Milford Opportunities

VERTICAL INFRASTRUCTURE

DESIGN CONSIDERATIONS AND CONSTRUCTION FEASIBILITY

10 JUNE 2024

VERTICAL INFRASTRUCTURE – DESIGN CONSIDERATIONS AND CONSTRUCTION FEASIBILTY

Milford Opportunities

WSP
Invercargill
65 Arena Avenue
PO Box 647
Invercargill 9810, New Zealand
+64 3 211 3580
wsp.com/nz

REV	DATE	DETAILS
A	11/03/2024	DRAFT for Client approval
B	03/04/2024	Final
C	22/04/2024	Final – CCE2 replaces CCE1, reference to NHRA Part B Assessment
D	10/06/2024	Final – Reference to NHRA Part B Assessment and Te Huakaue Knobs Flat updated

	NAME	DATE	SIGNATURE
Prepared by:	Ian Sutherland	10/06/2024	
Reviewed by:	Steven McConway	10/06/2024	
Approved by:	Andrew Bruce	10/06/2024	

This report ('Report') has been prepared by WSP exclusively for Milford Opportunities ('Client') in relation to providing professional engineering advice on the design considerations for the vertical infrastructure proposed in the Milford Opportunities Masterplan Stage 2 Report ('Purpose') and in accordance with the Milford Opportunities Project – Transport & Infrastructure Stream Engineering Feasibility Assessment Contract Number SI-O-406 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.

10 June 2024

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Stage Two of the Milford Opportunities Project (MOP) has identified the infrastructure required at Piopiotahi Milford Sound, and Te Anau together with the infrastructure required along the access corridor to support and strengthen the visitor experience when travelling to and spending time at Piopiotahi Milford Sound. One of the seven pillars / values identified for the project is the need for the infrastructure to be resilient to change and risk. The structural design parameters to enable this are discussed in this report.

This report provides high level commentary on the structural feasibility and design considerations required for the erection and assembly of structures, buildings, and infrastructure components that extend above ground level described as vertical Infrastructure. Brief commentary on fire protection is also provided.

There are numerous examples of the types of structures proposed by the Milford Opportunities Project, that have been successfully constructed throughout New Zealand. However, the structures that will be located at Piopiotahi Milford Sound have very specific site conditions that may affect their feasibility. The structures that provide natural hazard refuges and have post disaster functionality and are therefore deemed to have an Importance Level of 4, will require further investigation and analysis to confirm if the detailed design can meet these requirements.

The natural hazards in the area are significant and providing life safety and post disaster functionality at Piopiotahi Milford Sound will be 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.

The vertical infrastructure identified in the Stantec Report titled Milford Opportunities Project Infrastructure Report dated 3 March 2021 has been considered.

The names and descriptions of the infrastructure used in the Stantec Report are replicated within this report.

Table 1 provides a summary of the high-level commentary for each site. Additional and more detailed discussion is included in the body of the report.

TABLE 1 – SUMMARY OF MOP INFRASTRUCTURE DESIGN CONSIDERATIONS/FEASIBILITY

MOP Ref	Site Name	Location	Type	Basic description
	Hine-te-awa Upper Bowen Falls Lift Access	Piopiotahi Milford Sound	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.
	Specific design considerations and comments			
	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 the terminal buildings before confirming if a lift is viable, when all inputs to the design are fully understood.			
Phub2	Piopiotahi Visitor Hub	Piopiotahi Milford Sound	Visitor centre and focal point for entire visitor experience.	1800m2 Multi-level
	IL4 – crowd activity. No post disaster function. However, it is proposed that the Visitor Hub 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. (See comments in Phub3 for further commentary).			
PHub3	Piopiotahi Visitor Accommodation	Piopiotahi Milford Sound	100 bed accommodation. Emergency refuge – post-disaster function.	1540m2 Multi-level
	IL-4 – post-disaster function. 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.[i] 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.			

<table>
<tr><td></td><td colspan="4">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.</td></tr>
<tr><td rowspan="2">Phub4</td><td>Piopiotahi Staff Accommodation</td><td>Piopiotahi Milford Sound</td><td>280-320 bed accommodation.

Emergency refuge – post-disaster function</td><td>Multi- level

5100m2</td></tr>
<tr><td colspan="4">IL4 – post-disaster function.

Footprint constraints will require multi-levels.

Fire Protection – early warning smoke/heat detection and sprinklers.

See PHub3 comments.</td></tr>
<tr><td rowspan="2">Phub7</td><td>Piopiotahi Arrival Structures</td><td>Piopiotahi Milford Sound</td><td>“Bus-stop” Shelter

No post disaster function.

A covered way with open side(s) for bus access.</td><td>Single level.</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td rowspan="2">PHub 8</td><td>Piopiotahi Arrival Structures</td><td>Piopiotahi Milford Sound</td><td>Covered walkway from bus shelter to Visitor Experience Centre.</td><td>Single level

Basic shelter from wet weather. Open one side.</td></tr>
<tr><td colspan="4">6,000 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 structure users will be expected to retreat to higher ground immediately after an earthquake.</td></tr>
<tr><td rowspan="2">Phub12</td><td>Piopiotahi Wastewater Services</td><td>Piopiotahi Milford Sound</td><td>Structures associated with the WWTP.

Post-disaster function</td><td>Single level plantroom(s) and treatment pipework.</td></tr>
<tr><td colspan="4">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.</td></tr>
</table>

Phub13	Piopiotahi Water Services	Piopiotahi Milford Sound	Structures associated with the 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.			
Phub14	Piopiotahi Power Services	Piopiotahi Milford Sound	Structures associated with the Power Services Turbine and generator house. Intakes and penstocks Post-disaster function	Single level plantroom(s).
	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. See PHub12 for additional comments about resilience.			
PHub16	Piopiotahi Viewing Deck Walkway	Piopiotahi Milford Sound	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.			
PDel2	Piopiotahi Tracks & Observation	Piopiotahi Milford Sound	Visitor protection refuges. Stage 2 Report includes refuges from hazards. Visitor protection /shelters at Fresh Water Basin, Long Stay Parking, Deepwater Basin, and Cleddau Delta.	Single level Basic shelter(s) 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.[i] 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			

PDeI4	Piopiotahi Transport Terminal for Shuttles	Piopiotahi Milford Sound	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			
PDW2	Piopiotahi Commercial Fishing Port Deepwater Basin Experience Hub	Piopiotahi Milford Sound	No post disaster function.	Single level 300m2
	Standard structure. IL2. Construction is feasible.			
PFW2	Piopiotahi Ferry Terminal Renovation	Piopiotahi Milford Sound	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[ii].			
CKF1	Te Huakaue Knobs Flat Accommodation	Te Huakaue Knobs Flat – Node 3	Cabins Toilet blocks shelters Post disaster function to be determined.	Multi level 330m2 Sleeping activity – fire protection required.
	Due to proximity to good road access this cannot be not considered a back country hut and will need to comply with the New Zealand Building Code. It is considered that the NZBC dispensations for 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. There are natural hazards at this site but without the risk of tsunami the construction of this structure is considered feasible. Many other structures have been successfully constructed within the Eglinton Valley. An IL4 structure will require additional considerations with respect to maintaining services – power water and wastewater.			

CKF3	Te Huakaue Knobs Flat Interpretative Experience	Te Huakaue Knobs Flat – Node 3	Interpretative structures/ facilities Open structures/ shelters No post disaster function	Single level
	Standard structures. IL2. Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.			
CKF4	Te Huakaue Knobs Flat Interpretative Building	Te Huakaue Knobs Flat – Node 3	Interpretative building proving shelter and hall facility – community facility. No post disaster function.	Single level 100m2
	Standard structure. IL2 Small crowd activity – less than 100 people. Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.			
CKF7, CKF8, & CKF10	Te Huakaue Knobs Flat 3 waters -Potable water and wastewater infrastructure	Te Huakaue Knobs Flat - Node 3	Structures associated with the potable and water systems. Treatment 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.			
CKF9	Te Huakaue Knobs Flat – Kiosk Creek Accommodation	Te Huakaue Knobs Flat – Node 3	25 bed lodge. No post disaster function	462 m2 multi-level Sleeping activity – fire protection required.
	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. IL2 It is considered that the NZBC dispensations for available for back country huts will not apply here. Construction is feasible. Many other structures have been successfully constructed within the Eglinton Valley.			
CCE2	Homer Tunnel Western Portal	Homer Tunnel – Western Portal Loop 2	Parking area enhancement, including robust structure and retaining wall, with rockfall protection for parked buses and visitor experience.	Option to provide specialised structure designed to be resilient to rockfall and heavy snow/avalanche. Single level Open sided shelter

	This area has rockfall and avalanche hazards. The site is deemed a Class 1 Site with a sufficiently low hazard probability or exposure time so that risk to visitors is minimal. Existing hazard mitigation measures are deemed suitable. [ii] While the risks are deemed minimal consideration should be given to provide protection to parked buses and visitors with a shelter. Structure. Does not fall within standard definitions of Importance Levels. Structurally feasible but further investigations are necessary.			
CCE3	Te Rua o Te Moko Fiordland National Park Threshold	Te Rua o Te Moko Fiordland National Park – Node 1	Entrance/ departure structure Pou whenua	Signpost structures.
	Standard structures with signage and architectural features. Wind loads are likely to govern the design. IL2. Construction is feasible.			
CCE4	Te Rua o Te Moko Fiordland National Park Threshold	Te Rua o Te Moko Fiordland National Park - Node 2 Eglinton Reveal	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. Construction is feasible with similar requirements as the existing Cascade Creek campsite buildings.			
CCE8	Bus stops along the access corridor	Bus Shelter – “light” Various nodes and short stops.	Short stops bus shelter and toilet	Single level Open sided shelter 5 off
	“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.			
CCE9	Bus stops along the access corridor	Bus Shelter - "minor" Various nodes and short stops.	Short stops Bus shelter and toilet	Single level Open sided shelter 5 of
	“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. IL2. Construction is feasible.			
N/A	Countess Range Hut tramping hut	Countess Range	40 bed and 20 bed options for back country hut. Location to be confirmed but will be remote.	Single level 230m2 Sleeping activity

			No post-disaster function.	
	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.			
CCE12	Ōtāpara Cascade Creek Toilets	Ōtāpara Cascade Creek – Node 4	Toilets supporting modifications to existing campgrounds	Single level
	Toilets with vaulted toilet system. IL2. Construction is feasible – numerous other buildings at this location with same function.			
CTH1	Super Track Head	Whakatipu Trails Head – Node 5 (Hinepipiwai Lake Marian)	Experience hub – information facility No post disaster function	Single level 200m2
	Standard structures. IL2. Construction is feasible.			
CTH3 & CTH4	Super track head	Whakatipu Trails Head – Node 5 (Hinepipiwai Lake Marian)	Buildings and structures for water and wastewater infrastructure No post disaster function	Single level
	Standard structures. IL2. Construction is feasible.			
CTH5	Super track head	Whakatipu Trails Head – Node 5 (Hinepipiwai Lake Marian)	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 necessary to confirm scope of works and feasibility.			
TAV1	Te Ana Au Visitor hub structures – Visitor Experience	Te Anau	Visitor centre and focal point for entire visitor experience. No post-disaster function.	Likely greater than 300 visitors within the building so crowd activity. 1000m2
	Single level with close connection to lake/jetty and bus/roading network/carparking. Available footprint may require two level structure. IL3. Construction feasible.			

TAV3	Te Ana Au Visitor Hub Structure - Bus Stop	Te Anau	Te Anau Departure/arrival structure. Shelter No post-disaster function.	Likely greater than 300 visitors within the building so crowd activity.
	Single level with close connection to Visitor Hub. Standard structure. Large spans to accommodate buses. Likely crowd activity - IL3. Construction feasible. Refer also; *Milford Opportunities Project, Milford Sound Park and Ride Design Report, Feasibility Study - Draft*. Beca 23 February 2024			
TAV7	Te Ana Au Visitor Hub Structure – Jetty	Te Anau	Jetty aligned with Visitor hub No post-disaster function.	50m2
	Standard jetty structure. IL 2. Construction feasible			
TAB1	Te Ana Au Transport Terminal – Buses	Te Anau	Bus storage and maintenance facilities along with Driver facilities. No post-disaster function.	No crowd activity. 1000m2
	Single level with close connection to terminal pavement and visitor experience. Back of house functions. Standard structure. Large spans to accommodate buses. Likely crowd activity IL3. Construction feasible.			

1 INTRODUCTION

The Milford Opportunities Masterplan Stage 2 Report provides high level details for proposed hubs and nodes at, and between, Te Anau and Piopiotahi Milford Sound. The purpose of the hubs and nodes is to provide improved visitor experiences. There is various vertical infrastructure planned at the hubs and nodes and WSP has been requested to provide additional high-level inputs into the key considerations that will need to be implemented in the Detailed Design stage of the project.

This report does not provide all the requirements for the design of the proposed MOP vertical infrastructure to comply with the New Zealand Building Code. The New Zealand Building Code and the relevant standards clearly layout the requirements for building design and construction within New Zealand. Reputable design professionals have comprehensive knowledge of these design standards.

The report does however provide discussion for each site and type of structure where a specific aspect of the structure or site should have greater emphasis and be considered in detail. Table 1 in the Executive Summary summarises and comments on notable design aspects for all the proposed vertical infrastructure sites. Section 2 provides commentary on three key aspects of the detailed design: Importance Level, the New Zealand Building Code (and allowable dispensations for back country huts), and Design life. Section 3 comments on specific considerations for sites and the proposed types of structures.

The visitor hub at Piopiotahi Milford Sound will require significant design input and special studies to complete a detailed design that is resilient to change and risk. The requirements for post disaster functionality for some structures in this location comes with significant challenges to mitigate the risks from natural hazards.

The natural hazards are discussed briefly for some sites but are not considered in detail. Natural hazard risks and risk to life are assessed separately by WSP as part of the Engineering Feasibility contract.

2 FACTORS INFLUENCING DESIGN

2.1 IMPORTANCE LEVEL

The New Zealand Building Code and AS/NZS 1170 require the importance level of a structure to be determined in accordance with its occupancy and use. The Importance Level (IL) is used to determine the annual probably of exceedance of Ultimate Limit State and Serviceability Limit State events for Earthquake, Wind, Snow and Rainfall that the structure will be exposed to. The definitions of the Importance Levels, Tables 3.1 and 3.2 from AS/NZS 1170.0:2002, are included in Table 2-1 and Table 2-2 below.

The structures proposed as part of the Milford Opportunities Project vary from small bus stop type shelters and covered ways with an IL of 1 through to accommodation with post-disaster functions with an IL of 4.

Table 2-1 – Table 3.1 from AS/NZS 1170.0 - 2002

CONSEQUENCES OF FAILURE FOR IMPORTANCE LEVELS

Consequences of failure	Description	Importance level	Comment
Low	**Low** consequence for loss of human life, *or* **small or moderate** economic, social or environmental consequences	1	Minor structures (failure not likely to endanger human life)
Ordinary	**Medium** consequence for loss of human life, *or* **considerable** economic, social or environmental consequences	2	Normal structures and structures not falling into other levels
High	**High** consequence for loss of human life, *or* **very great** economic, social or environmental consequences	3	Major structures (affecting crowds)
		4	Post-disaster structures (post disaster functions or dangerous activities)
Exceptional	Circumstances where reliability must be set on a case by case basis	5	Exceptional structures

Table 2-2 – Table 3.2 from AS/NZS1170.0-2002

IMPORTANCE LEVELS FOR BUILDING TYPES—NEW ZEALAND STRUCTURES

Importance level	Comment	Examples
1	Structures presenting a low degree of hazard to life and other property	Structures with a total floor area of <30 m^2 Farm buildings, isolated structures, towers in rural situations Fences, masts, walls, in-ground swimming pools
2	Normal structures and structures not in other importance levels	Buildings not included in Importance Levels 1, 3 or 4 Single family dwellings Car parking buildings
3	Structures that as a whole may contain people in crowds or contents of high value to the community or pose risks to people in crowds	Buildings and facilities as follows: (a) Where more than 300 people can congregate in one area (b) Day care facilities with a capacity greater than 150 (c) Primary school or secondary school facilities with a capacity greater than 250 (d) Colleges or adult education facilities with a capacity greater than 500 (e) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities (f) Airport terminals, principal railway stations with a capacity greater than 250 (g) Correctional institutions (h) Multi-occupancy residential, commercial (including shops), industrial, office and retailing buildings designed to accommodate more than 5000 people and with a gross area greater than 10 000 m^2 (i) Public assembly buildings, theatres and cinemas of greater than 1000 m^2 Emergency medical and other emergency facilities not designated as post-disaster Power-generating facilities, water treatment and waste water treatment facilities and other public utilities not designated as post-disaster Buildings and facilities not designated as post-disaster containing hazardous materials capable of causing hazardous conditions that do not extend beyond the property boundaries
4	Structures with special post-disaster functions	Buildings and facilities designated as essential facilities Buildings and facilities with special post-disaster function Medical emergency or surgical facilities Emergency service facilities such as fire, police stations and emergency vehicle garages Utilities or emergency supplies or installations required as backup for buildings and facilities of Importance Level 4 Designated emergency shelters, designated emergency centres and ancillary facilities Buildings and facilities containing hazardous materials capable of causing hazardous conditions that extend beyond the property boundaries

2.2 DESIGN STANDARDS

2.2.1 NEW ZEALAND BUILDING CODE AND SPECIAL STUDIES

It is expected that the design for most of the vertical infrastructure associated with the proposed Milford Opportunities Project will comply with the New Zealand Building Code. Back Country Huts can have simplified design requirements due to their back country nature as discussed in Section 2.2.2.

Compliance with the Building Code will be relatively straight forward in some respects, with commonplace solutions in place and available, whereas other aspects will require specific design and bespoke detailing to deal with the specific challenges of the sites. These challenges include the proximity to the Alpine Fault (earthquake and tsunami), the harsh Fiordland environment with extreme weather events (rainfall, wind, and snow), and ground conditions (variable from bedrock to glacial moraine, alluvial fans, river deltas and potential reclaimed land).

The harsh environment will also require 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 of Te Rua o Te Moko Fiordland National Park.

The remote sites will also require specific consideration with respect to fire protection as firefighting capabilities are limited.

The Piopiotahi visitor experience centre, visitor accommodation, and staff accommodation are required to have a post disaster function which will require careful consideration to their site to minimise the flooding risk from the Cleddau River, overland flow, and to minimise the risk of tsunami inundation from Milford Sound. The detailed design of the buildings with post-disaster functions will require specific studies so that these structures can withstand tsunami and flood loads along with the accompanying debris loading.

Where structures are fully accessible from the roading networks or are within a short walk or if they are accessible tracks/trails it is recommended that these visitor structures be fully compliant with the NZ Building Code and the relevant standards.

2.2.2 BACK COUNTRY HUTS – ACCEPTABLE SOLUTION

The Department of Conservation Back Country huts have simplified requirements, with respect to compliance with the New Zealand Building Code, due to their special character as basic, remote facilities.

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.

The simplified requirements mean DOC's backcountry huts do not need:

- smoke alarms
- emergency lighting
- access and sanitary facilities for wheelchair users
- a drinkable water supply

- artificial lighting.

The design is, however, required to be in accordance with the Clause B1 (Structure) and B2 (Durability) of the New Zealand Building Code and relevant standards.

2.3 DESIGN LIFE

The NZ Building Code requires a minimum design life of 50 years. This is considered appropriate for the Milford Opportunities Project proposed vertical infrastructure. To achieve a 50-year design life, regular and ongoing maintenance of the structures will be necessary and a detailed asset management plan for each structure is recommended. The design details will require due consideration to allow the easy replacement of componentry as individual items reach end of life e.g. roofing, gutter elements, and bolts etc.

The design of the structures shall consider durability and specify materials and detailing appropriate for the Te Rua-o-Te-Moko Fiordland National Park environment.

Other design considerations with respect to durability should include ease of cleaning, with safe access, and vandal proof finishes.

3 SPECIFIC SITE AND STRUCTURE TYPE CONSIDERATIONS

3.1 HINE-TE-AWA UPPER BOWEN FALLS LIFT ACCESS

3.1.1 LIFT OPTIONS

The Milford Opportunities Project includes an option to provide a lift to allow easy visitor access from the Piopiotahi Milford Sound township to the proposed viewing platforms over the Hine-te-awa Upper Bowen Falls. Walkways are proposed but other lift access may need to be considered to provide full accessibility to the viewing platforms. The views of the falls and Milford Sound are notable.

The discussion provided here is high level and provides some discussion points. Further investigations are required to progress this further.

No geometric survey has been undertaken to provide any certainty in an alignment for a lift or locations of terminal buildings but to assist with discussions a possible alignment for a lift is shown in Figure 3-1 and Figure 3-2.

The estimated vertical lift taken from the topographical map is 200m over a horizontal distance of 300m. This is comparable to the Queenstown Skyline Gondola Lift gradient.

The final section of lift type will be influenced by the required capacity. It is estimated that an average of 6,000 visitors per day and 1,000 visitors per hour will visit Piopiotahi Milford Sound but not all would use the lift. Further investigation is necessary to confirm the necessary lift capacity.

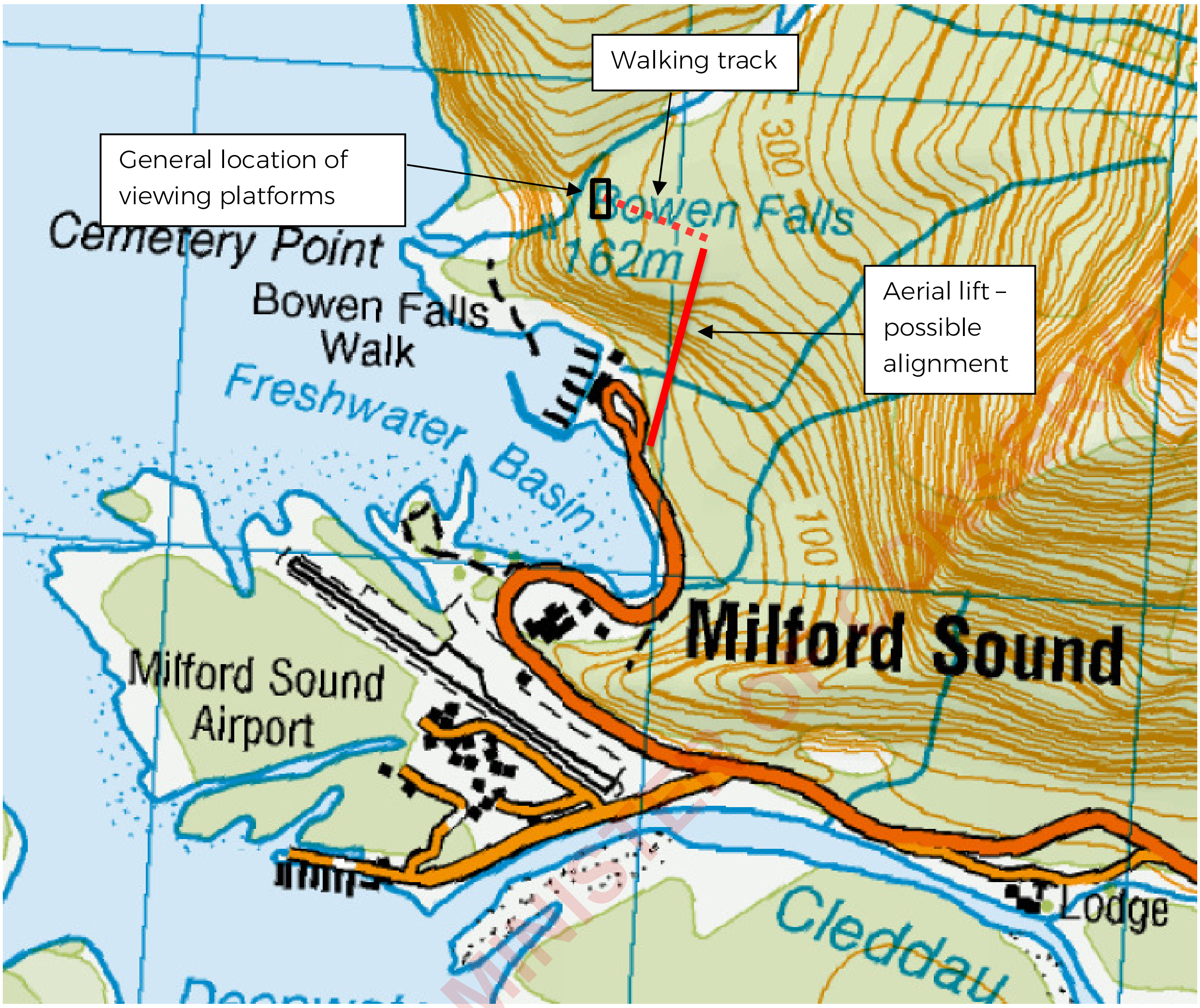

Figure 3-1 – Possible aerial lift location – topographic map

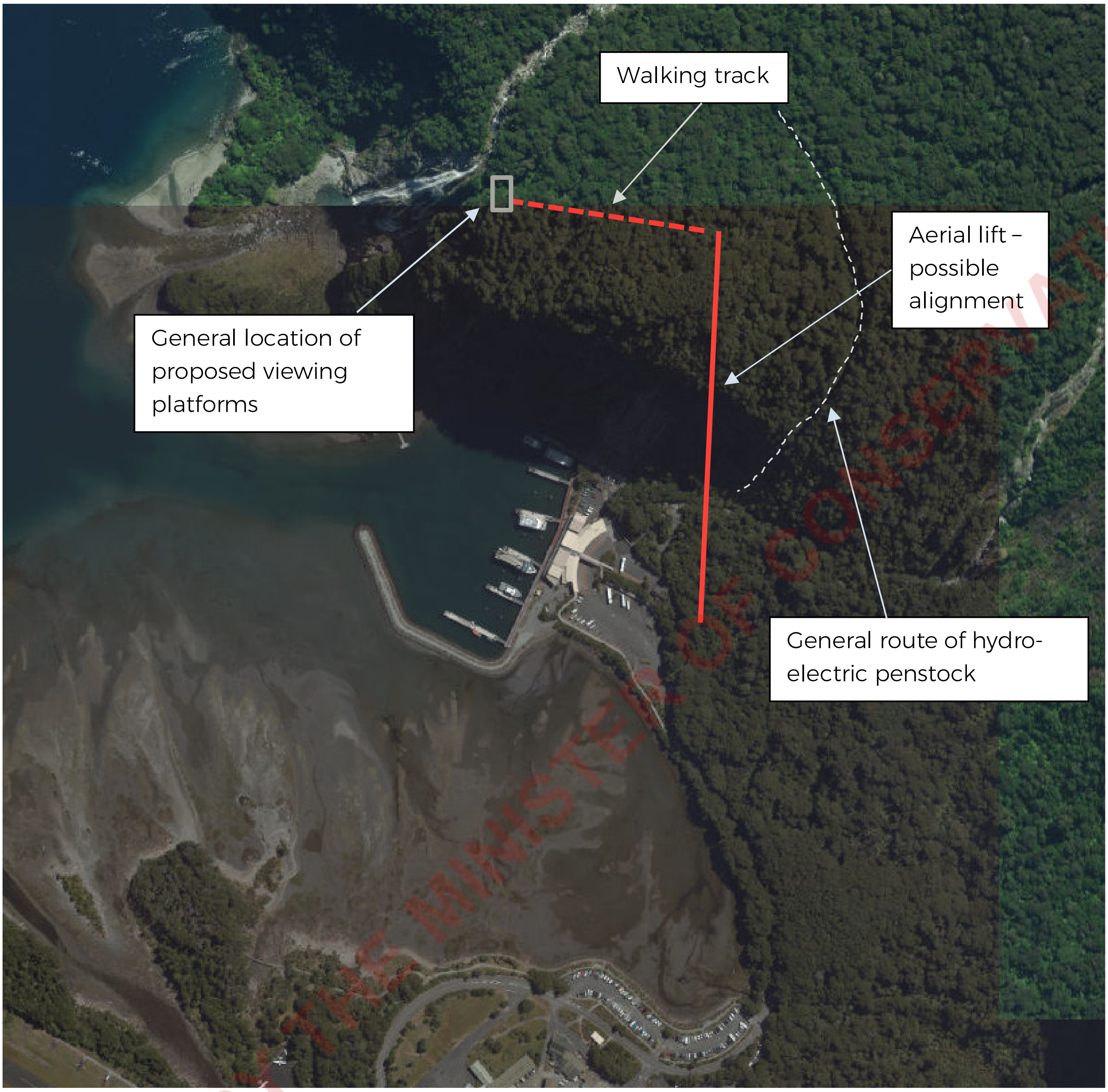

Figure 3-2 Possible aerial lift location – aerial photograph – courtesy SDC/ESRI

The options for the lift include an incline elevator, funicular railway, gondola lift, or cable car/aerial tramway. Each lift type has varying capacities based on cabin/car size. See Table 3-1. A funicular railway has two cars that run on rails that synchronously counterbalance one another via cable that runs around a wheel at the top terminal. An incline elevator also runs on rails but has only one car that is self-driven. A gondola lift has a series of individual cabins supported and propelled by cables from above supported at the top and bottom terminal buildings and at intermediate towers. A cable car or aerial tramway typically has two cabins supported and propelled by cables from above which are supported at the top and bottom terminal building only with and no intermediate towers.

Table 3-1 Lift Type and Capacity

Lift Type	Capacity (People per hour)
Incline Elevator – 50 Passenger car	300-400
Funicular railway – 50 Passenger car	300-400
Cable car/Aerial tramway - 15-30 passenger car	250-500
Gondola lift – 8 passenger cabin	> 1,000

Note: Car/cabin size can be selected to match the required capacity.

The incline elevator and funicular will require the full clearance of vegetation from a strip of land inclined up the slope to allow the construction of rails and a rail support structure. The rails could be at a consistent slope with the car having fixed seating or the rails could have a variable incline as there are international examples of cabins that adjust to the angle of the incline. It is considered that an incline elevator or funicular would have the greatest impact on natural character due to the necessary vegetation clearance along the entire length of the rail track. See Figure 3-3 for examples. It has been proposed that a rail mounted car system could follow the route of the hydroelectric penstocks and also provide maintenance access to the penstocks. See Figure 3-2 for the penstock route. Providing a rail mounted system with a dual role may require compromises to be made on the functionality of the cabins with respect to conflicting requirements for maintenance tasks and the comfort/experience of the visitors.

Figure 3-3 Above left, Incline Elevator – Source: Poma Group website; Above right, Funicular – Wellington "Cable Car" – Source Internet.

A gondola lift will provide the greatest capacity and could achieve the capacity required for all daily visitors to Milford Sound, with a rate of 1,000 (or more) visitors per hour, to visit the viewing platforms. It is unlikely that all visitors to the Piopiotahi Milford Sound will use a lift. The impact of gondola lift construction on the vegetation could be limited with the intermediate towers being constructed in isolation. Construction access can be gained by the use of a construction aerial tramway. The height of the gondola towers would need to be determined to confirm if the cabins would travel above or below the bush canopy. Travelling below the bush canopy will require vegetation clearance and regular vegetation maintenance.

A cable car or aerial tramway would provide the least impact on the natural vegetation as there would be no intermediate towers. The top and bottom terminals will however need to have an elevation large enough to achieve the necessary clearances over vegetation and possibly other structures. Construction access to the top terminal building using a construction aerial tramway would be necessary. See Figure 3-5

It is considered that a Gondola lift or Cable Car would provide sufficient capacity and would be best suited for the site with less environmental impact than rail mounted cars.

See Figure 3-4 for examples.

All of the options mentioned have been constructed in numerous difficult and remote locations around the world and it is considered that construction at the proposed location could be successful. However significant further investigation is necessary to confirm the topography of the site, ground conditions and environmental impact as part of a detailed construction feasibility and lift selection process.

Figure 3-4 – Aerial tramway at Mt Messenger road construction – Source: YouTube – Porter Equipment

Figure 3-5 – Above left – Aerial tramway/Cable car – Source: Doppelmayr; Above right – Gondola lift – Source: Skyline website.

3.1.2 STRUCTURAL SYSTEM

Prioritising the prefabrication of building componentry is an important consideration for the proposed lift structures to limit on site work and in-situ concrete. Structural steel frame with rock anchored reinforced concrete foundation is a likely solution for the top terminal building. The intermediate lift supports will be structural steel towers with rock anchored reinforced concrete foundations. The base terminal building will be structural steel frame with a robust reinforced concrete slab potentially with deep piled foundation and /or ground improvements.

3.2 VISITOR HUBS

3.2.1 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. The location of the visitor hub is shown in Figure 3-6.

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 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.[i]

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 possible impact on the surrounding native vegetation.

The buildings that will not act as an emergency refuge but have crowd activities will have an Importance Level of 3, however due 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.

3.2.1.1 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[iii].

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.

Figure 3-6 – Aerial view of Piopiotahi Milford Sound showing location of visitor hub. Source: SDC/ESRI

3.2.2 TE ANAU VISITOR HUB

The site of the Te Anau visitor hub is yet to be determined but it will be located within the Te Anau town boundary and current intentions are for it to have strong links to transportation and Te-Ana-au Lake Te Anau. It will provide a focal point for the entire visitor experience with interpretative displays and departure/arrival structures.

The Te Anau Visitor Hub will not have post disaster function and so it is not required to have an Importance Level of 4. The Visitor Hub will have an area where more than 300 people can congregate which is deemed a crowd activity and will therefore have an Importance Level of 3.

There are no special considerations for the design of the structures however the safety of pedestrians, vehicle parking and transit through the hub will be a strong driver of the design. An example of a design with these considerations in mind is the Christchurch Bus interchange – see Figure 3-7.

3.2.2.1 STRUCTURAL SYSTEM

The structural system for the Te Anau visitor hub will be standard structure with structural frames and shear walls on a reinforced concrete slab on grade. The Te Anau township has generally good foundation conditions and piles are not expected to be necessary.

The design does not require the same emphasis on prefabrication as Pipopiotahi structures, but for consistency the same construction methods maybe desired.

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.

Figure 3-7 Christchurch Bus Interchange – Source: Environment Canterbury website.

3.3 CORRIDOR ACCOMMODATION

3.3.1 *TE HUAKAUE KNOBS FLAT ACCOMODATION*

A 25 bed lodge is proposed at Kiosk Creek as part of the Te Huakaue Knobs Flat node. Due to its proximity to good road access this lodge cannot be not considered a back country hut and the dispensations available to back country huts will not apply and the requirement to fully comply with the New Zealand Building Code is expected.

The lodge will not have a post disaster function and does not include any crowd activities and so is considered to have an Importance level of 2.

Early warning smoke/heat detection will be necessary, and sprinklers should be considered.

The accommodation will have numerous small internal spaces with short roof spans and numerous walls to resist lateral loading. A lightweight timber framed structural system will likely be acceptable. The ground conditions are not known but this lightweight structure will likely allow the building to be founded on shallow timber piles.

3.3.2 *COUNTESS RANGE TRAMPING HUT*

A 40-bed and 20-bed option for a tramping hut is planned for the Countess Range. The final site is not confirmed but it will be located on remote site and so the simplified requirements for compliance with the New Zealand Building Code that the BCH/AS1 Acceptable Solution for Backcountry Huts provides, is likely to be acceptable.

The hut will not have a post disaster function and does not include any crowd activities and so is considered to have an Importance level of 2.

The style of the hut is likely to be similar to many of the Department of Conservation back country huts. See Figure 3-8.

The accommodation will have numerous small internal spaces with short roof spans and numerous walls to resist lateral loading. A lightweight timber framed structural system will likely be acceptable. The ground conditions are not known but this lightweight structure will likely allow the building to be founded on shallow timber piles.

Additional Information can be found in the WSP Report *Critical Structures for Walking and Cycling Construction Feasibility* Report dated 11 March 2024.

Figure 3-8 Moonlight Tops Hut – 20 beds – Source: Department of Conservation website.

3.4 BUILDING SERVICES

The potable water, wastewater and power supply functions at Piopiotahi Milford Sound are required to function after an ULS event to support the functionality of the emergency refuge structures. Ultimate Limit State (ULS) is defined in the New Zealand "Loadings" standard; Australia/New Zealand Standard, Structural design actions (AS/NZS 1170.0). ULS is used to determine the earthquake load limit at which; structural systems and supports or parts of buildings must avoid collapse. To also avoid damage to non-structural systems, necessary for emergency evacuation, that renders them inoperative.

The buildings that house these services along with their restraints and supports, inside and outside the buildings, will need to be designed to an Importance Level of 4.

The confirmed sites for the services and services buildings are unknown but due to the post-disaster functionality and IL4 status these services and services buildings will require robust foundations. Deep piled foundation or ground improvement maybe necessary. The buildings are likely to be lightweight, but the foundations and the services support structures and restraint will be robust.

Design should have emphasis on prefabrication to minimise on site works and minimise in-situ concrete, however the wastewater containment and processing may require construction with reinforced concrete for durability.

In addition, emergency power generation and backup diesel generators are likely to be necessary as the hydroelectric power generation at Piopiotahi Milford Sound is likely to be disrupted in the event of an ULS Earthquake.

3.5 SHELTERS AND COVERED WAYS

Various short stop bus shelters and covered ways are planned along the route from Te Anau to Piopiotahi Milford Sound and at the destination. These structures will be Importance Level 2 Structures. The type of structures envisaged are shown in Figure 3-9.

The Masterplan Stage 2 Report includes the following shelters, which we consider the design requirements for the structures at these sites should be adjusted;

- Bus stops along the access corridor – described as "light" or "minor" structures. It is considered that no light or temporary structures should be considered as the weather conditions, primarily wind and snow loading, will likely cause damage to any structure that is not permanent and designed to the requirements of AS/NZS 1170.
- Piopiotahi track and observation area – 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.[i] 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.

The sheltered and covered ways can have foundations that are concrete slab on grade with lightweight frame structures. The design should have an emphasis on prefabrication to minimise on site works and minimise in-situ concrete. There should be an emphasis on durability as the structures will be exposed to the environment and so structural steel with durable coatings and/or possibly engineered timber (LVL. CLT, Glulam) should be considered.

Figure 3-9 – Left – bus shelter. Auckland – Source: Auckland Transport website, Middle – typical coveredway, Right – Routeburn Shelter - Source: DOC website.

REFERENCED DOCUMENTS

---

[i] *Milford Opportunities Project Natural Hazards Assessment Part B: Basic Risk Assessment.* WSP. June 2024.

[ii] *Milford Opportunities Project Natural Hazards Assessment Part A: Preliminary Screening Analysis. WSP. 26 March 2024*

[iii] *Preliminary Geotechnical Report for Concept Design, Multi-Level Carpark Milford Sound*, February 2019. Ref:180430. Geosolve Limited