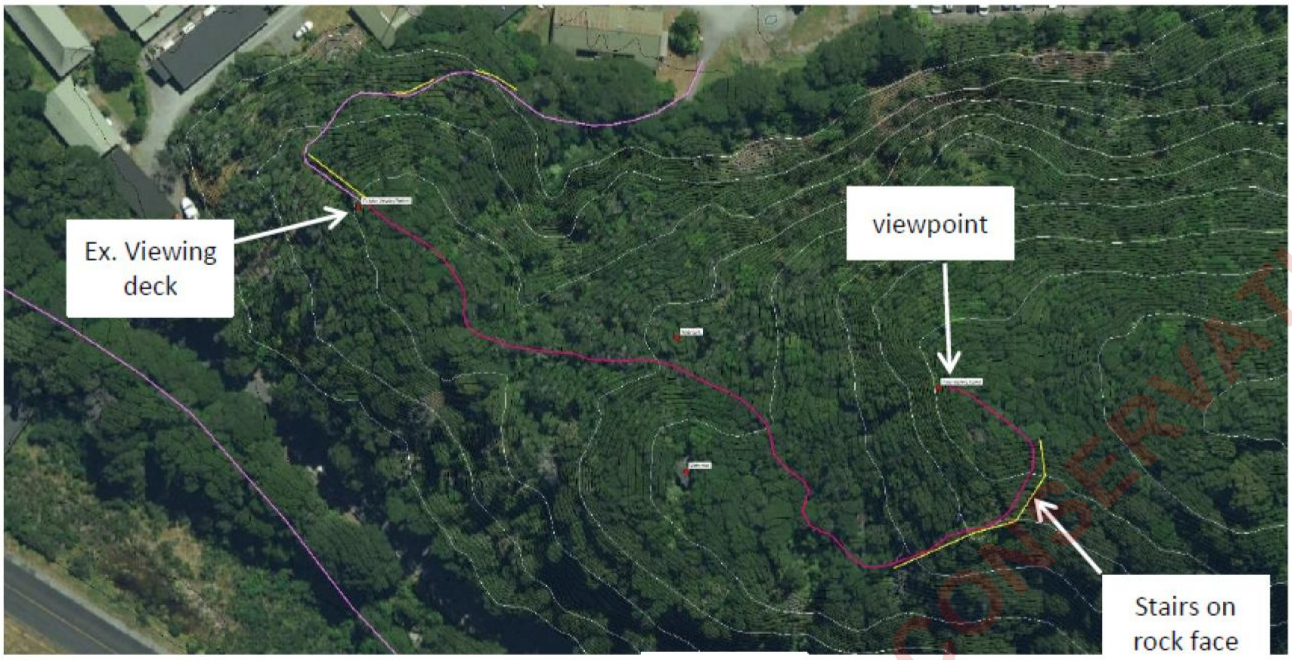


Figure 90: Barren Peak Spur Stairs and Viewing Platform location (Source: Southern Land)

The site has shallow topsoil 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.

16.5.2 LOWER HINE – TE AWA BOWEN FALLS ACCESS

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.

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 because 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.

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. Land span ramps would be necessary at each to accommodate tidal variation.

LOWER HINE-TE-AWA BOWEN FALLS ACCESS PONTOON CONCLUSION

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.

17 LIMITATIONS

Short Form Disclaimer/Limitation Statement

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Milford Opportunities Project in relation to the Engineering Feasibility report ('Purpose') and in accordance with the with the Contract SSI-O-406 dated 11 October 2023. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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