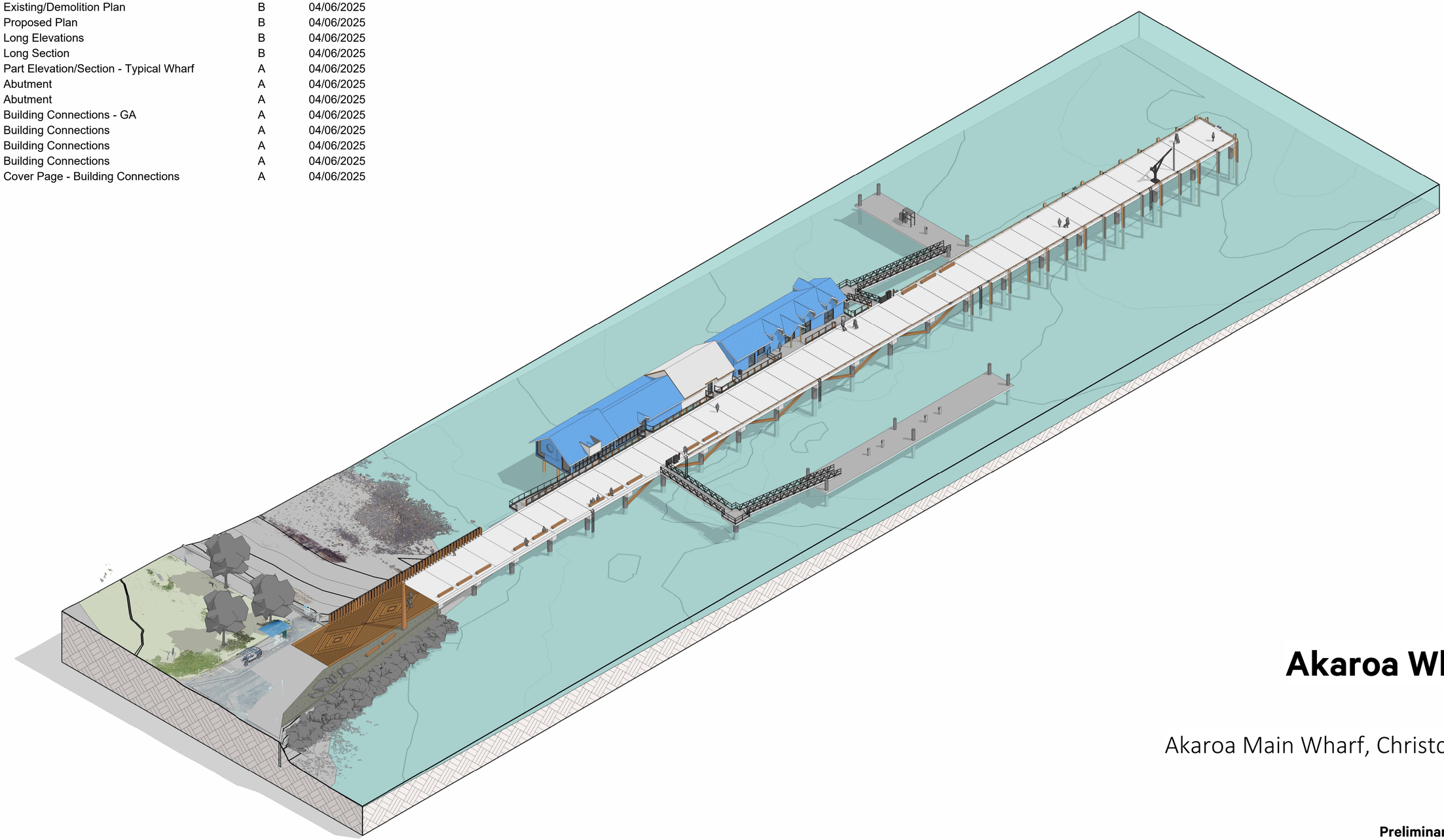
Sheet No.	Sheet Name	Revision	Current Revision Date
A0-000	Cover Page	B	04/06/2025
A0-010	Site Context	B	04/06/2025
A1-001	Existing/Demolition Plan	B	04/06/2025
A1-003	Proposed Plan	B	04/06/2025
A2-001	Long Elevations	B	04/06/2025
A3-001	Long Section	B	04/06/2025
A4-001	Part Elevation/Section - Typical Wharf	A	04/06/2025
A4-100	Abutment	A	04/06/2025
A4-101	Abutment	A	04/06/2025
A5-001	Building Connections - GA	A	04/06/2025
A5-002	Building Connections	A	04/06/2025
A5-003	Building Connections	A	04/06/2025
A5-004	Building Connections	A	04/06/2025
Ax-001	Cover Page - Building Connections	A	04/06/2025



Akaroa Wharf

Akaroa Main Wharf, Christchurch

Preliminary Design
04/06/2025

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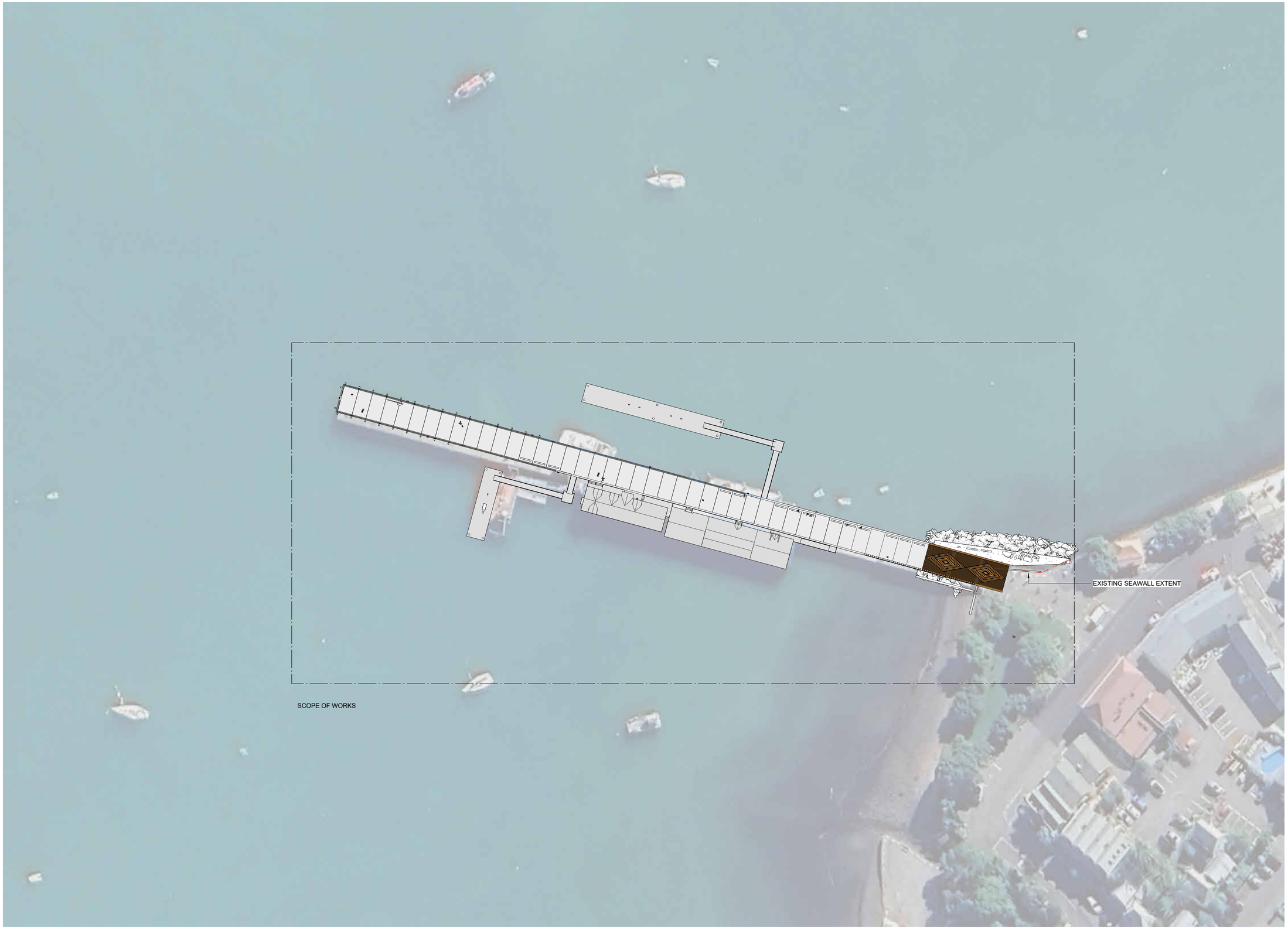

SITE DESCRIPTION

SITE ADDRESS:	AKAROA MAIN WHARF, AKAROA, CHRISTCHURCH 7520
LEGAL DESCRIPTION:	ADJACENT LOT 1 DEPOSITED PLAN 2864 & LOT 1 DEPOSITED PLAN 2867

GENERAL NOTES

NOTE OUR DOCUMENTATION IS BASED ON THE 2020 POINT CLOUD PROVIDED BY CCC. WE RECOMMEND A CADASTRAL SURVEY IS COMPLETED TO ENHANCE ACCURACY IN DETAILED DESIGN DOCUMENTATION.

PLEASE NOTE THE WHARF ALIGNMENT IS YET TO BE CONFIRMED TO ENABLE PILING ADJACENT TO EXISTING BUILDINGS. ABUTMENT EXTENTS AND BUILDING CONNECTIONS WILL NEED TO BE REVISED TO SUIT ONCE THIS IS CONFIRMED. REFER HOLMES CONCEPT DOCUMENTATION FOR AKAROA WHARF CONSENT EXTENTS.

PLEASE READ IN CONJUNCTION WITH STRUCTURAL ENGINEER'S DOCUMENTATION.

1 SITE CONTEXT
1 : 500

Rev.	Description	Date
B	PRELIMINARY DESIGN	04/06/2025
A	PRELIMINARY DESIGN 50%	22/10/2024

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Current Status
Preliminary Design

Job Name
Akaroa Wharf

Drawing Title
Site Context

Scale
As indicated @ A1
50% @ A3

Revision
B

Job No.
4389

Drawing No.
A0-010

SITE DESCRIPTION

SITE ADDRESS:	AKAROA MAIN WHARF, AKAROA, CHRISTCHURCH 7520
LEGAL DESCRIPTION:	ADJACENT LOT 1 DEPOSITED PLAN 2864 & LOT 1 DEPOSITED PLAN 2867

GENERAL NOTES

NOTE OUR DOCUMENTATION IS BASED ON THE 2020 POINT CLOUD PROVIDED BY CCC. WE RECOMMEND A CADASTRAL SURVEY IS COMPLETED TO ENHANCE ACCURACY IN DETAILED DESIGN DOCUMENTATION.

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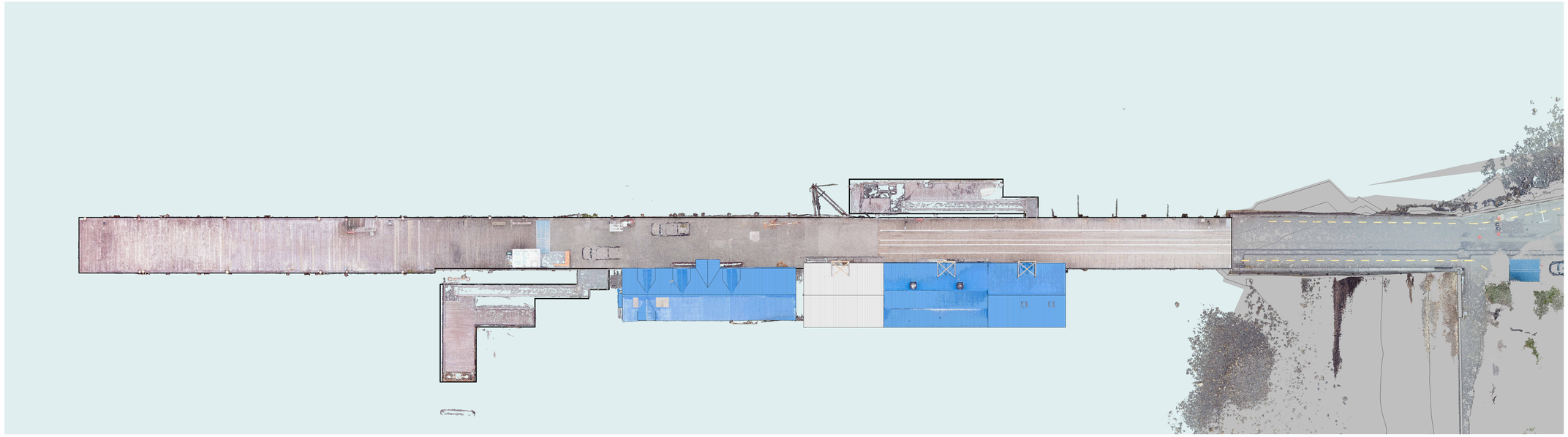
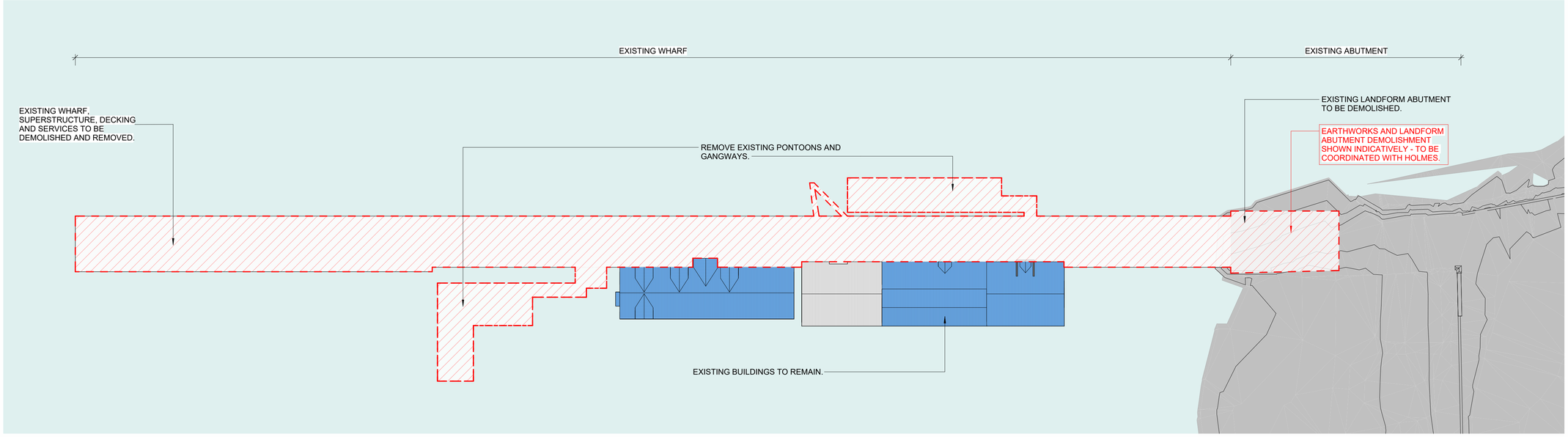
PLEASE READ IN CONJUNCTION WITH STRUCTURAL ENGINEER'S DOCUMENTATION.



1 EXISTING PLAN
1 : 300



2 DEMOLITION PLAN
1 : 300

Rev.	Description	Date
B	PRELIMINARY DESIGN	04/06/2025
A	PRELIMINARY DESIGN 50%	22/10/2024

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Drawing Title
Existing/Demolition Plan

Current Status
Preliminary Design

Job Name
Akaroa Wharf

Scale
As indicated @ A1
50% @ A3

Revision
B

Job No.
4389

Drawing No.
A1-001

SITE DESCRIPTION

SITE ADDRESS:	AKAROA MAIN WHARF, AKAROA, CHRISTCHURCH 7520
LEGAL DESCRIPTION:	ADJACENT LOT 1 DEPOSITED PLAN 2864 & LOT 1 DEPOSITED PLAN 2867

GENERAL NOTES

NOTE OUR DOCUMENTATION IS BASED ON THE 2020 POINT CLOUD PROVIDED BY CCC. WE RECOMMEND A CADASTRAL SURVEY IS COMPLETED TO ENHANCE ACCURACY IN DETAILED DESIGN DOCUMENTATION.

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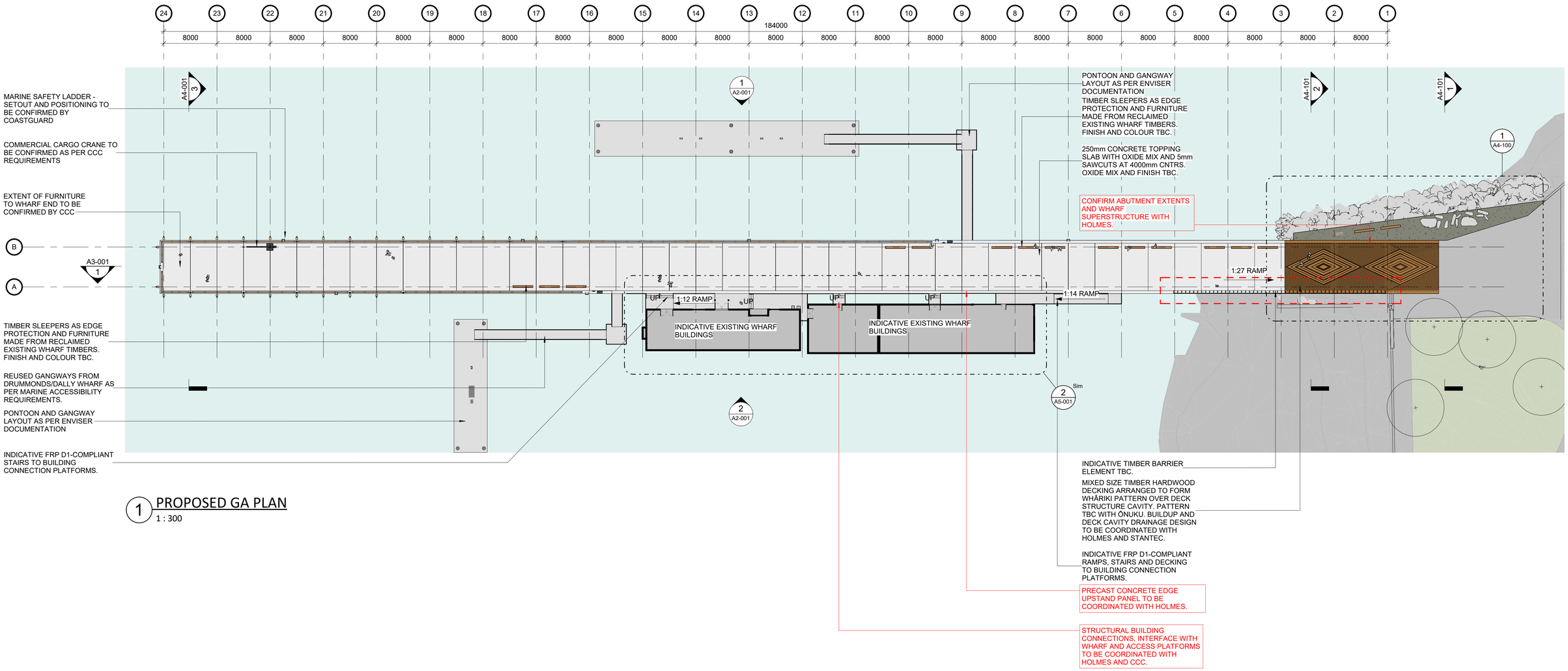
PLEASE READ IN CONJUNCTION WITH STRUCTURAL ENGINEER'S DOCUMENTATION.



1 PROPOSED GA PLAN
1 : 300

Rev.	Description	Date
B	PRELIMINARY DESIGN	04/06/2025
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Drawing Title
Proposed Plan

Current Status
Preliminary Design

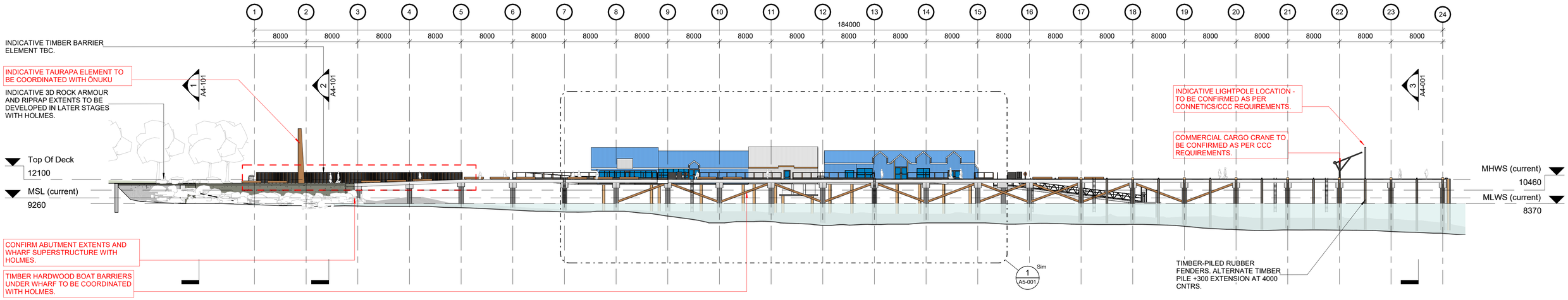
Job Name
Akaroa Wharf

Scale
As indicated @ A1
50% @ A3

Revision
B

Job No.
4389

Drawing No.
A1-003



1 GA ELEVATION - NORTHEAST
A1-003 1 : 300

2 GA ELEVATION - SOUTHWEST
A1-003 1 : 300

Rev.	Description	Date
B	PRELIMINARY DESIGN	04/06/2025
A	PRELIMINARY DESIGN 50%	22/10/2024

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Drawing Title
Long Elevations

Current Status
Preliminary Design

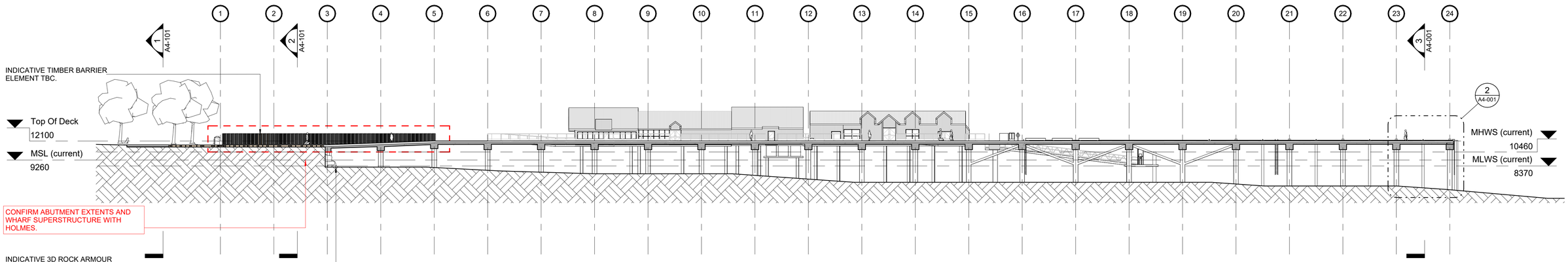
Job Name
Akaroa Wharf

Scale
1 : 300 @ A1
50% @ A3

Revision
BB

Job No.
4389

Drawing No.
A2-001



1 / A1-003 GA SECTION - LONG

1 : 300

Rev.	Description	Date
B	PRELIMINARY DESIGN	04/06/2025
A	PRELIMINARY DESIGN 50%	22/10/2024

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4/06/2025 5:03:45 pm

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Drawing Title
Long Section

Current Status
Preliminary Design

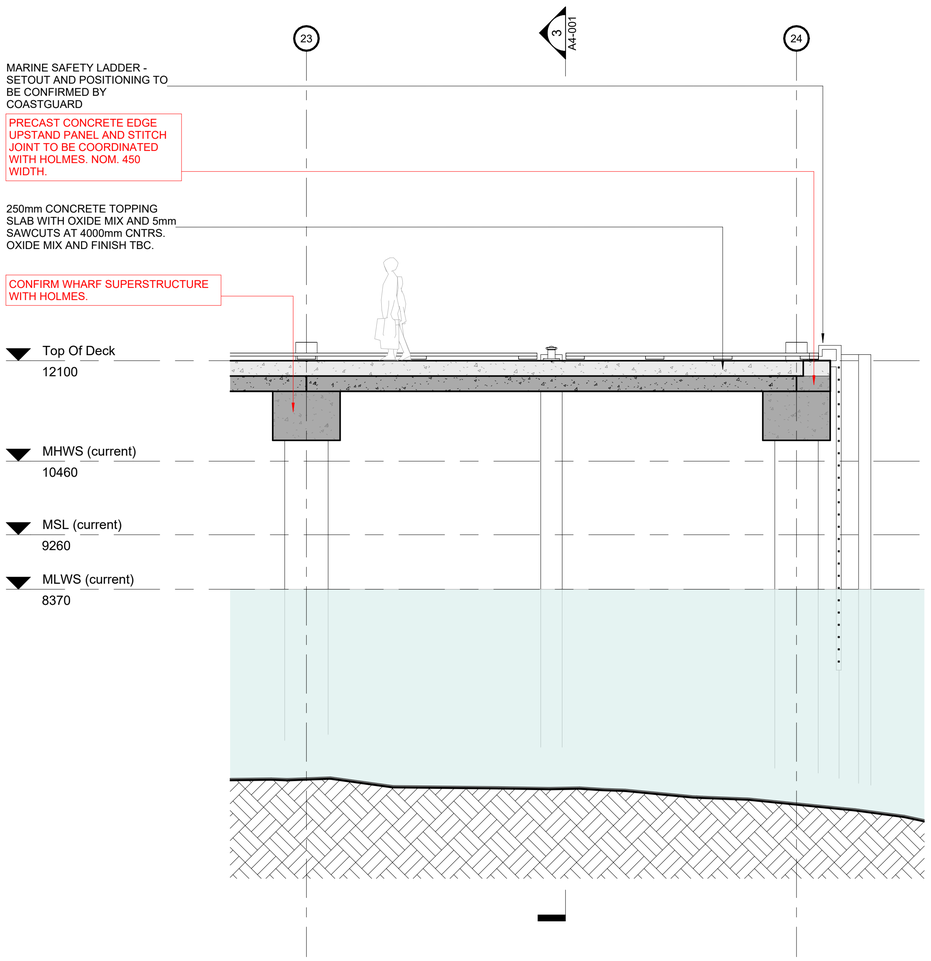
Job Name
Akaroa Wharf

Scale
1 : 300 @ A1
50% @ A3

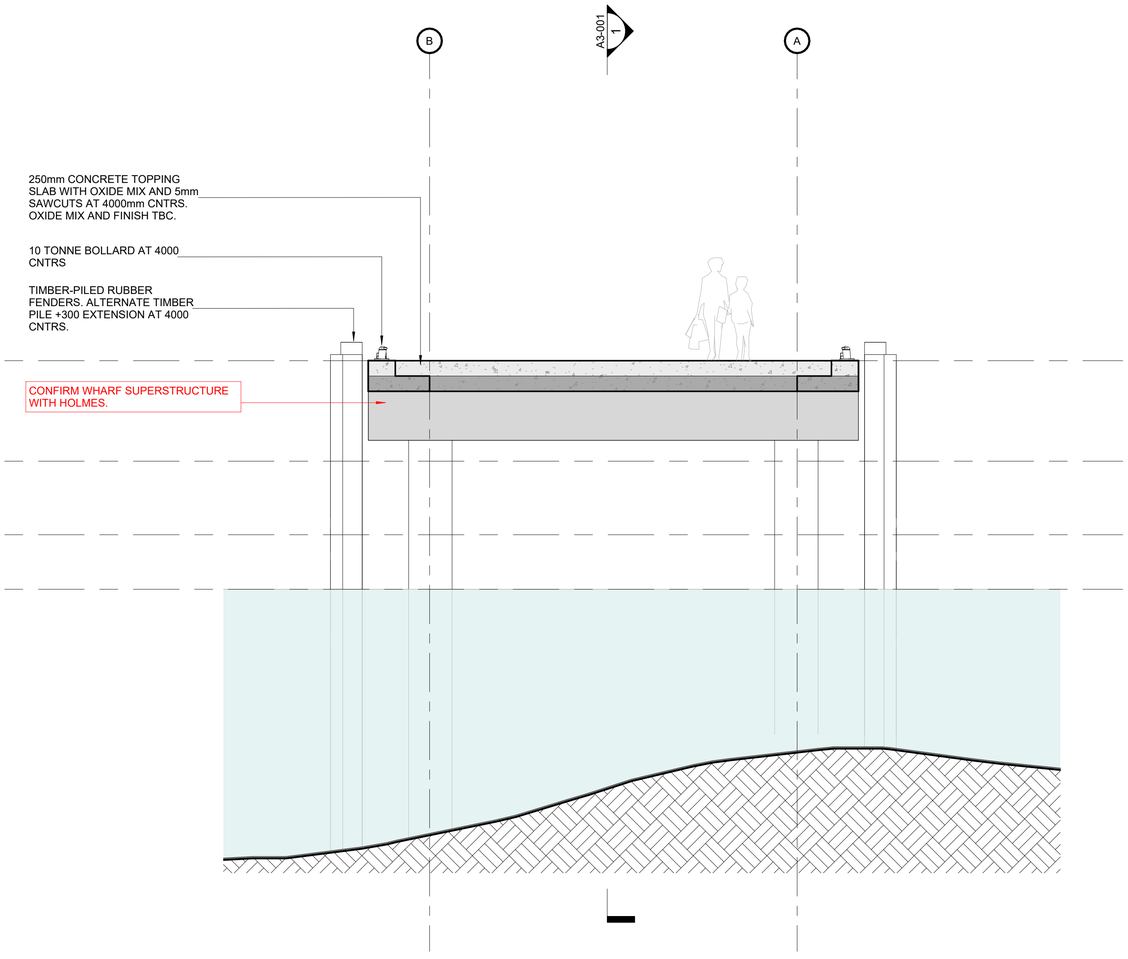
Revision
BB

Job No.
4389

Drawing No.
A3-001

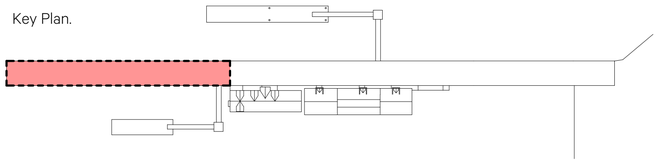


2 A3-001 PART SECTION - WHARF END
1 : 50



3 A1-003 GA SECTION - TYP. WHARF
1 : 50

Key Plan.



Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Current Status
Preliminary Design

Job Name
Akaroa Wharf

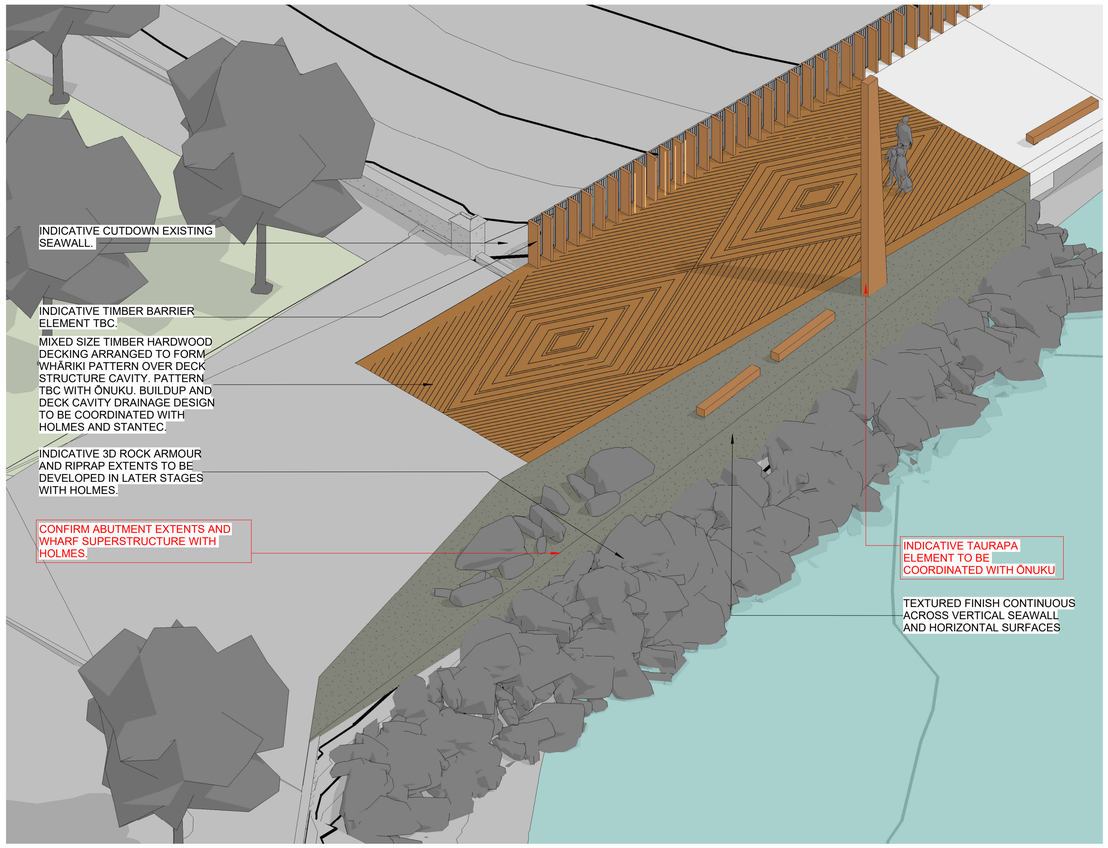
Drawing Title
Part Elevation/Section - Typical Wharf

Scale
1 : 50 @ A1
50% @ A3

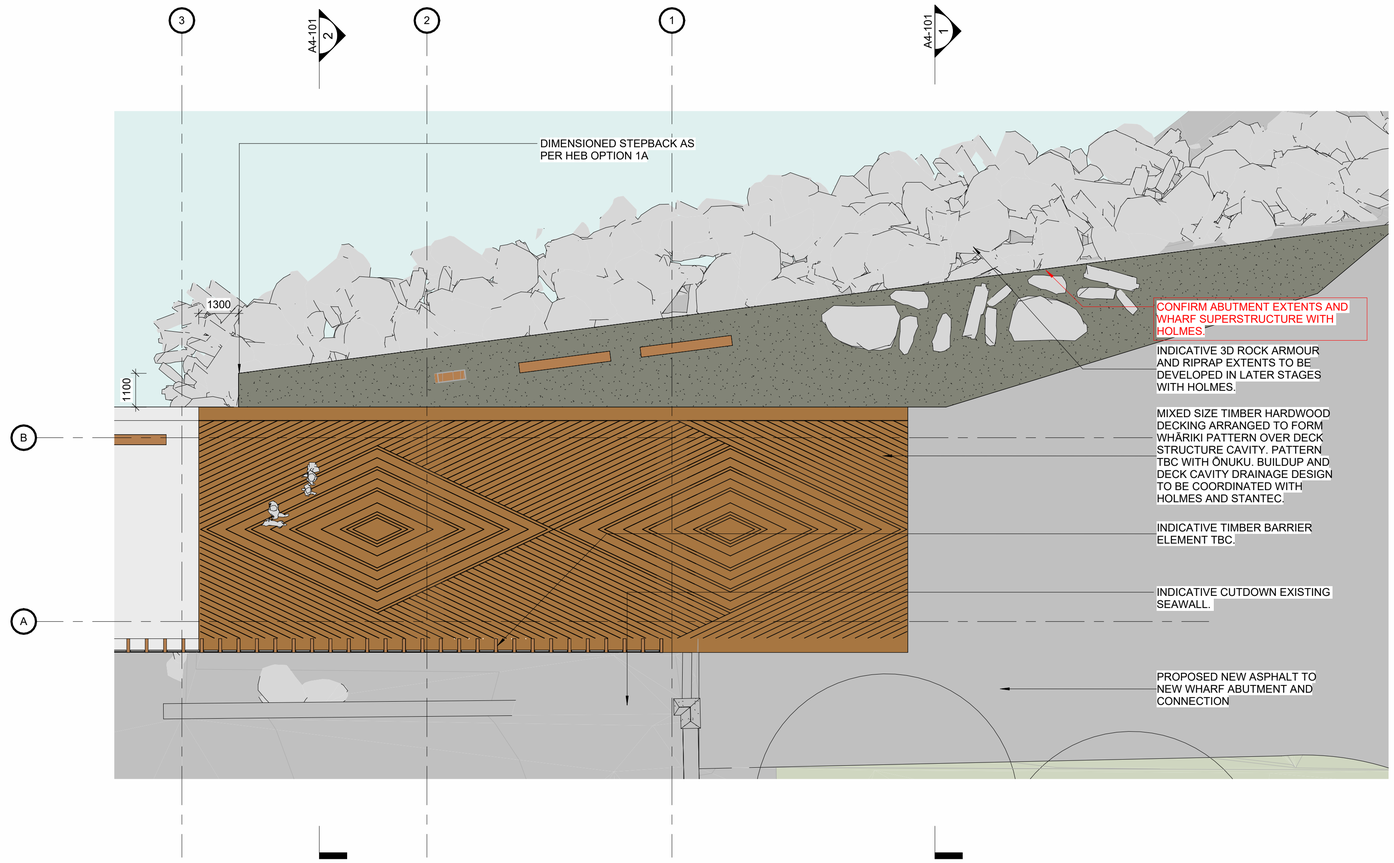
Revision
A

Job No.
4389

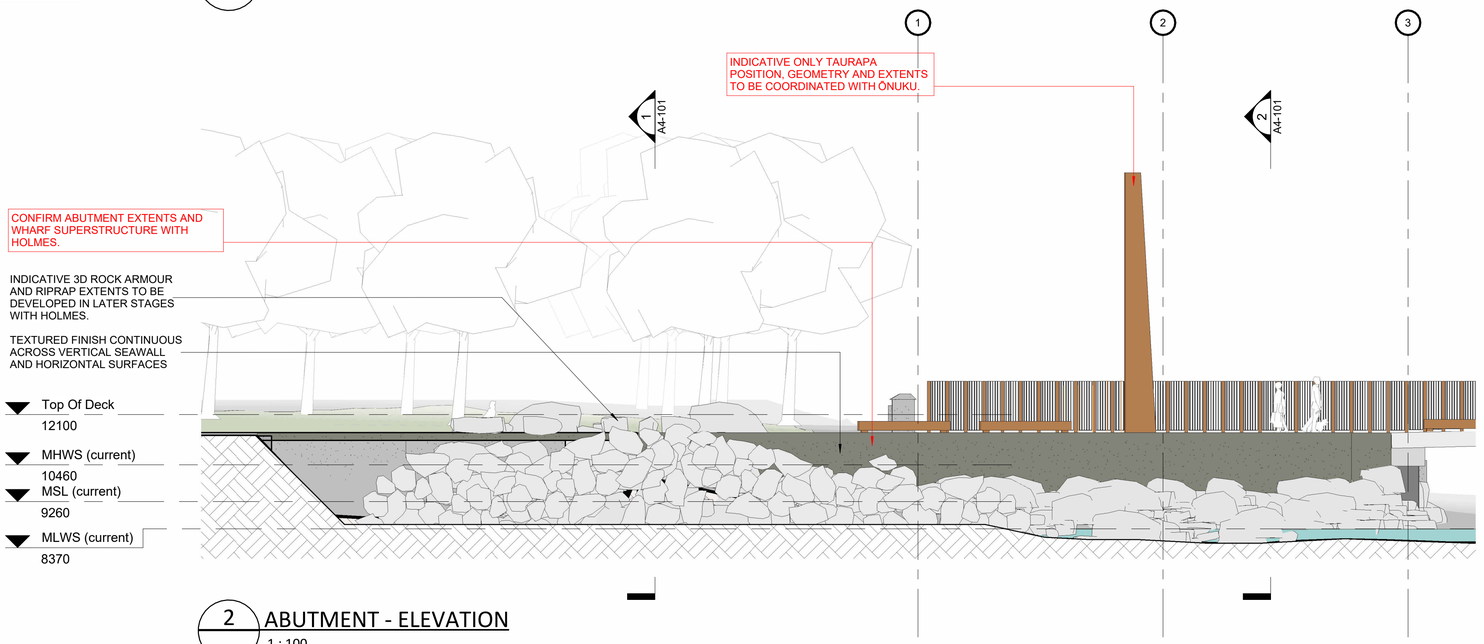
Drawing No.
A4-001



ABUTMENT - OVERALL 3D

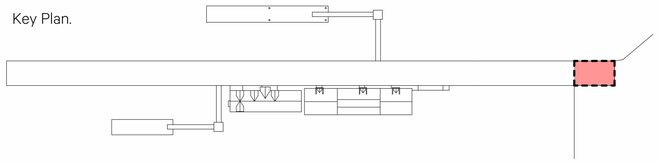


1 / A1-003 — PART PLAN - ABUTMENT
1 : 100



2 — ABUTMENT - ELEVATION
1 : 100

Key Plan.



Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Drawing Title
Abutment

Current Status
Preliminary Design

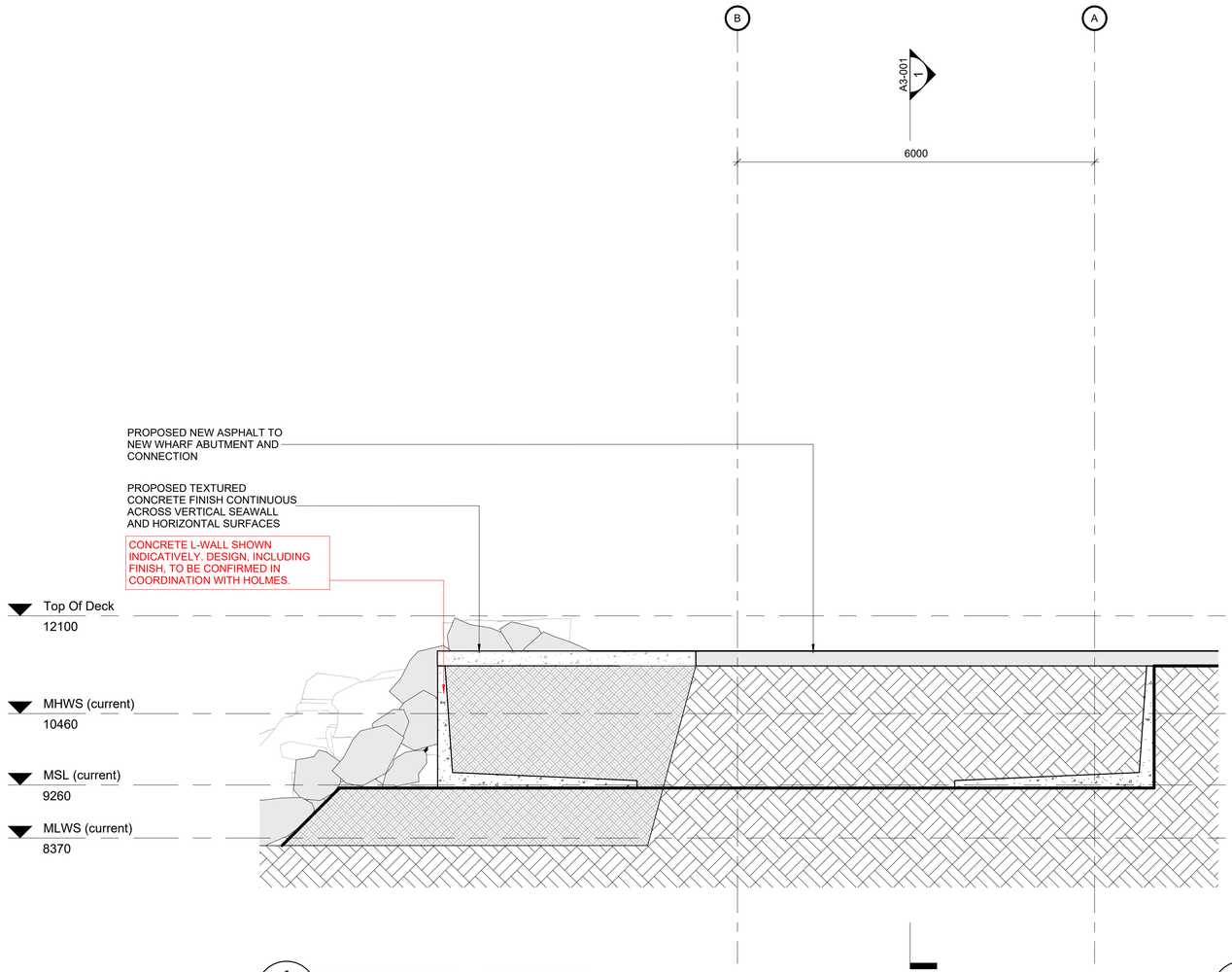
Job Name
Akaroa Wharf

Scale
1 : 100 @ A1
50% @ A3

Revision
A

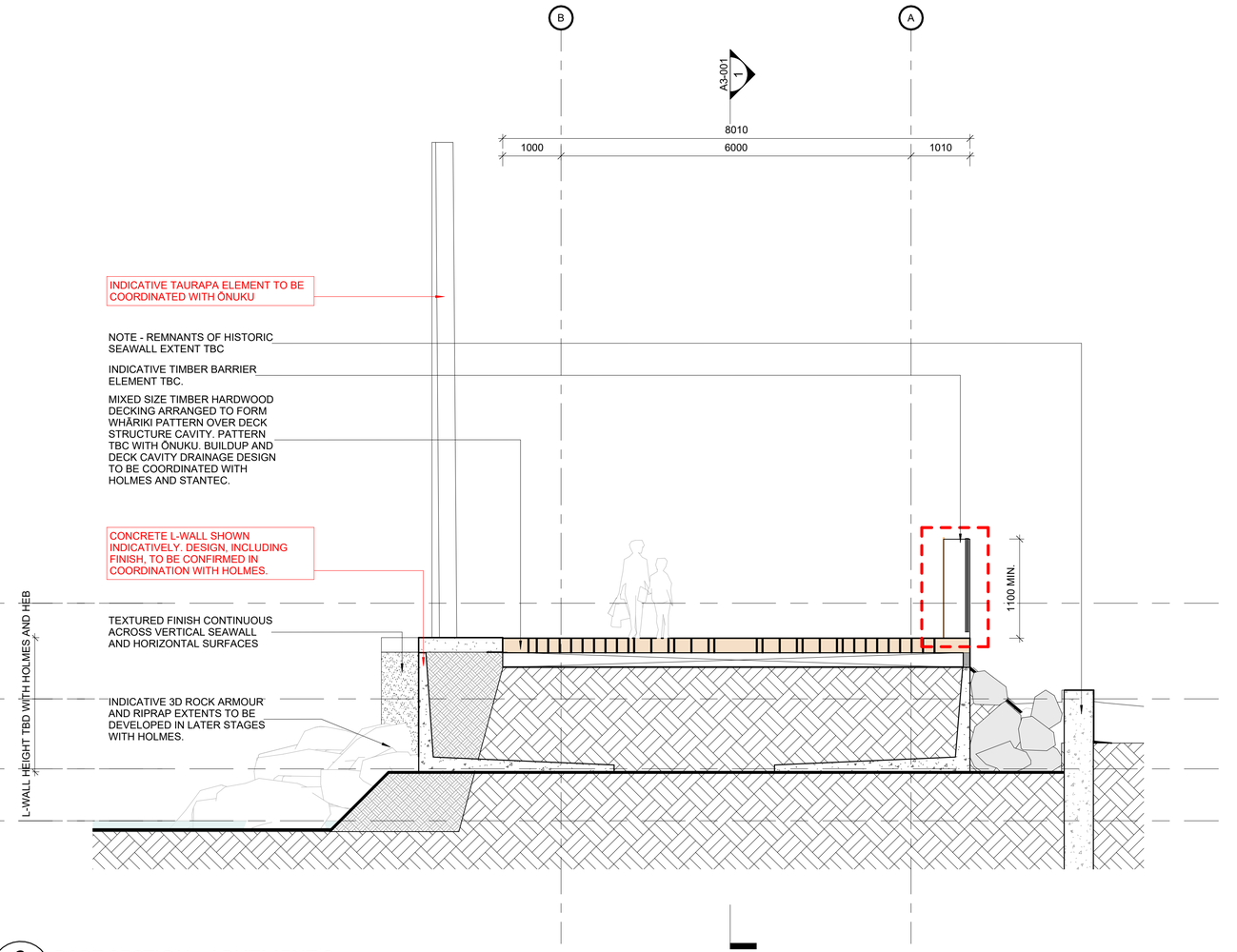
Job No.
4389

Drawing No.
A4-100



1 A1-003 PART SECTION - ABUTMENT

1 : 50

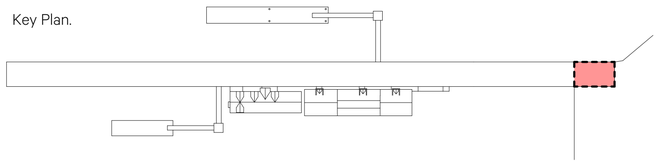


2 A1-003 PART SECTION - ABUTMENT 2

1 : 50

PLEASE NOTE ABUTMENT BUILDUP SHOWN INDICATIVELY. BUILDUP AND STRUCTURE TO BE DEVELOPED IN LATER STAGES.

Key Plan.



Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Drawing Title
Abutment

Current Status
Preliminary Design

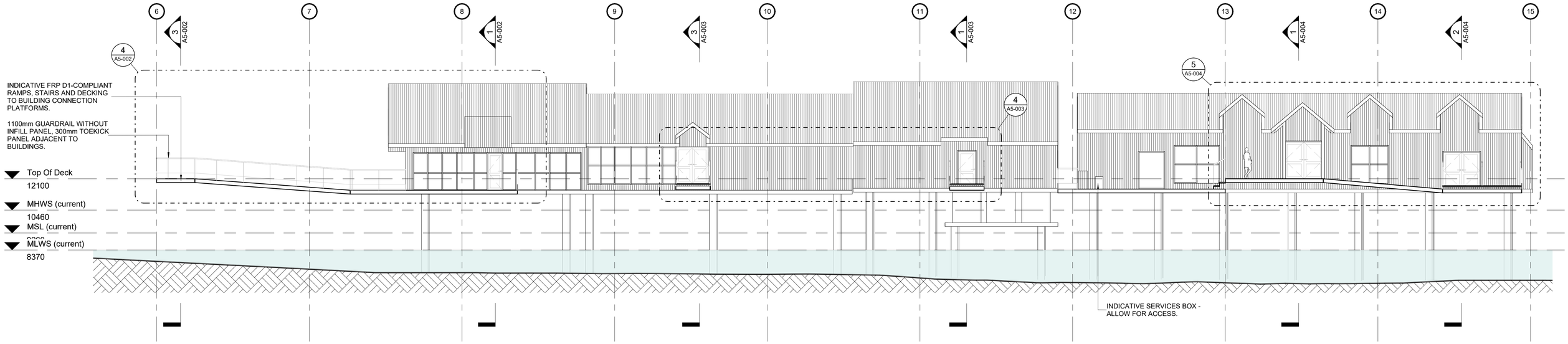
Job Name
Akaroa Wharf

Scale
1 : 50 @ A1
50% @ A3

Revision
A

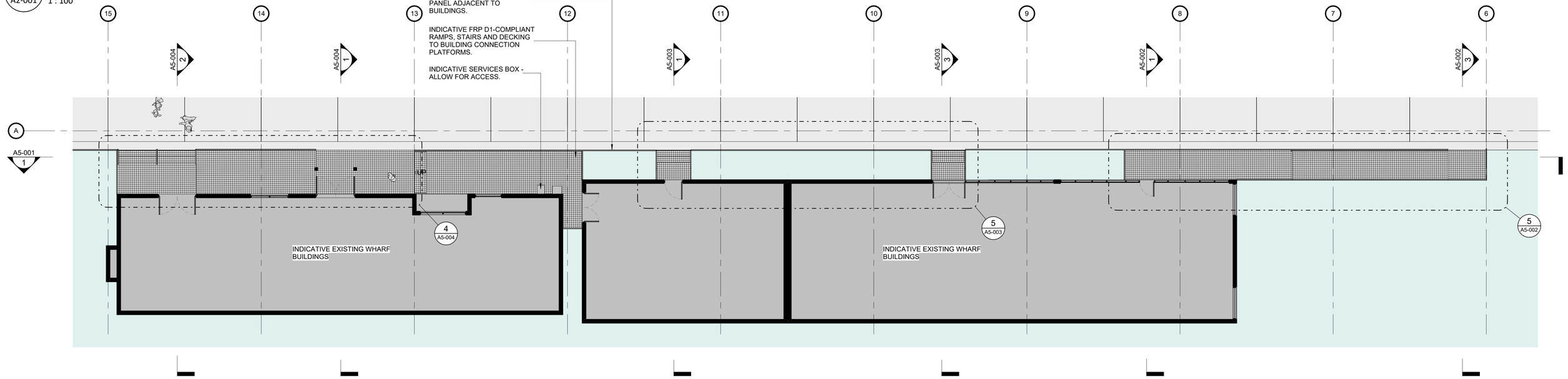
Job No.
4389

Drawing No.
A4-101



1 PART SECTIONAL ELEVATION - BUILDING INTERFACE

A2-001 1 : 100



2 PART PLAN - BUILDING INTERFACE

A1-003 1 : 100

PLEASE NOTE BUILDING CONNECTIONS ARE SHOWN INDICATIVELY AND WILL NEED FURTHER DEVELOPMENT ONCE WHARF STRUCTURAL SETOUT IS CONFIRMED.

Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Drawing Title
Building Connections - GA

Current Status
Preliminary Design

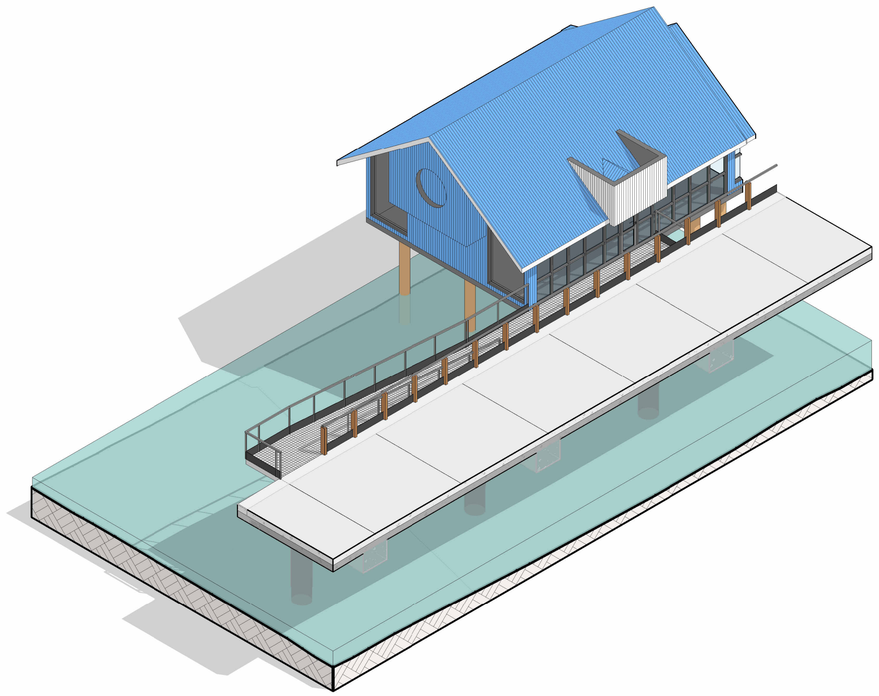
Job Name
Akaroa Wharf

Scale
1 : 100 @ A1
50% @ A3

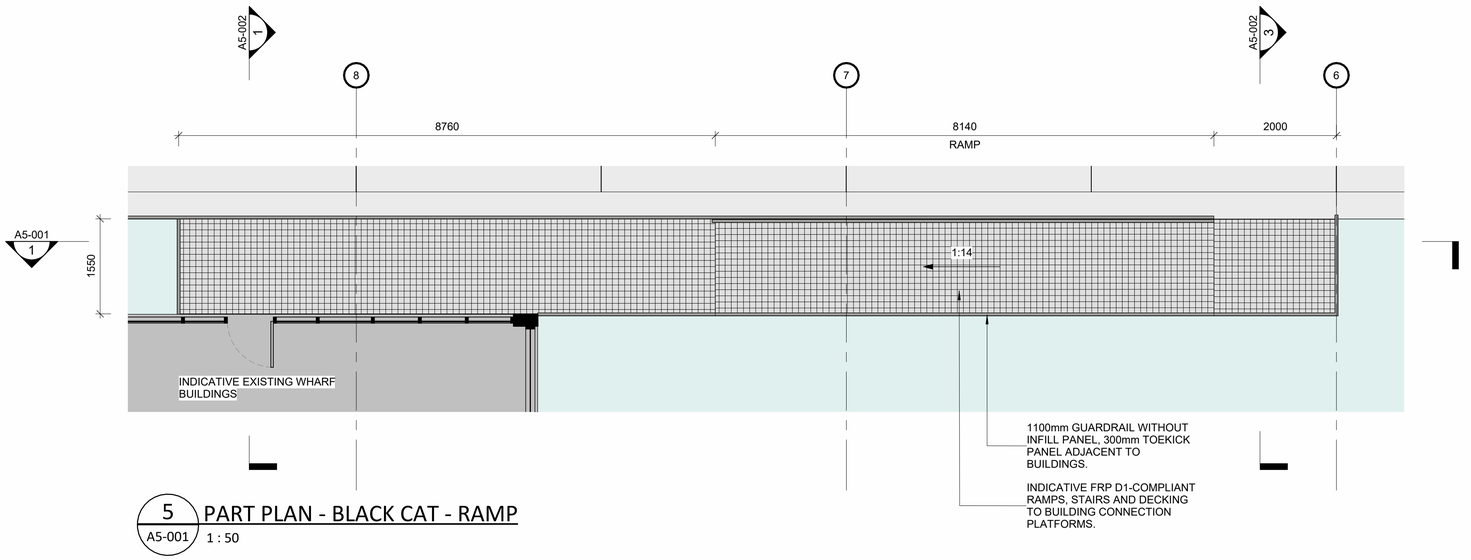
Revision
A

Job No.
4389

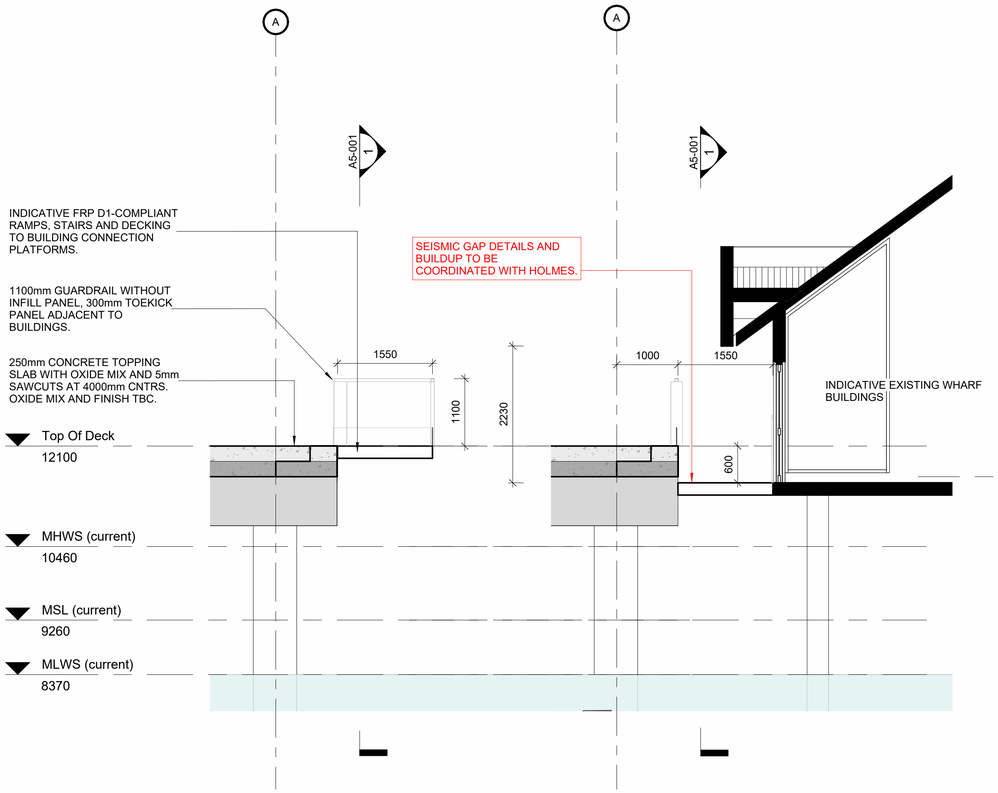
Drawing No.
A5-001



BLACK CAT - OVERALL 3D

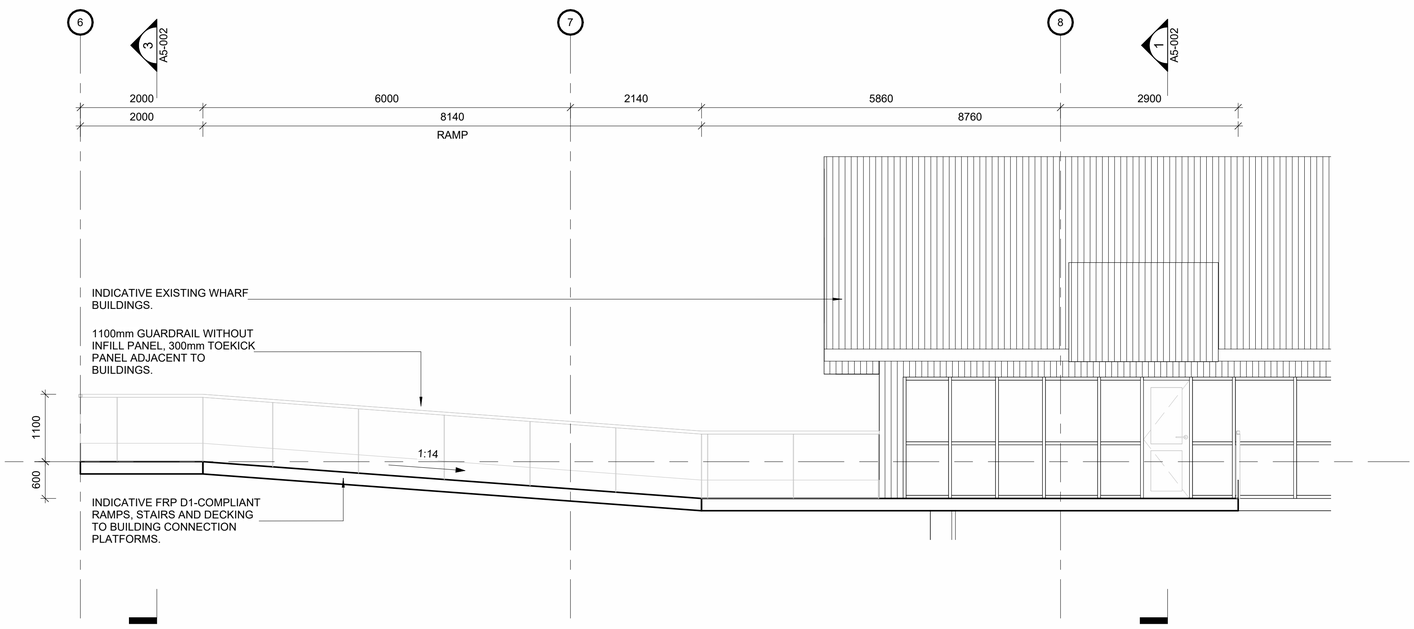


5 A5-001 PART PLAN - BLACK CAT - RAMP
1 : 50



3 A5-001 PART SECTION - TOP OF RAMP
1 : 50

1 A5-001 PART SECTION - BOTTOM OF RAMP
1 : 50



4 A5-001 PART SECTIONAL ELEVATION - BLACK CAT - RAMP
1 : 50

PLEASE NOTE BUILDING CONNECTIONS ARE SHOWN INDICATIVELY AND WILL NEED FURTHER DEVELOPMENT ONCE WHARF STRUCTURAL SETOUT IS CONFIRMED.

Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Current Status
Preliminary Design

Job Name
Akaroa Wharf

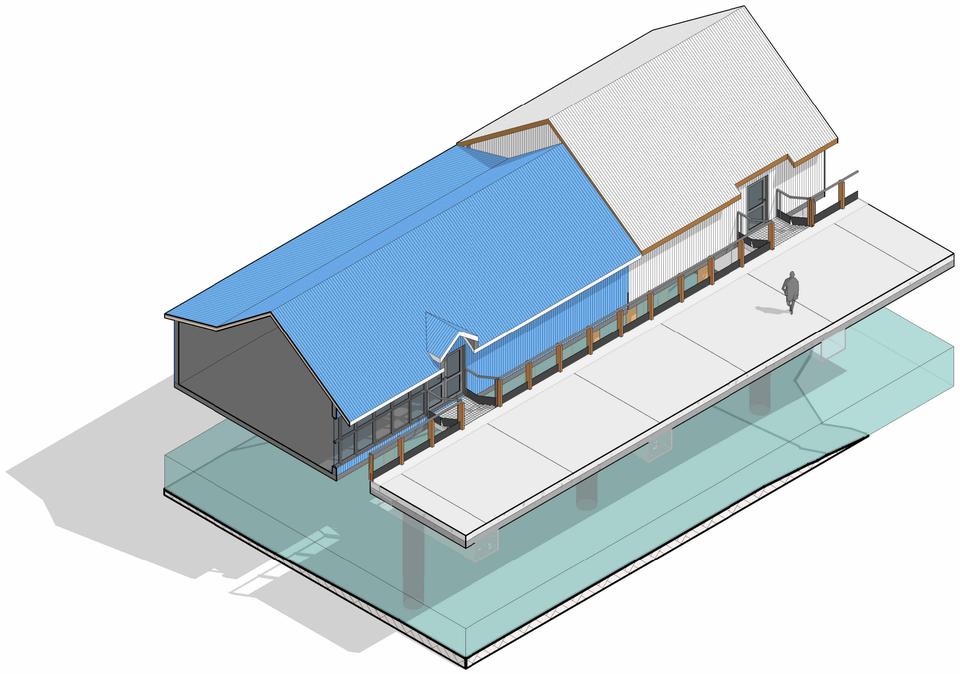
Drawing Title
Building Connections

Scale
1 : 50 @ A1
50% @ A3

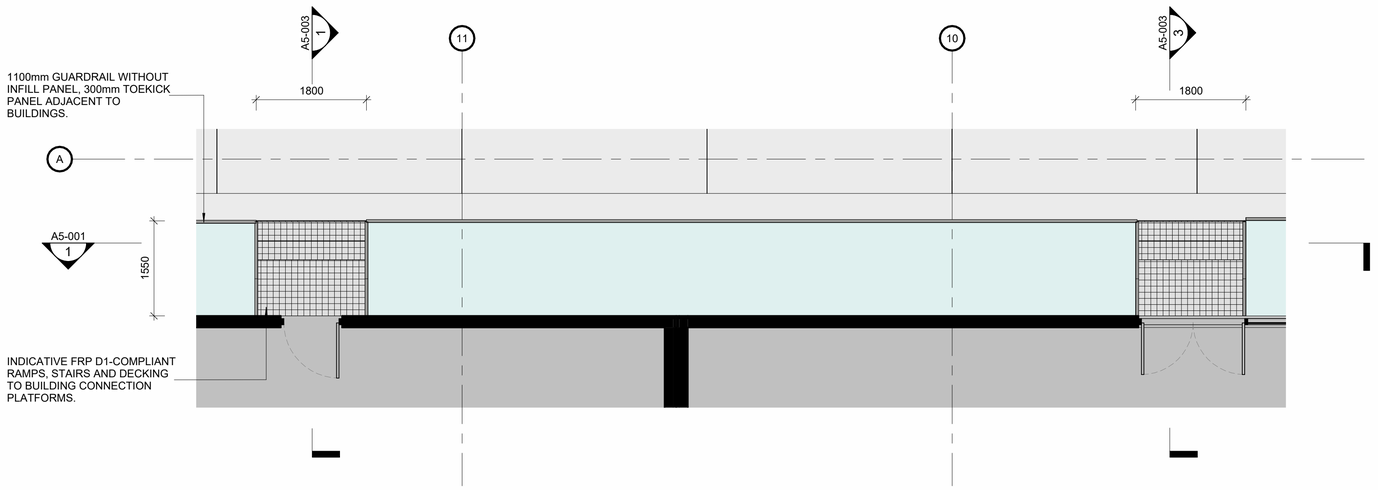
Revision
A

Job No.
4389

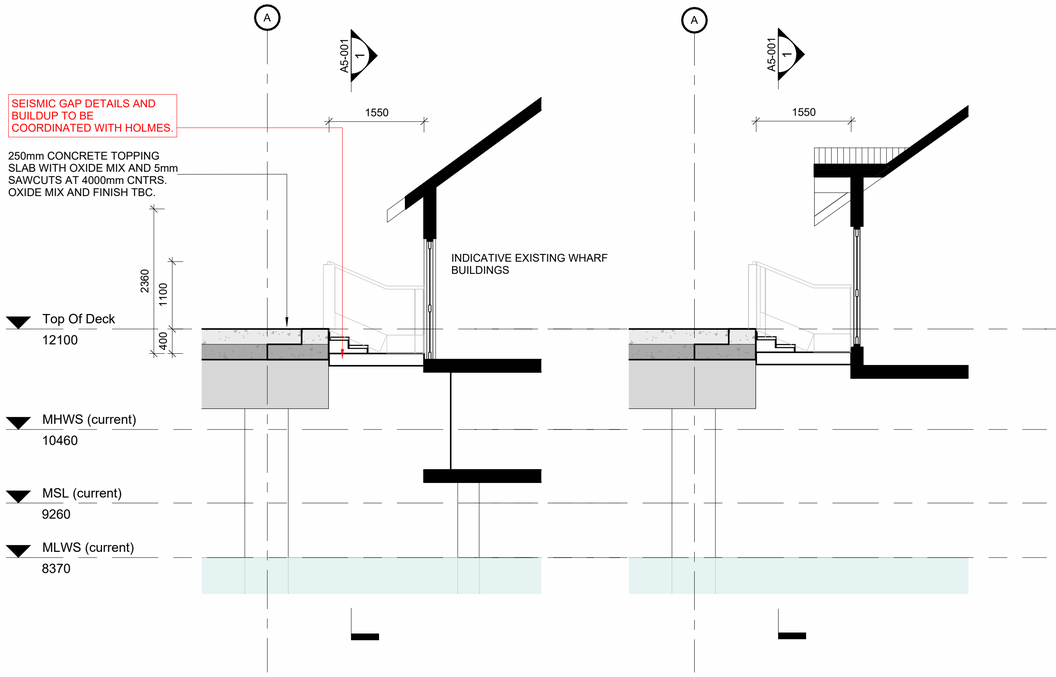
Drawing No.
A5-002



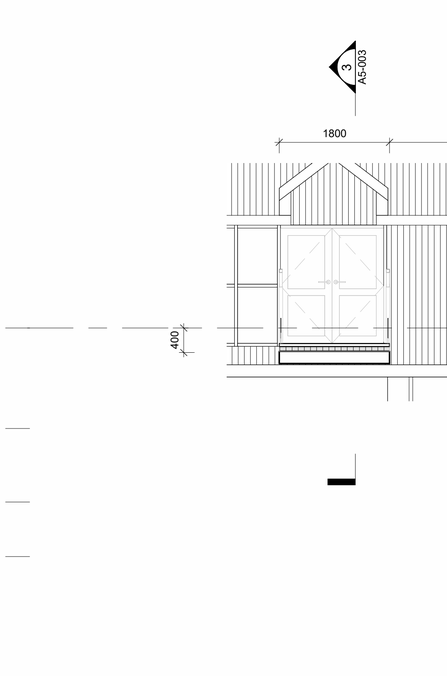
BLACK CAT - SERVICE STAIRS - OVERALL 3D



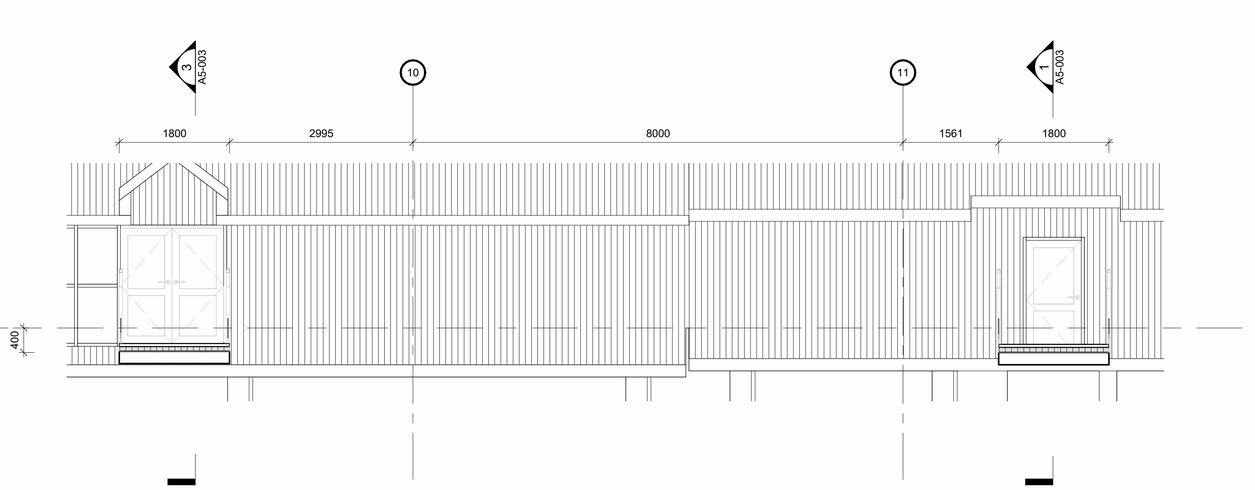
5 A5-001 PART PLAN - BLACK CAT - SERVICE STAIRS
1 : 50



1 A5-001 PART SECTION - SERVICE STAIRS
1 : 50



3 A5-001 PART SECTION - SERVICE STAIRS 2
1 : 50



4 A5-001 PART SECTIONAL ELEVATION - BLACK CAT - SERVICE STAIRS
1 : 50

PLEASE NOTE BUILDING CONNECTIONS ARE SHOWN INDICATIVELY AND WILL NEED FURTHER DEVELOPMENT ONCE WHARF STRUCTURAL SETOUT IS CONFIRMED.

Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Drawing Title
Building Connections

Current Status
Preliminary Design

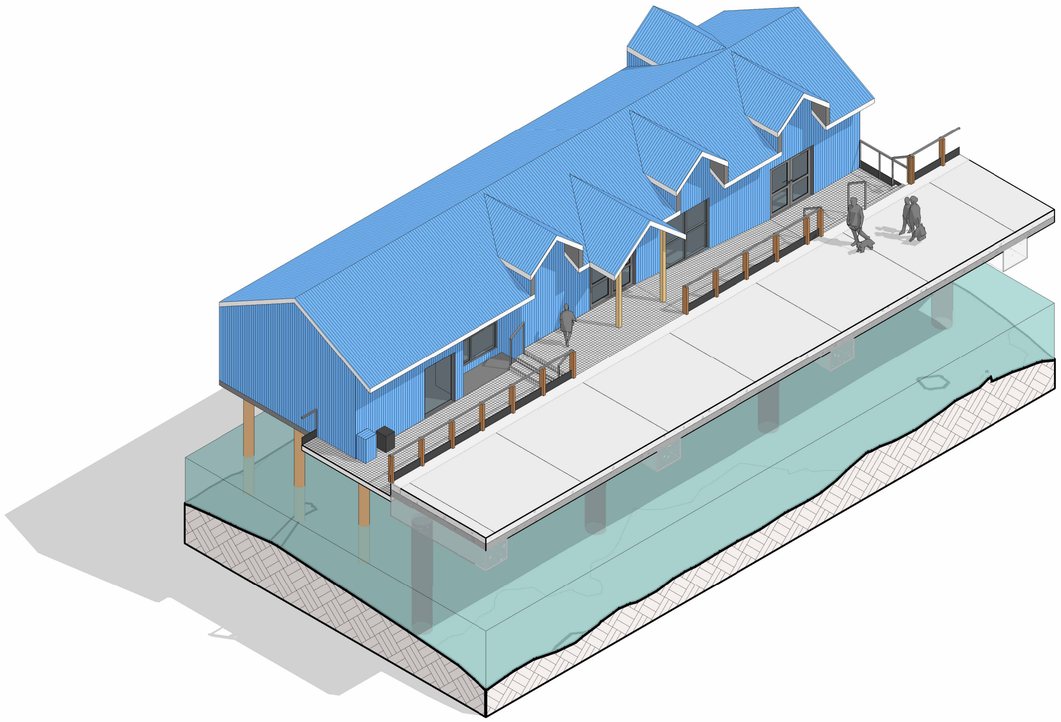
Job Name
Akaroa Wharf

Scale
1 : 50 @ A1
50% @ A3

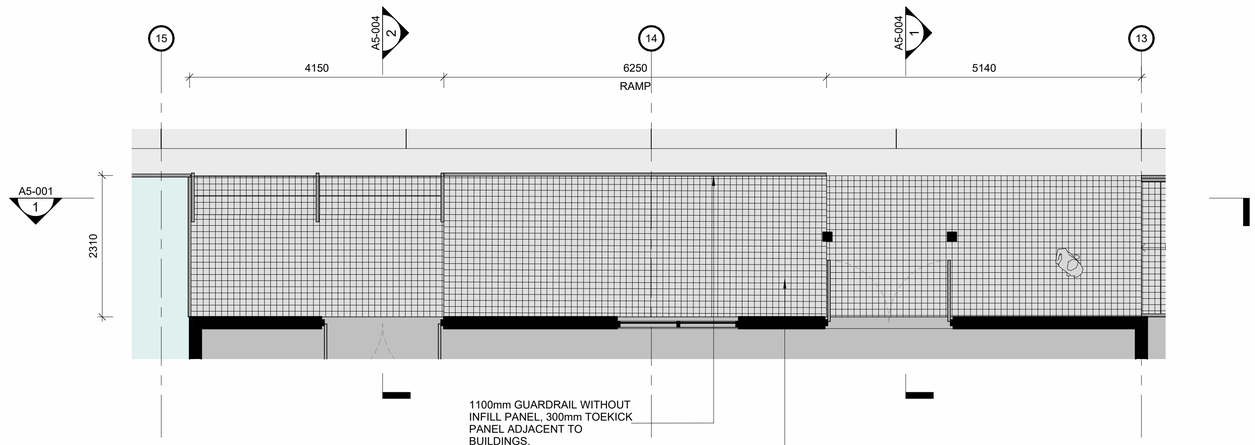
Revision
A

Job No.
4389

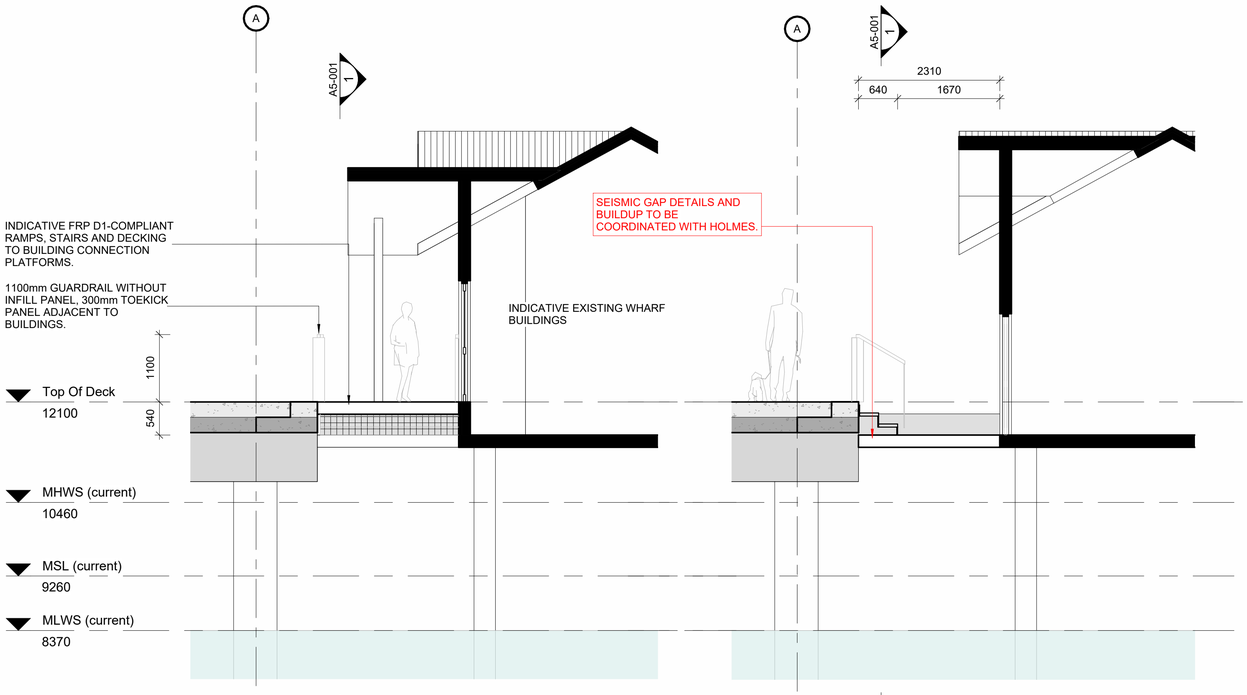
Drawing No.
A5-003



BLUE PEARL - OVERALL 3D



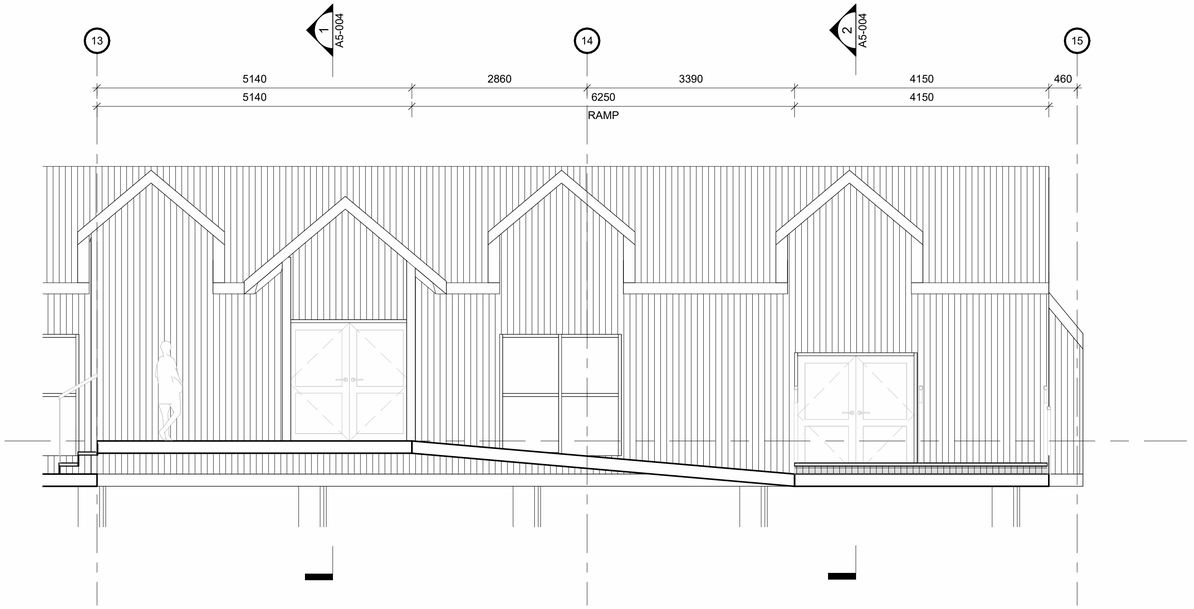
4 A5-001 — PART PLAN - BLUE PEARL
1 : 50



1 A5-001 — PART SECTION - BLUE PEARL - TOP OF RAMP
1 : 50

2 A5-001 — PART SECTION - BLUE PEARL - BOTTOM OF RAMP
1 : 50

PLEASE NOTE BUILDING CONNECTIONS ARE SHOWN INDICATIVELY AND WILL NEED FURTHER DEVELOPMENT ONCE WHARF STRUCTURAL SETOUT IS CONFIRMED.



5 A5-001 — PART SECTIONAL ELEVATION - BLUE PEARL
1 : 50

Rev.	Description	Date
A	PRELIMINARY DESIGN	04/06/2025

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Drawing Title
Building Connections

Current Status
Preliminary Design

Job Name
Akaroa Wharf

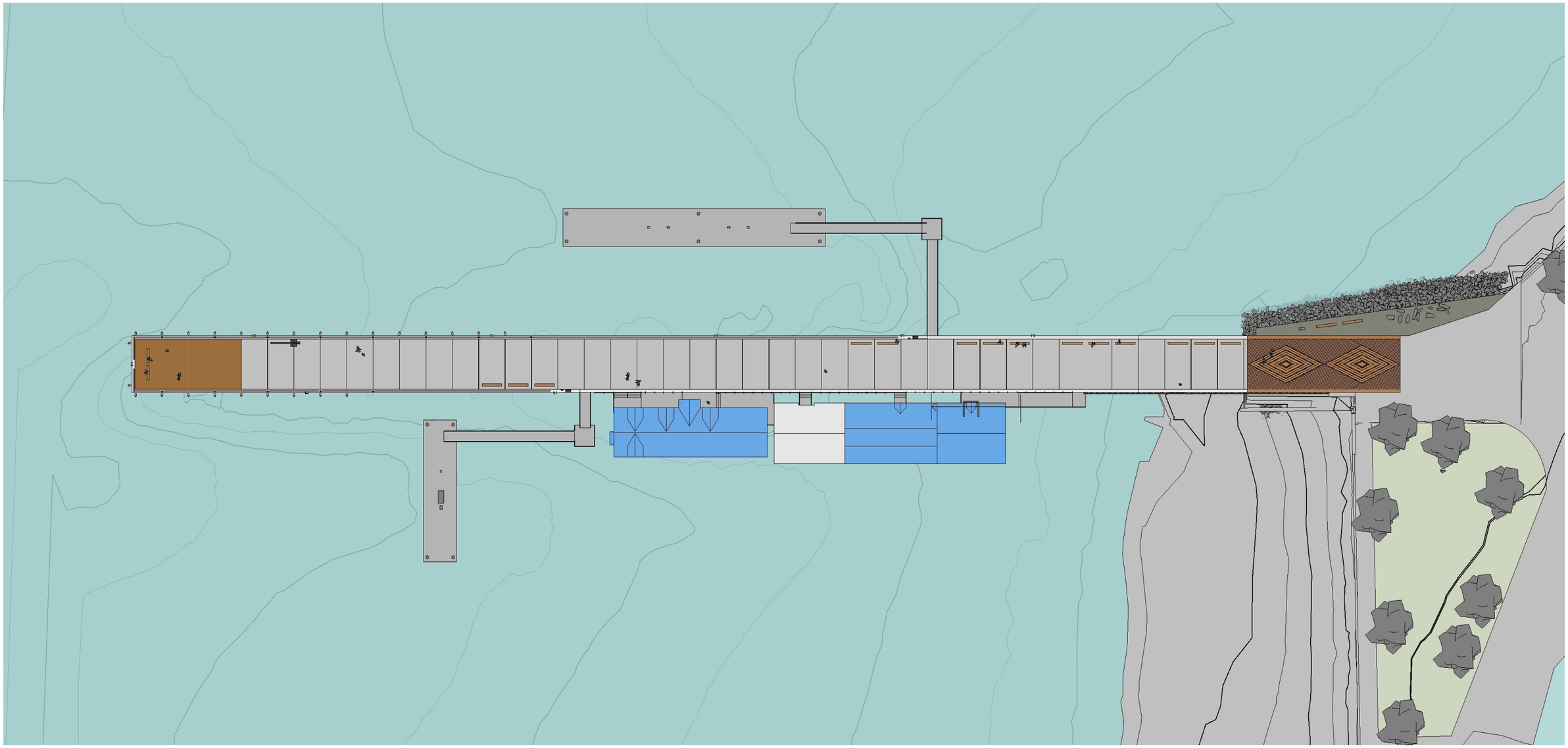
Scale
1 : 50 @ A1
50% @ A3

Revision
A

Job No.
4389

Drawing No.
A5-004

Akaroa Wharf Concept.
Site plan.



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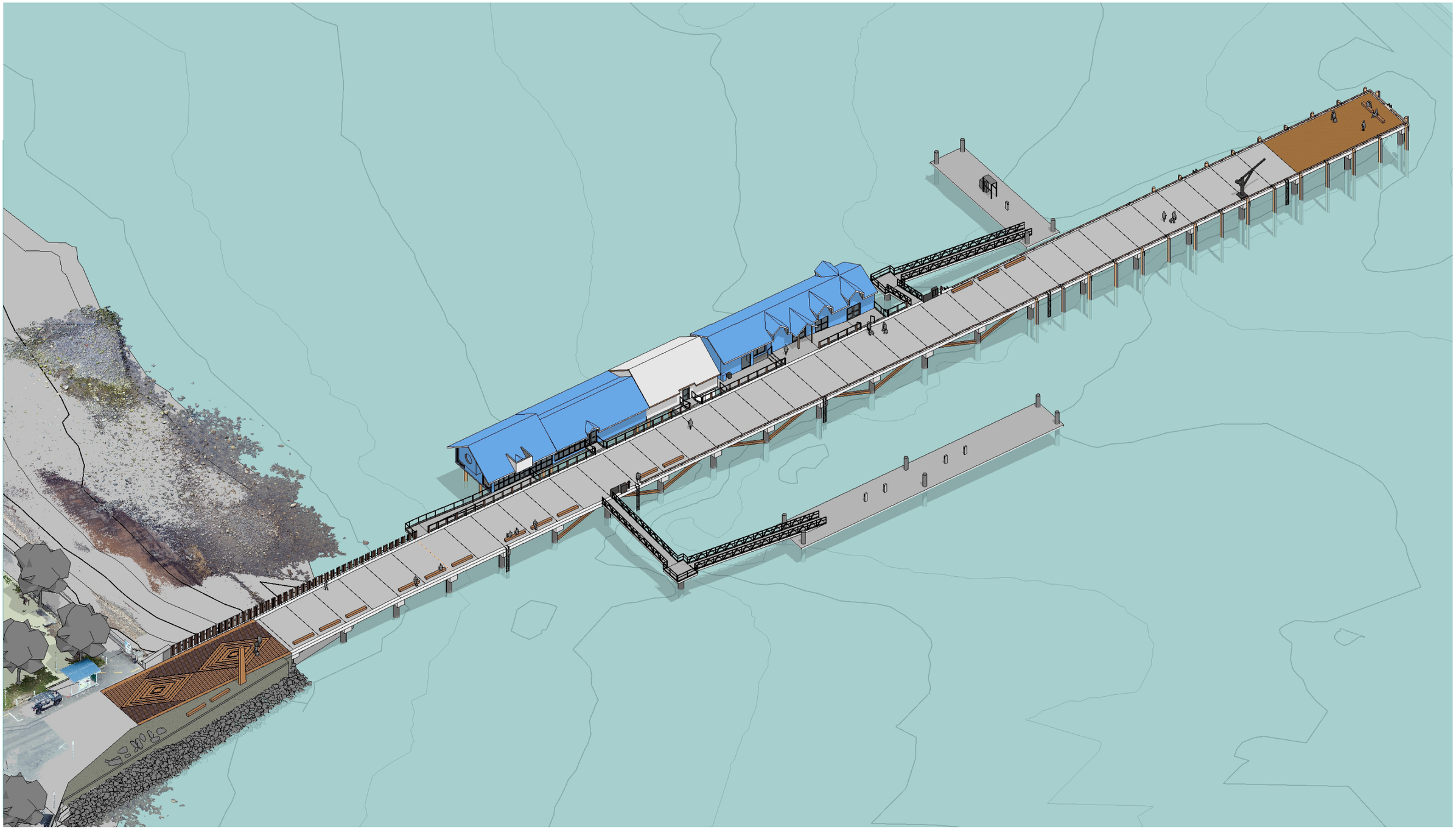
Akaroa Wharf Concept Design.
CCC.
22 July 2025.

Akaroa Wharf Concept.
Axonometric.



Isthmus.

Akaroa Wharf Concept Design.
CCC.
22 July 2025.

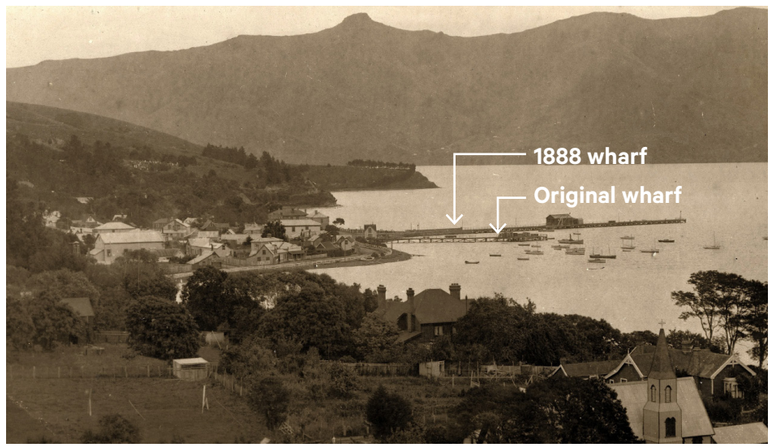
Akaroa Wharf.
Revised Abutment Concept.

04 June
2025

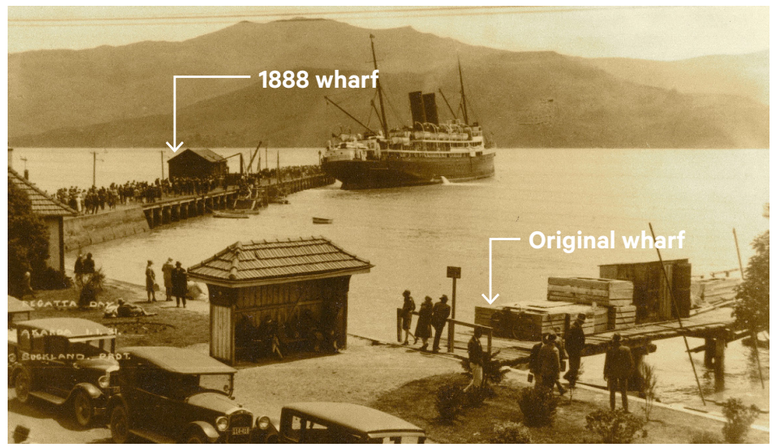
Isthmus.

Revised Abutment Concept.
Edge Condition Over Time.

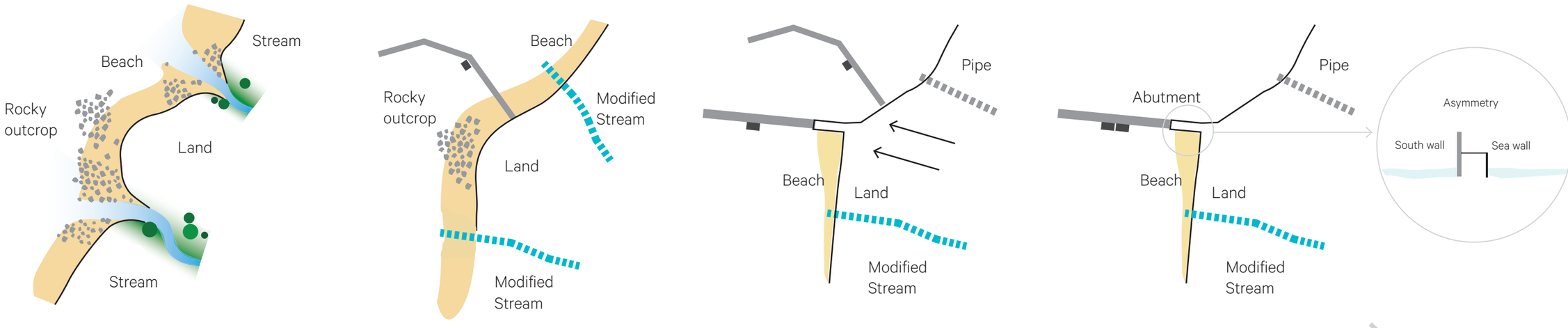
Early 1880's Akaroa, Original 1850's wharf. H.Poulton, Jan Shuttleworth Collection



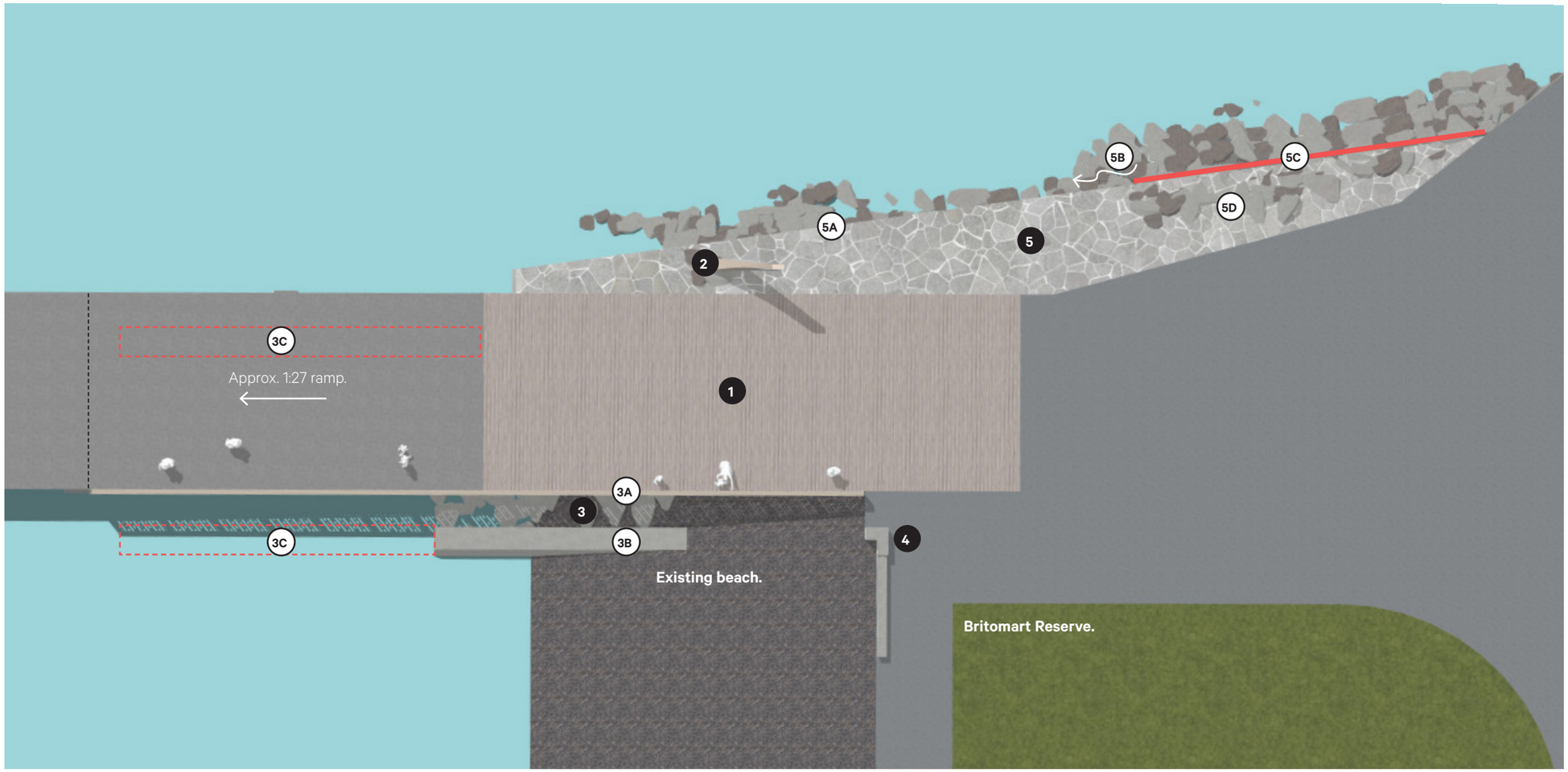
1908, Akaroa South, Jan Shuttleworth Collection.



1931 Regatta Day, Jan Shuttleworth Collection



Revised Abutment Concept.
Indicative Plan.

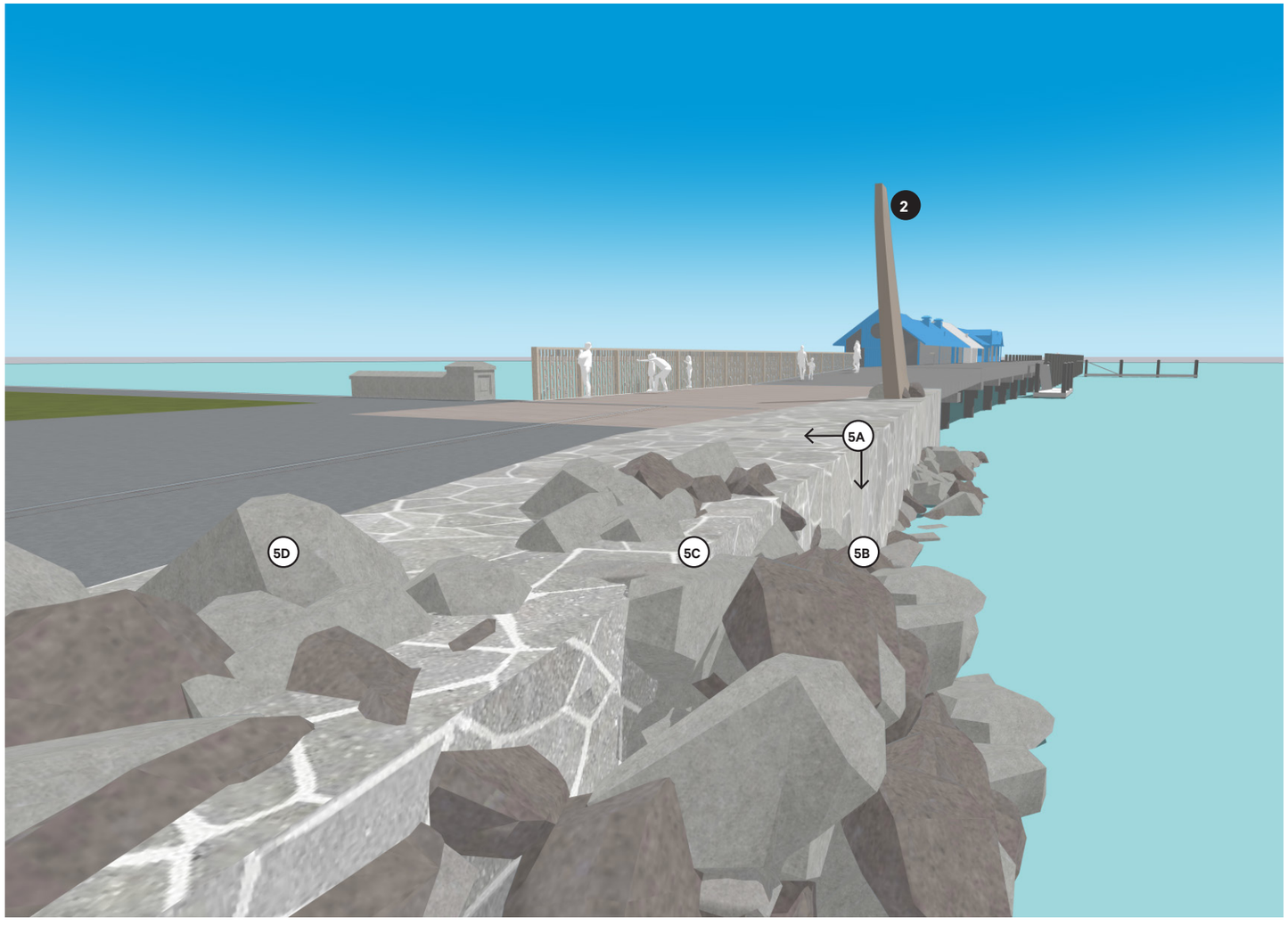


Legend

1	Whāriki (shown indicatively).
2	Taurapa.
3	Weighted edge.
3A	New railing.
3B	Retained portion of heritage seawall - cut cleanly. Gap between sea wall and L wall filled with rock armour.
3C	Ruined portion of heritage seawall - snapped at base. Similar approach could be used for other historic seawall under wharf.
4	Historic plauqe.
5	New ‘3D’ seawall and surface.
5A	Textured finish continuous across vertical seawall and horizontal surfaces.
5B	Informal steps created in rip rap.
5C	Rip rap extends higher up seawall in this location.
5D	Selected stones placed in surface to create informal seating and tactile elements.

Note.
Drawing not to scale and indicative to communicate look and feel for revised abutment concept only.

Revised Abutment Concept.
‘3D’ Seawall & Surface.



Taurapa. 2

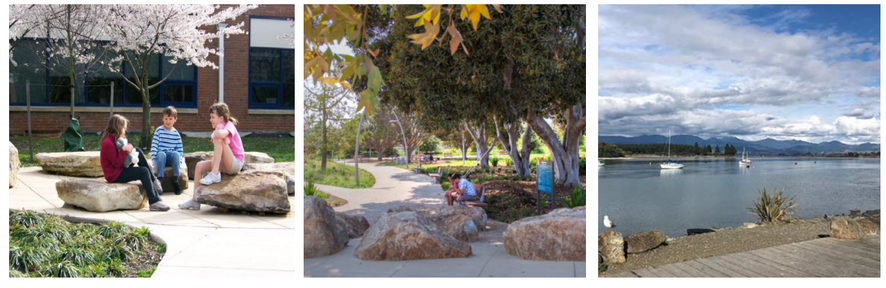
Textured finish continuous across vertical seawall and horizontal surfaces. 5A

Informal steps created in rip rap. 5B

Rip rap extends higher up seawall in this location. 5C

Selected stones placed in surface to create informal seating and tactile elements. 5D

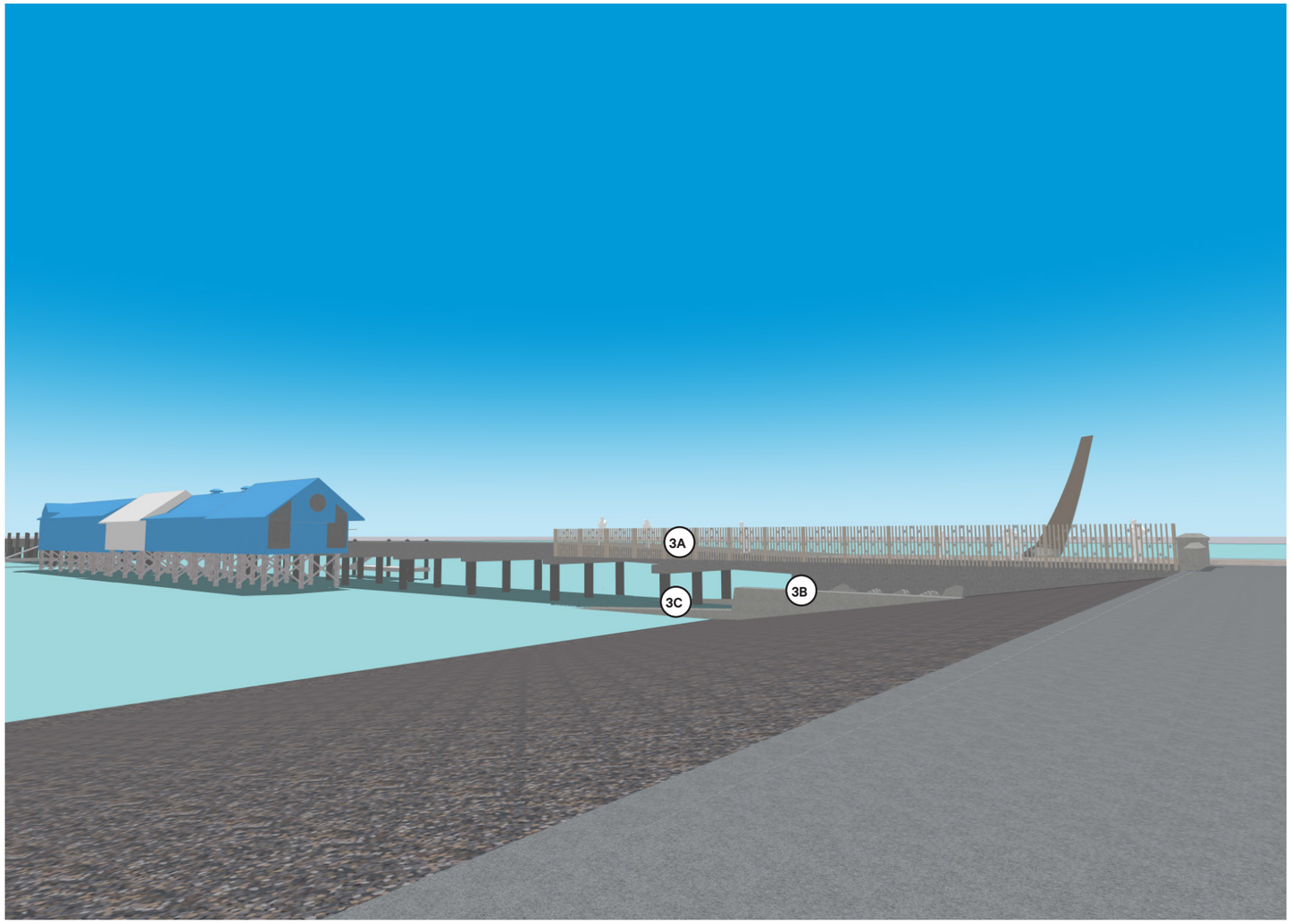
5A 3D finish wraps over vertical and horizontal surfaces. A variety of different finishes could be tested for this element to meet budget and functional constraints. Key design intent is that surface feels textured and should not attempt to replicate the existing seawall surface.



5D Selected stones are placed on top of the new surfacing. These can provide informal seating, protect the edge from vehicle movement and offer moments of interest.

Revised Abutment Concept.
Retained Abutment Seawall.

New railing. 3A
Retained heritage seawall. 3B
Retention of part of heritage seawall in this section to be reviewed 3C



3B The retained heritage seawall provides a familiar, textured element in the new wharf. It also helps retain the beach and new rock armour. The portion of seawall shown is cleanly cut and extends slighlty beyond the new abutment.

3C The second half of the wall beyond the new abutment could be snapped at low level and left to ruin, providing further protection to the beach and an interesting heritage remanant to explore at low tide. The same strategy could be employed for the northern heritage sea wall extent under the new wharf.

Land.
People.
Culture.
Isthmus.

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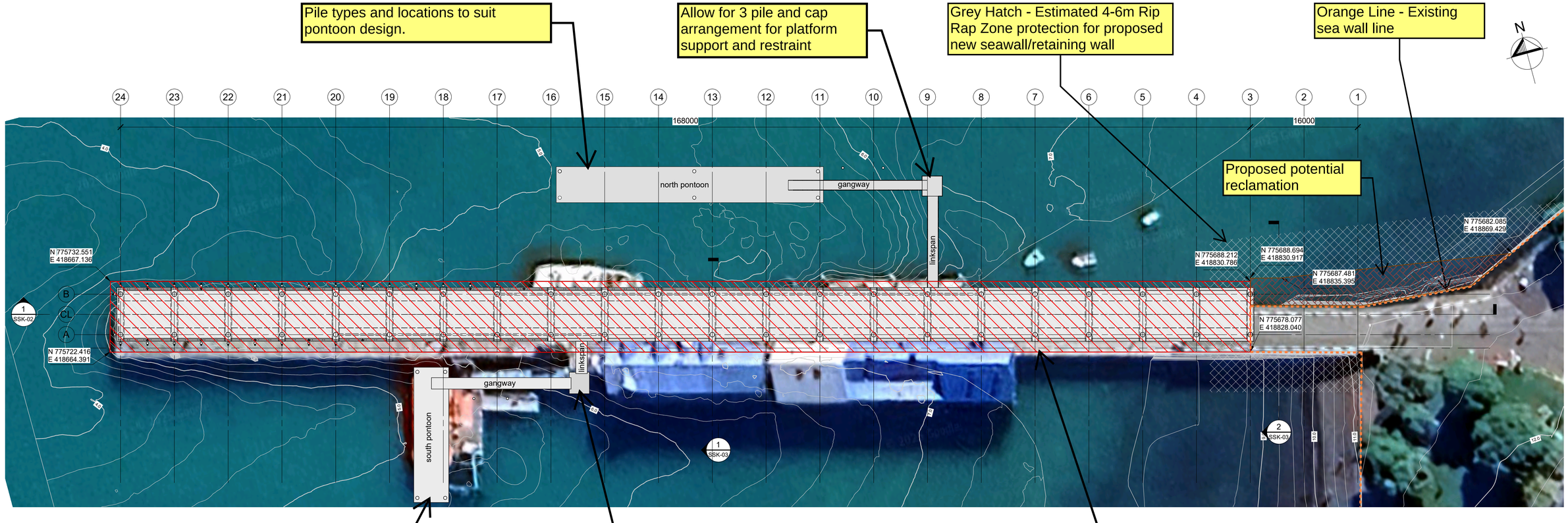

1 / - general arrangement plan
1 : 300

Notes:

- All coordinates are approximate only as they are based on Calibre Lidar Survey and initial CCC topo data provided by CCC in 2020. All design documentation subject to final confirmation with cadastral survey of existing wharf.
- The coordinate system used is Mount Plesent 2000
- All Wharf coordinates are based on the edge of the proposed wharf and exclude fenders, ladders and other components
- All existing seawall and proposed reclamation coordinates are based on the outer edge of the top of the sea wall.
- Total bent numbers may vary from 24 to 18. Total number of wharf piles may also vary from 48 to 42 (exc pontoon and platform piles)
- Pontoon, platform and gangway layout taken from Enviser Pontoon Concept Layout option F Rev 0. Design by others.

Rev	Date	Appd	Reason
B	4/06/2025	AZE	Resource Consent WIP
A	9/04/2025	AZE	Resource Consent WIP

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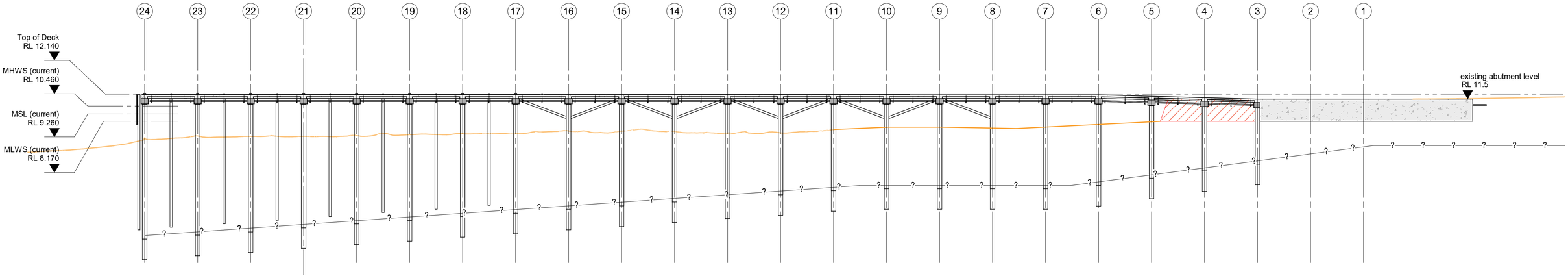
AKAROA WHARF RENEWAL

Sheet Title: general arrangement plan

Drawn: DLP | Scale: 1:300 (at A1)
Filename: 145457.31_Akaroa Wharf Renewal.rvt
Job Number: 145457.31 | Sheet Number: SSK-01 | Rev: B



1 / - longitudinal section
1 : 300

Notes:

- All coordinates are approximate only as they are based on Calibre Lidar Survey and initial CCC topo data provided by CCC in 2020. All design documentation subject to final confirmation with cadastral survey of existing wharf.
- The coordinate system used is Mount Plesent 2000
- All Wharf coordinates are based on the edge of the proposed wharf and exclude fenders, ladders and other components
- All existing seawall and proposed reclamation coordinates are based on the outer edge of the top of the sea wall.
- Total bent numbers may vary from 24 to 18. Total number of wharf piles may also vary from 64 to 44 (exc pontoon and platform piles)
- Pontoon, platform and gangway layout taken from Enviser Pontoon Concept Layout option F Rev 0. Design by others.

All dimensions to be verified on site before making any shop drawings or commencing any work.

Rev	Date	Appd	Reason
B	4/06/2025	AZE	Resource Consent WIP
A	9/04/2025	AZE	Resource Consent WIP

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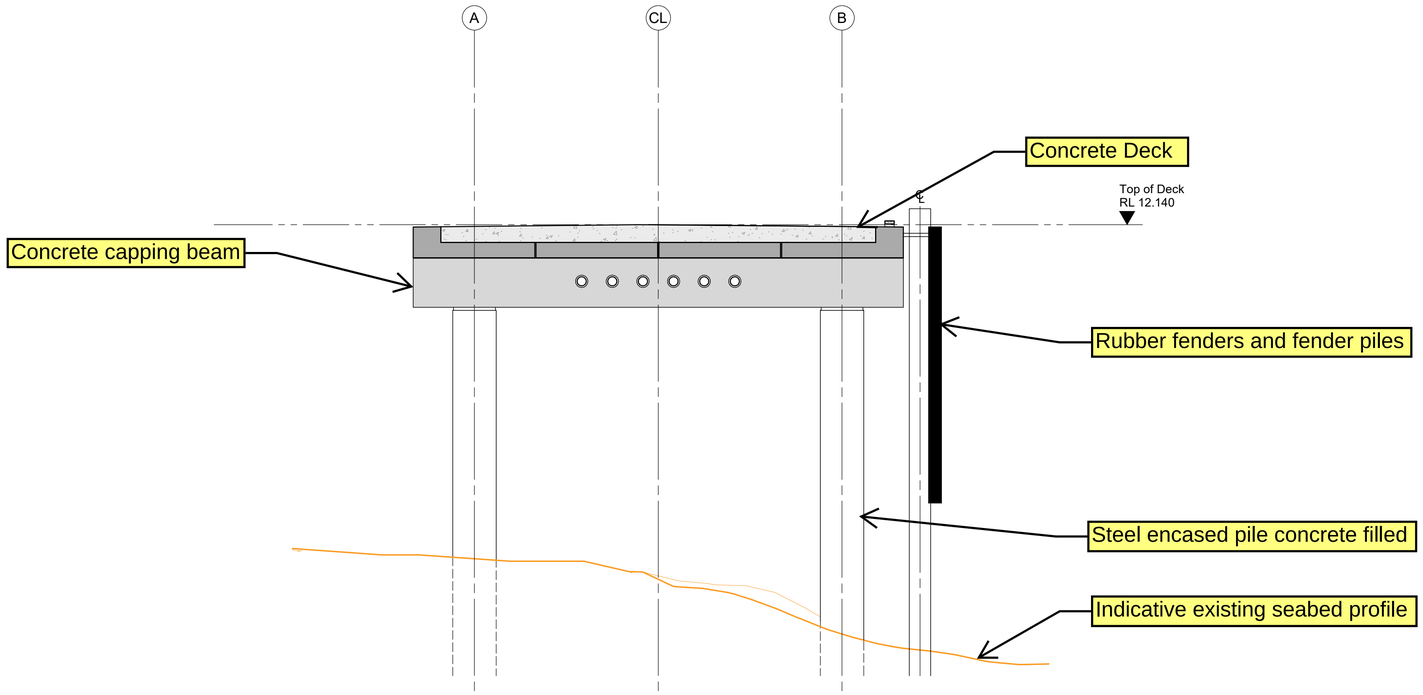
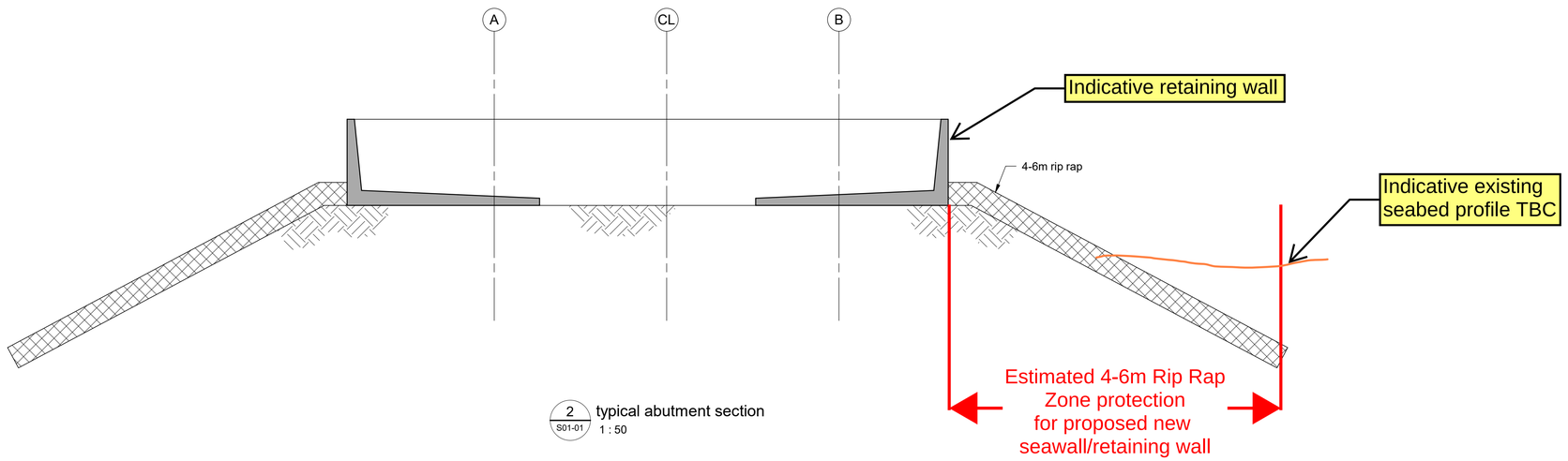
AKAROA WHARF RENEWAL

Sheet Title: longitudinal section

Drawn: AJW | Scale: 1:300 (at A1)
Filename: 145457.31_Akaroa Wharf Renewal.rvt
Job Number: 145457.31 | Sheet Number: SSK-02 | Rev: B



1 S01-01 typical bent section at buildings platform
1 : 50



2 S01-01 typical abutment section
1 : 50

Rev	Date	Appd	Reason
B	4/06/2025	AZE	Resource Consent WIP
A	9/04/2025	AZE	Resource Consent WIP

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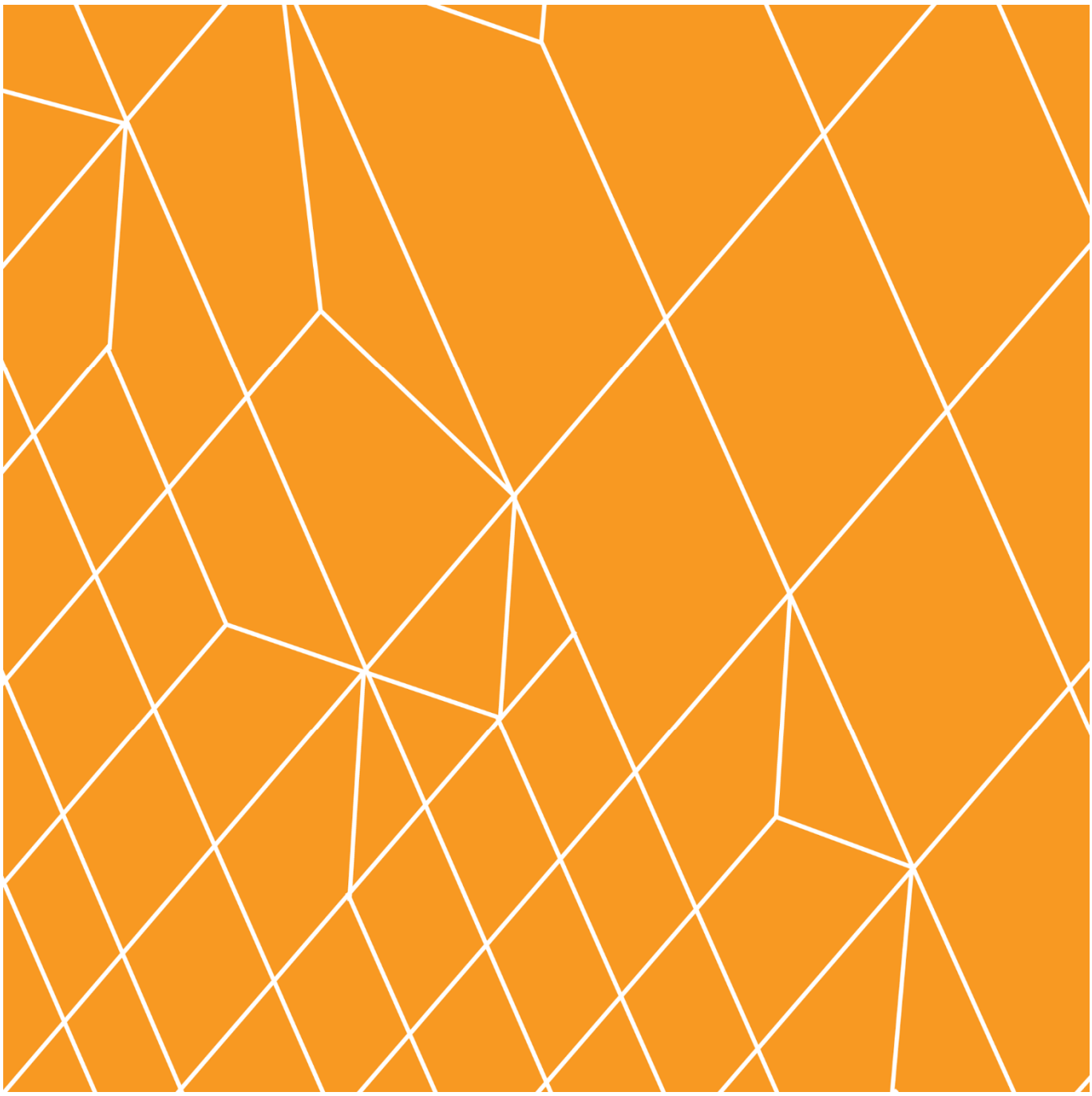
AKAROA WHARF RENEWAL

Sheet Title: typical sections

Drawn: DLP | Scale: 1:300 (at A1)

Filename: 145457.31_Akaroa Wharf Renewal.rvt

Job Number	Sheet Number	Rev
145457.31	SSK-03	B



Akaroa Wharf Renewal

Akaroa Wharf

Christchurch

Design Features Report – Resource Consent

Holmes

Version 5
August 2025
145457.31

Design Features Report
Akaroa Wharf Renewal

Prepared for
Christchurch City Council

Date: 11 August 2025
Project No: 145457.31
Revision No: 5

Prepared by:

Nigel van den Akker
Project Engineer
Holmes NZ LP

Approved by:

Ashley Eyles
Project Director
Holmes NZ LP

Report Issue Register

DATE	REV. NO.	REASON FOR ISSUE
05 July 2024	1	Concept Design (Client Issue) – *Draft*
29 October 2024	2	Concept Design (Final)
16 December 2024	3	Preliminary Design (Client Issue) - *Draft*
4 June 2025	4	Resource Consent
11 August 2025	5	Resource Consent Update

CONTENTS

1 GENERAL

1.1 Objective

The Design Features Report (DFR) is a detailed document defining the structure's design criteria and recording key decisions or outcomes. It outlines design loading, safety, structural modelling assumptions, material properties, foundation requirements, and design standards. The DFR also defines the calculation procedure and checking principles to be followed, providing a clear explanation of the full structural design.

The DFR also is a live document that will be updated as the design and construction proceeds. At completion, it forms a part of the design record and should be archived for future reference if required.

1.2 Scope

The scope of work is in accordance with the Principal's Requirements Guide (PR's) and is described in this DFR.. This report relates to the Structural elements only but should be read in conjunction with the latest Geotechnical Report prepared by Holmes NZ LP.

Specifically, this report covers:

- Structural design of the wharf including deck, piles, and fender support systems.
- Abutment / connection to shore.
- Abutment reinforced concrete retaining walls

This report excludes the following items:

- Demolition of the existing wharf
- The existing buildings along the southern edge of the wharf and their support structure.
- Structure to provide access between the new wharf and the adjacent buildings after demolition of the existing wharf.
- The design of the new floating pontoon structures either side of the wharf including elements to provide access between these and the new wharf e.g., gangways/linkspan and support platforms.
- Design of architectural elements
- Utility services and their support
- Scour protection
- Civil works e.g., pavement design to tie into the new wharf

2 THE PROJECT

2.1 Overview of the Project

Christchurch City Council (Council) is planning to replace the 135-year-old Akaroa Wharf. The wharf is a 155m timber structure which serves commercial and recreational users in the area. The wharf is used regularly by residents, visitors, and commercial fishing and tourism operations.

Holmes NZ LP (Holmes) have been engaged by Council as the Lead Designer for the supply of design services for the renewal of the Akaroa Wharf. Holmes are required to assume responsibility for the structural and geotechnical engineering design services in-line with the scope outlined above. The design services also included Contaminated Land Investigations, a Coastal Engineering Assessment, and producing Principal's Requirements suitable for Council to use in tendering the physical works to the construction market.

Council have recently revised the delivery model from a Design-and-Build (D&B) to a conventional design delivery model followed by physical works. Council will also make use of Early Contractor Involvement (ECI) to commence after the Preliminary Design phase. As such, the development of the Principal's

Requirements is no longer required with this DFR communicating the basis of structural design for the wharf.

2.2 Previous and Parallel Studies

The pre-existing studies, reports, and documentation that have been referenced in carrying out the design services for the new wharf are outlined in Table 1. The studies and documentation that are being progressed in parallel with the design of the new wharf are outlined in Table 2.

Table 1 - Summary of pre-existing reports & documentation

Document Name	Date	Author / Supplied By
Existing Design / Requirements:		
▪ Pre-Concept Drawings: ▪ 25724203 Akaroa Wharf Renewal_Pre Concept Drawing_S240 ▪ 25724203 Akaroa Wharf Renewal_Pre Concept Drawing_S110		Calibre
▪ 25724203 Akaroa Wharf Renewal_User Requirements Report	2021	Enviser
▪ 25724203 Akaroa Wharf Renewal_Draft Landscape Urban Design Concept Report	2022	Isthmus
▪ 25724203 Akaroa Wharf Renewal_Principals Requirements Guide	2023	Calibre
Background to Existing Design:		
▪ 25724203 Akaroa Wharf Renewal_Renewal Options Report	2021	Calibre
▪ 25724203 Akaroa Wharf Renewal_Multi Criteria Analysis Report	2021	Beca
Coastal Hazards Review:		
▪ 25724203 Akaroa Wharf Renewal_Coastal Hazards Review_Initial Report	2019	Jacobs
▪ 25724203 Akaroa Wharf Renewal_Coastal Hazards Review_Addendum	2021	Jacobs
▪ 25724203 Akaroa Wharf Renewal_Coastal Hazards Review_Confirming sea level rise for design	2022	Jacobs
Consultation Summary:		
▪ 25724203 Akaroa Wharf Renewal_Stakeholder Feedback	2021	CCC
▪ 25724203 Akaroa Wharf Renewal_Public Consultation Results	2022	CCC
25724203 Akaroa Wharf Renewal_Scoping and Strategy Report	2019	Planz
25724203 Akaroa Wharf Renewal_Hydrographic Survey	2020	Southern Hydrographic

Document Name	Date	Author / Supplied By
25724203 Akaroa Wharf Renewal_Conservation Plan	2021	Origin
25724203 Akaroa Wharf Renewal_Utilities Survey	2021	CCC
25724203 Akaroa Wharf Renewal_Drummonds Jetty Concept Drawing	2023	Calibre
25724203 Akaroa Wharf Renewal_NZCIC Guidelines Markup	2023	CCC
Akaroa Wharf Condition Report	2021	Calibre

Table 2 - Summary of parallel studies & documentation

Document Name	Date	Author / Supplied By
Coastal Processes Report – Akaroa Main Wharf	2024	PDP
Contaminated Land Investigation – Akaroa Wharf Renewal Project	2024	PDP
Geotechnical Investigation Report – Akaroa Main Wharf and Drummonds Wharf	2024	PDP
Geotechnical Interpretive Report - Akaroa Wharf and Drummonds Wharf – Foundation Design Advice	2024	Holmes
Preliminary Design – Akaroa Main Wharf	2024/2025	Isthmus
Coastal Engineering Assessment (New Wharf & Pontoons)	2024/2025	Enviser

2.3 Preferred Structural Form

The form of the wharf has been further developed through Preliminary Design in collaboration with Council, Isthmus, Holmes and other stakeholders. Minor updates to the detailing of the deck and capping beams have been made since Concept Design through development of the aesthetics of the wharf. The general arrangement of the wharf is shown in the Figures below. Further development of the wharf is expected during the next stages of the design in preparation for Building Consent Exemption with input from Ōnuku and the ECI Contractor.

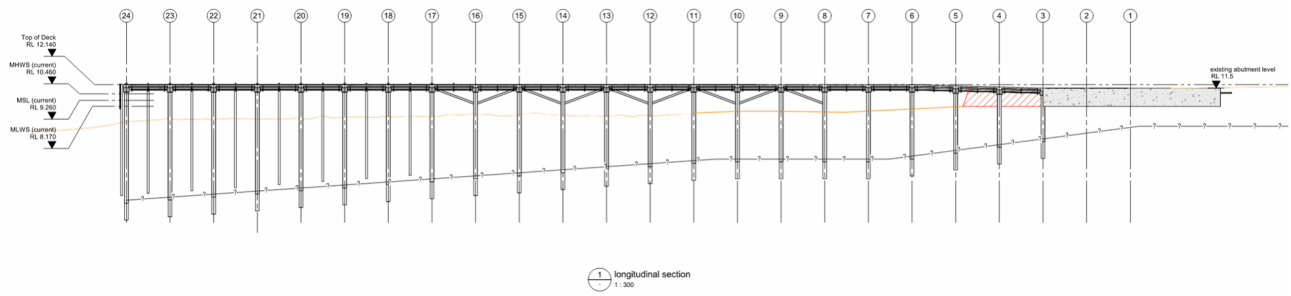


Figure 1 - New wharf long-section

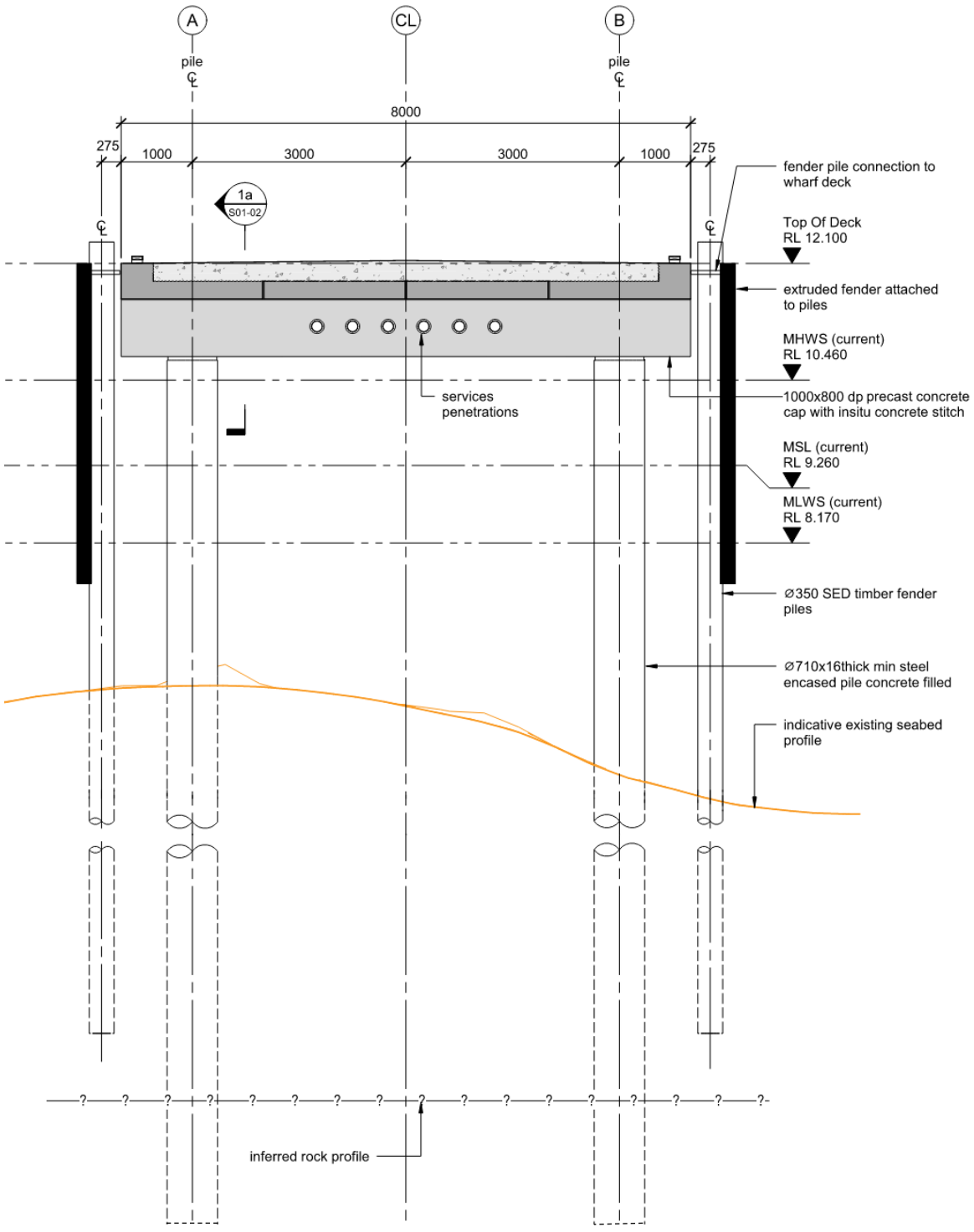


Figure 2 - New wharf typical bent arrangement

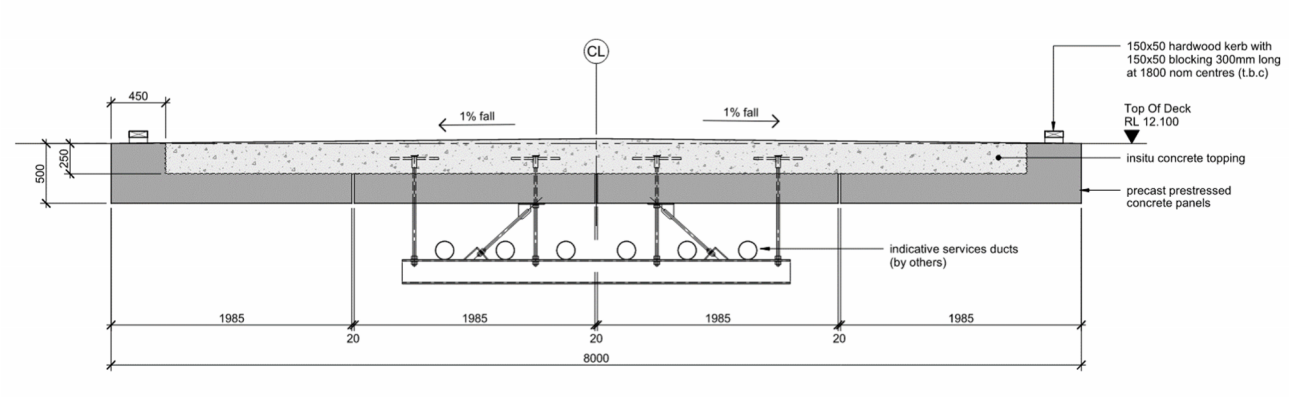


Figure 3 - New wharf typical deck arrangement

2.4 Health and Safety in Design

A Safety in Design register has been developed with input from Holmes, CCC and Isthmus. This will be developed further through the next design stages with input from stakeholders and the wider project team.

2.5 Project Risks

A Quantitative Risk Assessment (QRA) for the Akaroa Wharf project was run by Council with input from WT and Holmes. The aim of the session was to review, identify, analyse, and quantify potential risks to inform the project contingency to be included in pricing. Risks were broken down by phase and included planning, design, consenting, procurement, and construction. The key design phase risks identified were:

- Wharf design not meeting the needs of commercial and recreational users.
- Insufficient consideration of buildability in final design leading to an increase in ongoing or construction costs (note: constrained site), with this risk relating predominantly to pile design and methodology.
- Peer review identifying major changes, resulting in additional cost late in the project.
- Geotechnical conditions not fully known/uncertain, resulting in design change later in project leading to project cost increases.
- Design for building support requiring additional effort and cost. Cost of additional temporary support to buildings.
- Poor services co-ordination leading to clashes and rework.

Refer to the register for the complete breakdown of risks and management strategies. This is a live document that will be developed throughout the design and construction phases. Holmes will continue to work with Council and the project team to identify and manage these risks.

2.6 Sustainability

Sustainability efforts to date have been focused on achieving the most efficient structural design possible that fits within both Council's monetary budget and satisfies user requirements. Key considerations have been function, whole-of-life cost, affordability, durability, and longevity through selection of materials.

Further consideration will be given to this during the Detailed Design phase, with some key examples being:

- Use of lower carbon concrete design through the specification of supplementary cementitious materials (SCM's). This is done inherently to satisfy the requirements of being in a Class C environment.
- Utilising high strength reinforcing steels to reduce the overall quantity of reinforcement.
- Consideration to source of materials, with a focus on minimising incorporated energy.

3 THE WHARF STRUCTURE

The existing wharf consists of an approximately 30m long earth formation and 155mm longer timber structure as shown in Figure 4. There are two buildings - the Blue Pearl and Black Cat building - connected to the wharf along its southern edge and are accessed from the wharf. These buildings and their supporting structure will remain after the wharf and land formation have been demolished. The new wharf structure will be approximately 168m long and 8m wide, consisting of 21 continuous 8m spans integral with the piers and abutments. The new wharf will tie into the current ground level at the abutment, but to accommodate future sea level rise, the new deck level will generally be 500mm higher than the current wharf. The change in level will be taken out within the first five spans by varying the pile heights. This is still subject to change through development of the cultural narrative and urban design requirements for the entrance and first section of the wharf.

To allow for the construction of the new wharf and to allow for suitable access to be provided between the new wharf and the existing buildings after construction, it has been agreed to offset the southern edge of the new wharf approximately 1.5-2.5m from the northern edge of the Black Cat building. This offset will need to be re-evaluated during the next stages of design as the access requirements between the new wharf and buildings are developed to ensure that it is still sufficient. The increased width of the new wharf and offset of its location, creates a pinch point for access on and off the wharf. To remove this pinch point and improve functionality for the wharf users, it is proposed that a new seawall is constructed using reinforced concrete 'L' panels along the northern edge of the abutment in front of the existing seawall.

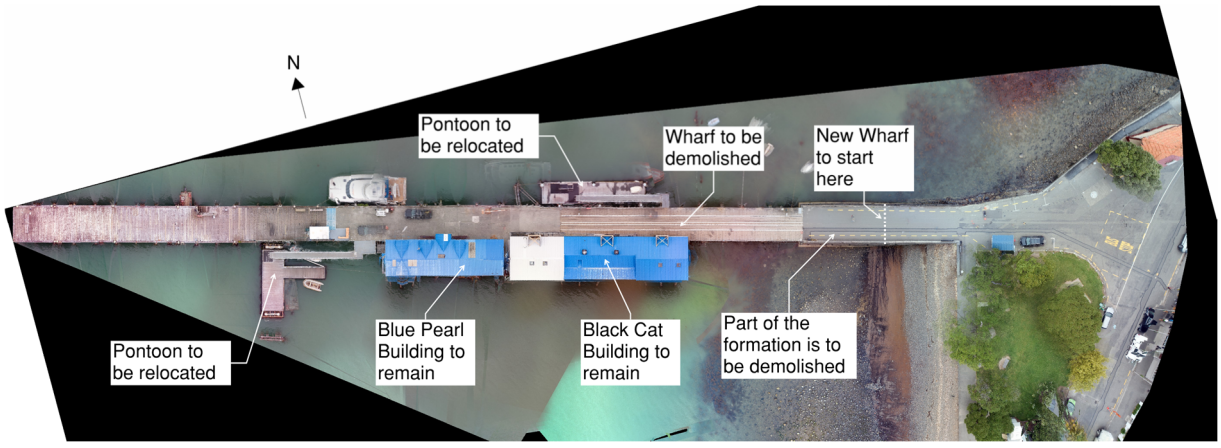


Figure 4 - Existing wharf and structures

4 SITE CONDITIONS

4.1 Site Location

Akaroa is a town on the Banks Peninsula, southeast of Christchurch, New Zealand. The Akaroa Wharf is on the eastern shore of the Akaroa Harbour. Refer to Figure 5 for the site location.

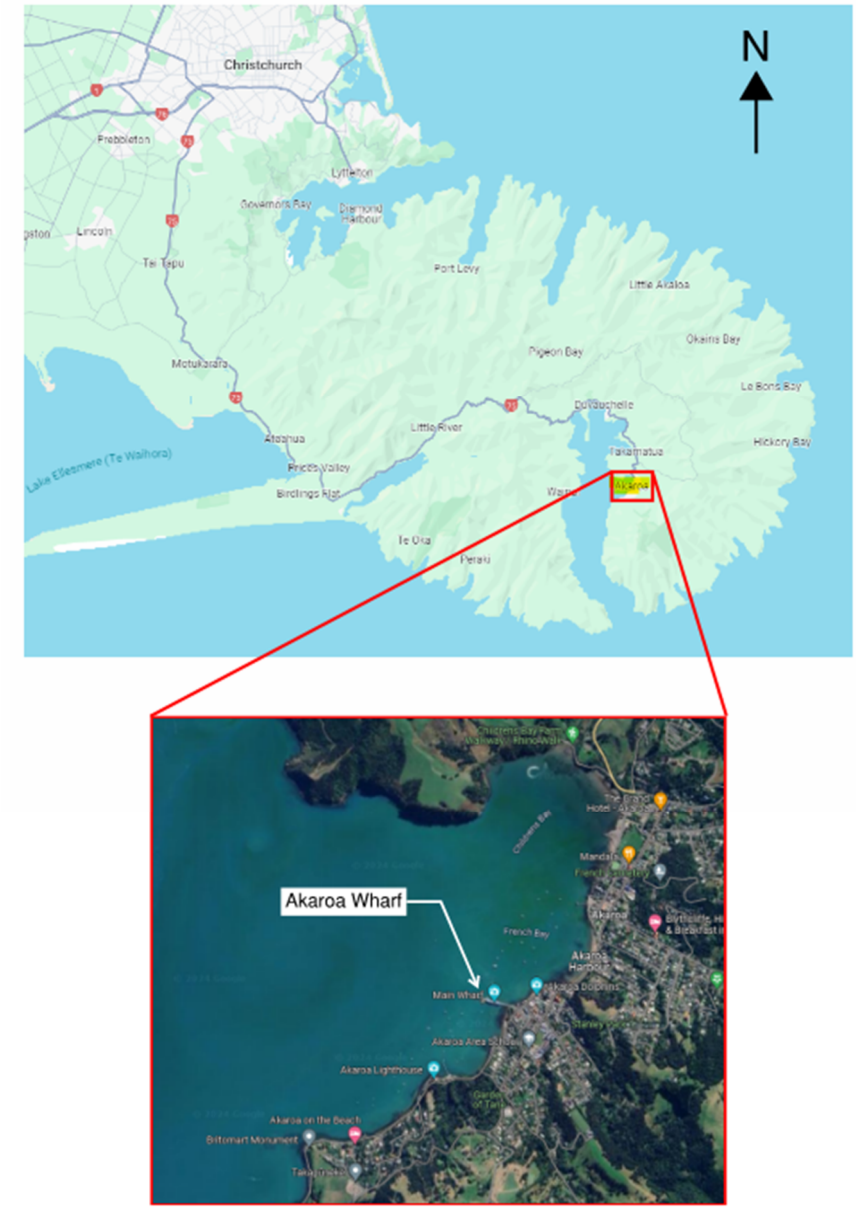


Figure 5 - Akaroa Wharf site location

4.2 Land Survey

Council conducted a land survey in June 2019 of the approach formation and surrounding area. The Topographical survey used the following controls:

- Horizontal: Mount Pleasant 2000
- Vertical: Christchurch Drainage Datum (CDD)

Holmes used the same survey controls above for the modelling of the wharf. Further surveying of the existing wharf footprint and levels has been requested to aid in the set-out of the new wharf.

4.3 Bathymetry

A bathymetry survey was completed on the 7th and 8th June 2020 by Southern Hydrographic. This survey was undertaken for Council as part of the new wharf optioneering phase. The bathymetry survey used the following controls:

- Horizontal: Mount Pleasant 2000
- Vertical: Chart Datum (CD)

The vertical datum for the bathymetry data has been converted to CDD to match that of the land survey in our model.

4.4 Datum Conversions

The following datum conversions have been confirmed with Council.

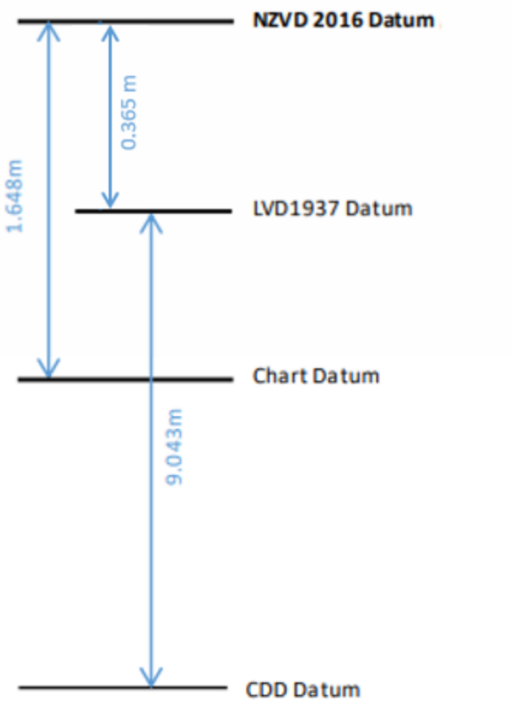


Figure 6 - Vertical datum conversions

4.5 Wharf and Tide Levels

Table 3 shows the wharf and tide levels to be used for the design of the Akaroa wharf as provided in the PR's and PDP Coastal Processes Report. This table is a summary only and does not contain sufficient information to be read on its own. Refer to the PDP report for more detailed information on the background and derivation of current and future tide levels. Approximate freeboard values between tide level and the proposed deck soffit are also given in Table 3 based on a deck thickness of 500 mm.

Table 3 - Present deck and tide levels for Akaroa wharf

Levels	Level in Chart Datum (CD)	Level in Christchurch Drainage Datum (CDD)	Freeboard to Deck Soffit
Wharf level (proposed)	+ 4.34 m (PR's, PDP,2024)	+ 12.10 m (PR's, PDP,2024)	-
Wharf level (current)	+ 3.84 m (PR's)	+ 11.60 m (PR's)	-
Mean High Water Springs (MHWS)	+ 2.728 m (PR's) + 2.7 m (PDP, 2024)	+ 10.488 m + 10.5 m	1.1 m
Mean Sea Level (MSL)	+ 1.5 m (PDP, 2024)	+9.3 m	2.3 m
Mean Low Water Springs (MLWS)	+ 0.41 m (PR's)	+8.17 m	3.4 m

4.6 Coastal Processes Assessment

A coastal processes assessment was carried out by PDP during the Concept Design phase.

The scope of the assessment completed by PDP is outlined below.

- Determine relevant coastal parameters for Concept and Preliminary Design stages including:
  - Assessment of geomorphological setting and dominant coastal processes including qualitative assessment of potential local effects on the local sediment transport patterns.
  - Review and evaluate appropriateness of existing Jacobs reports on dominant hydrodynamics including tides, waves, and storm surge.
  - Analysis of wind conditions – directions, speeds, duration of wind events.
  - Estimate maximum possible wind wave heights empirically using common-practice techniques such as the Carter (1982) relationships for duration and/or fetch limited waves.
- Consider the potential impacts of climate change and sea level rise on local coastal processes and interactions with proposed designs.
  - This will include consideration of extreme sea level estimates already provided by Jacobs.

4.6.1 Sea Level Rise

Sea level rise (SLR) has been considered as part of the design of the new wharf. SLR of 1.04 m has been used to inform the new deck level following a decision between Council, Jacobs and PDP. This decision was based on factors such as available information, risk, uncertainty, and the practicality of maintaining access to the buildings adjacent and tying into existing ground levels at the abutment. The value of 1.04 m corresponds to potential SLR under RCP8.5+ by 2100 but does not account for any vertical land movement (VLM). Refer to the Coastal Processes Report for further information and background.

Refer to Section 5.12 for sea level rise considerations in the design of the new wharf.

4.6.2 Storm Surge and Wave Heights

Table 4 gives the values for storm surge and wave heights to be considered in the design based on the recommendations from PDP. This table does not provide sufficient background to the recommended values and should be read in conjunction with the Coastal Processes Report.

Table 4 - Storm surge and wave heights

Parameter	Value
1% AEP storm surge	0.63 m
Wave set-up	0.05 m
Maximum wave height	1.58 m

4.6.3 Qualitative Assessment

A qualitative assessment of potential interactions/impacts of the proposed wharf design on local coastal processes including waves and sediment transport was to be delivered by PDP during Preliminary Design, but Council has since removed this from PDP's scope, and has been completed by Enviser.

4.7 Groundwater

Groundwater levels outlined below have been taken from the geotechnical factual report. Ground water levels to be used in design will be developed with the Geotechnical Engineer during Detailed Design.

Groundwater levels were taken at boreholes (BH) done at the existing wharf as part of the initial site investigation works. BH04 is located behind the new Akaroa wharf abutment. The groundwater level within BH04 was noted at 3m below ground level as taken at 7:40am on 26 October 2023. It should be noted though that given that the Akaroa Wharf is located at the coastline the groundwater is controlled by the sea level tidal fluctuations. It is not known what the tide height was during the investigation, but the mean high water springs level is approximately 1.6m below the ground level.

4.8 Services and Lighting

Stantec and Connetics have been engaged by Council to develop and document the extent and location of utility services on the wharf. These will be developed in parallel with the design of the wharf.

The following services are included:

- Power
- Lighting
- CCTV
- Weather station
- Fibre
- Water
- Wastewater
- Stormwater (Not currently required as deck falls towards wharf edge)
- Diesel
- Spare ducts (for future charging boats/ ferries)

Possible locations for the running of services on or below the wharf was discussed with Council and the project team. Council has chosen to progress with the option of running services directly beneath the soffit of the deck. The rational for this was due to aesthetics and to simplify detailing of the deck and ease of future adaption if required. A general arrangement of what this could look like is shown in Figure 7 and Figure 8. This will be developed further with the services designers during Detailed Design.

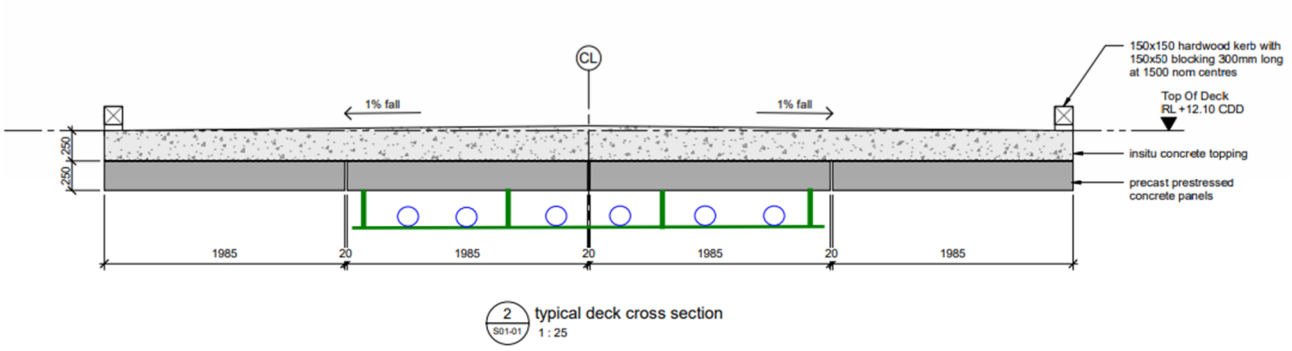


Figure 7 - Services hung from deck soffit concept

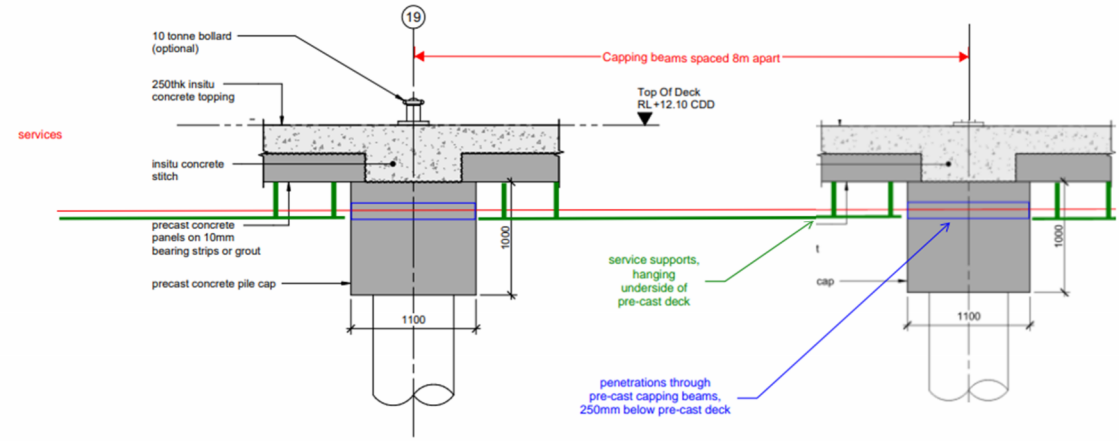


Figure 8 - Penetrations through precast capping beams for services

4.9 Drainage

It is currently understood that Council has permission to discharge stormwater directly to the ocean and piped stormwater management on the wharf is not required. It is proposed to construct the deck with a central crown and cross-falls either side to encourage water-runoff and prevent ponding. Discrete timber kerb supports will allow for water flow beneath.

4.10 Berth pocket / Localised Dredging

Council has confirmed that no dredging or shaping/deepening of the berth pocket is required. It is possible that seabed levels directly under the existing wharf are higher than adjacent areas due to the deposition of sediment around the piles. This could result in a difference in seabed levels along the southern edge of the new wharf with the 1.5-2.5m offset in wharf position. It is not expected that this would be significant enough to have an impact on the operation of the wharf, but this could be reviewed during/following construction to see if any intervention is required.

4.11 Construction Sequence

The following construction sequence has been assumed in development of the Preliminary Design of the wharf:

- Sacrificial pile casings with an Oslo tip are driven through the marine deposits to a competent basalt layer. The piles are then driven until the toe of the pile is sufficiently embedded into the basalt to provide the required end bearing capacity and translational fixity. If the end bearing

capacity cannot be demonstrated, then an alternative could be to change to a Franki pile type construction methodolgy. This methodolgy is a cross between a bored pile and a driven pile in which the basalt is augered out sufficiently to construct a concrete plug. This plug is then driven using a hammer to verify its vertical capacity prior to constructing the rest of the pile.

- Reinforcing steel cages are dropped inside the casing and concrete cast to below the capping beam level.
- Precast reinforced concrete pile caps are installed over the piles and temporarily supported.
- Precast prestressed concrete deck planks are placed on the capping beams to form the lower half of the deck system.
- The in situ reinforced concrete topping and piles stitches are cast.
- Secondary items and wharf furniture are installed.

Refer to Section 5.14 for specific construction loads considered.

The impact of creep and shrinkage on the construction sequencing of the deck will be developed during the next stages of design.

4.12 Clearance and Future Access to Buildings

The offset of the new wharf from the adjacent buildings and their supporting structure is currently proposed as being approximately 1.5-2.5m from the Black Cat building. Although any work associated with the buildings and their supporting structure, including future access onto the wharf, is excluded from the scope of this design package, due consideration will be given to these during the next stages of design.

5 DESIGN CRITERIA

5.1 General

As per the PR's, the Wharf will be designed as an Importance Level 3 structure with a 100-year design life except for the seismic design which will consider a 50-year design life. The annual probability of exceedance (AEP) for wind and earthquake loads will be taken from AS/NZS 1170.0:2002.

The AEP for wave loading is covered in AS 4997:2005 and is determined by the Function Category assigned to the wharf. The PR's do not distinguish a Function Category to use and so we have adopted Function Category 2 as this seems the most appropriate for the new wharf.

The AEP values to be used for design are summarised in Table 5.

Table 5. Annual probability of exceedance for wind, earthquake, and wave loads

Limit State	Wind	Earthquake	Wave
SLS	1/25	1/25	-
ULS	1/2500	1/1000	1/1000

New Zealand Standard, NZS1170.0:2002 Structural Design Actions Part 5 Earthquake Actions, clause 2.1.4 specifies that in order to meet the requirements of the New Zealand Building Code, design of structures is to allow for two earthquake scenarios:

- (ULS) - "Ultimate limit state for earthquake loading shall provide for avoidance of collapse of the structural system, or loss of support to parts, damage to non-structural systems necessary for emergency building evacuation that renders them inoperative".
- (SLS) - "Serviceability limit states for earthquake loading are to avoid damage to, the structure and non-structural components that would prevent the structure from being used as originally intended without repair after the SLS earthquake".

5.2 Design Standards and Building Code Compliance

The design of the wharf will be prepared using the following standards and guidance documents:

- New Zealand Building Code
- AS/NZS 1170 Structural Design Actions
- AS 4997:2005 Guidelines for the design of maritime structures
- ASCE 61-14 Seismic Design of Piers and Wharves
- BS 6349-4:2014 Maritime Works – Code of Practice for Design of Fendering and Mooring Systems
- PIANC WG33 (2002) Guidelines for Design of Fender Systems
- NZS 3101: 2006 Concrete Structure Standard
- MIBE/ NZGS Earthquake Geotechnical Engineering Practice Modules 1 to 6
- AS 2159: Piling – Design and Installation, 2009
- AS 1720.1:2010 Timber Structures

As the NZ Building Code Verification Methods do not fully address the needs of wharf design, we propose to use Verification Method 1 documents for buildings, such as AS/NZS 1170, and NZS 3101, supplemented by specific wharf design standards such as AS 4997 (Standards Australia) and ASCE 61-14 (USA), as an Alternative Solution under the Code. This compliance pathway is currently the generally accepted approach for wharf design in NZ and used on most large wharf design projects.

5.3 Dead Loads

The weights of structural elements have been determined in accordance with the following material densities:

- 77kN/m^3 for structural steel
- 25kN/m^3 for reinforced concrete
- 11kN/m^3 for hardwood timber

5.4 Superimposed Deadloads

The following allowances for secondary items have been included. These have been applied as a uniformly distributed load over the footprint of the wharf deck and will be reviewed during the next stages of design to ensure that they are still appropriate. Where local concentrated loads are critical, these will be checked on a case-by-case basis.

- 0.5 kPa – wharf furniture such as barriers, kerbs, bollard etc.
- 0.25 kPa – services
- 2.5 kPa – future deck raise allowance (refer Section 5.12)

5.5 Imposed (Live) Loads

5.5.1 Wharf structure

In accordance with the PR's, the wharf will be designed for Class 15 loads to AS 4997:2005, as listed below:

- 15 kPa (1500 kg/m^2) uniformly distributed load
- 200 kN Point Loads at 4m centres in any direction

This loading requirement may be revisited with Council during the next stage of design if reducing this to a more appropriate allowance will lead to meaningful savings. The following feedback has been provided by Council on the vehicles required to operate on the wharf:

- Fire engine/truck not required as confirmed by FENZ.
- Crane with a one tonne payload. This presumably applies to the fixed 1 tonne SWL crane to be mounted to the wharf rather than a mobile crane.
- Forklift with a one tonne payload.

We have reviewed the expected loading of these vehicles, and they are all well within the loading covered by the Class 15. The vehicle loads will be applied without a dynamic load allowance (or factor), given that any vehicles on the wharf will be driven at walking pace.

5.5.2 Barriers, Handrails and Kerbs

The extent of edge/fall protection along the wharf has been developed between Council and Isthmus to ensure compliance with the Building Code. Refer to Figure 9 for the currently agreed extent of edge/fall protection. Feedback from Isthmus on compliance is as follows:

Akaroa Wharf is classed as a working wharf with both commercial and recreational access and activity. As per clause F4.3.1 and Determination 2017/041, working wharves and loading docks are excluded from F4 barrier requirements with "appropriate measures" to be defined by the local authority in question.

The edge protection for Akaroa Wharf is designed in accordance with Council-defined risk. Council is to assess the acceptable level of risk mitigation for working wharf vs recreational use. IGL to work with Council/Holmes to provide design solution controls that meet Council acceptable risk and agreed compliance pathway.

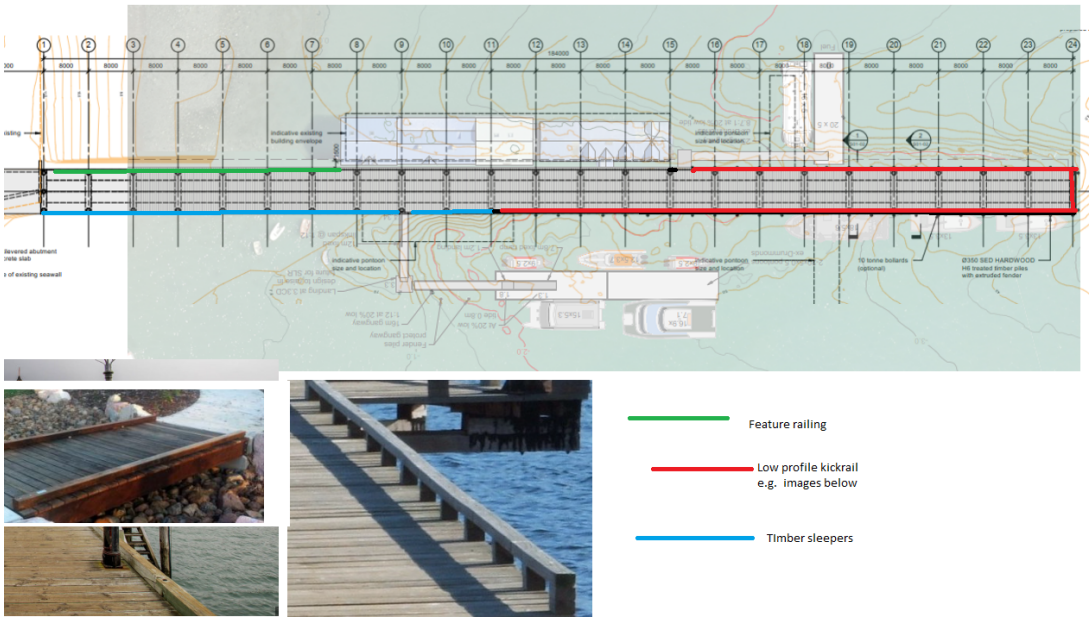


Figure 9 - Agreed extent of edge protection as provided by Isthmus

The specification and design of barriers, handrails and kerbs on the wharf will be developed with Council and Isthmus through the next stages of design.

5.6 Seismic Loads

Seismic design actions will be derived from NZS1170.5: 2004 using the seismic design parameters outlined in Table 6. The Geotechnical Engineer has established that the site subsoil class will fall between C and D. Recommendation from the Geotechnical Engineer is to conservatively adopt class D for the design of the new wharf.

Table 6. Seismic load site parameters

Design Parameter	Value
Site subsoil class	D
Hazard factor, Z	0.3
Return period factors, R Rs: SLS Ru: ULS Rm: MCE	 0.25 1.3 1.5xRu = 1.95
Near-fault factor, N(T,D)	1.0

The seismic design philosophy of the wharf will be informed by the displacement-based design principles set out in ASCE 61-14 - Seismic Design of Piers and Wharves. The terminology in this standard differs from that in NSZ1170.5, but we consider that the operating level earthquake (OLE) and contingency Level Earthquake (CLE) are equivalent to the SLS and ULS level earthquakes respectively. As such, strain limits used in the displacement-based design process will be in accordance with Table 3-1 and Table 3-2 of ASCE 61-14 for these events.

The above is related to the structural seismic loading, which is different to the geotechnical seismic hazard which is outlined in the Geotechnical Interpretive Report.

5.7 Marine Loads

The vessel parameters to be used to determine the mooring and fendering loads have been taken from the 'User Requirements Needs Assessment for Akaroa Wharf' report, dated March 2021 prepared by Enviser. Parameters from this report are reproduced in Table 7. An addendum to this report was issued in June 2024 but there were no changes made to the design vessels.

Table 7. Design vessel parameters

Parameter	Commercial Fishing	Commercial Tourism	Cruise Tenderers	Recreational Vessels
Estimated maximum vessel occupancy	5	50 - 100	100 - 260	5 - 10
Length(m)	22	24	16	10
Beam (m)	4.5	7.1	5.0	3.0
Draft (m)	1.5	1.6	-	1.2
Displacement (t)	45	70	43	5.5

5.7.1 Berthing Loads

Berthing loads have been calculated in accordance with AS 4997:2005 and BS6349-4:2014, for the design vessel, considering "severe' exposure conditions, and "ferries up to 100t" vehicle class. 15 degrees has been taken for the maximum berthing angle, and the point of impact (berthing point) has been taken as the quarter-point of the vessel. A maximum berthing velocity of 0.4m/s has been considered. A berthing energy factor of 2 has been taken for the design berthing event.

The design of the fender system and supporting elements (fender piles, wharf) will be designed in accordance with AS 4997:2005.

The location of fenders has been confirmed by Council and are shown in the Preliminary Design drawings.

5.7.2 Mooring Loads

Wind and current loads acting on a moored vessel will be primarily transferred to the structure via bollards fixed to the deck. The use of the fender piles as mooring points is desired by Council and will be explored during Detailed Design. Due consideration (with input from Council) will be given to the design of the pile connection to address any potential hazard of entrapment and/or crushing of limbs during use by the public. An example could involve the incorporation of cover plates. Mooring loads have been calculated in accordance with AS 4997:2005 using the design vessels in Table 7.

The location of bollards has been confirmed by Council with locations shown in the Preliminary Design drawings.

5.7.3 Wave Loads

Wave loading on the wharf is not considered critical to the design. The design of the deck to withstand buoyancy forces resulting from sea level rise will be considered during Detailed Design.

5.7.4 Pontoon Gangways and Linkspan

Council is currently proposing to adopt Pontoon Concept Layout Revision F Rev 0 for the layout of the pontoons and gangways/link spans. Refer to Figure 10 below. Loadings and connections to the wharf from these structures will be developed with the gangway designer during Detailed Design.

The following unfactored vertical load allowances applied to the wharf deck at the location of the link spans will be adopted:

- Dead load – 7.0 kN. This is based on half the weight of the 14m aluminium link span for Drummonds wharf as taken from the link span construction drawings. This will be prorated down for the shorter link span on the southern side.
- Live load – 53 kN. This is based on a 5 kPa applied over to the full length of the 14m link-span as used for its design. This will be prorated down for the shorter link span on the southern side.

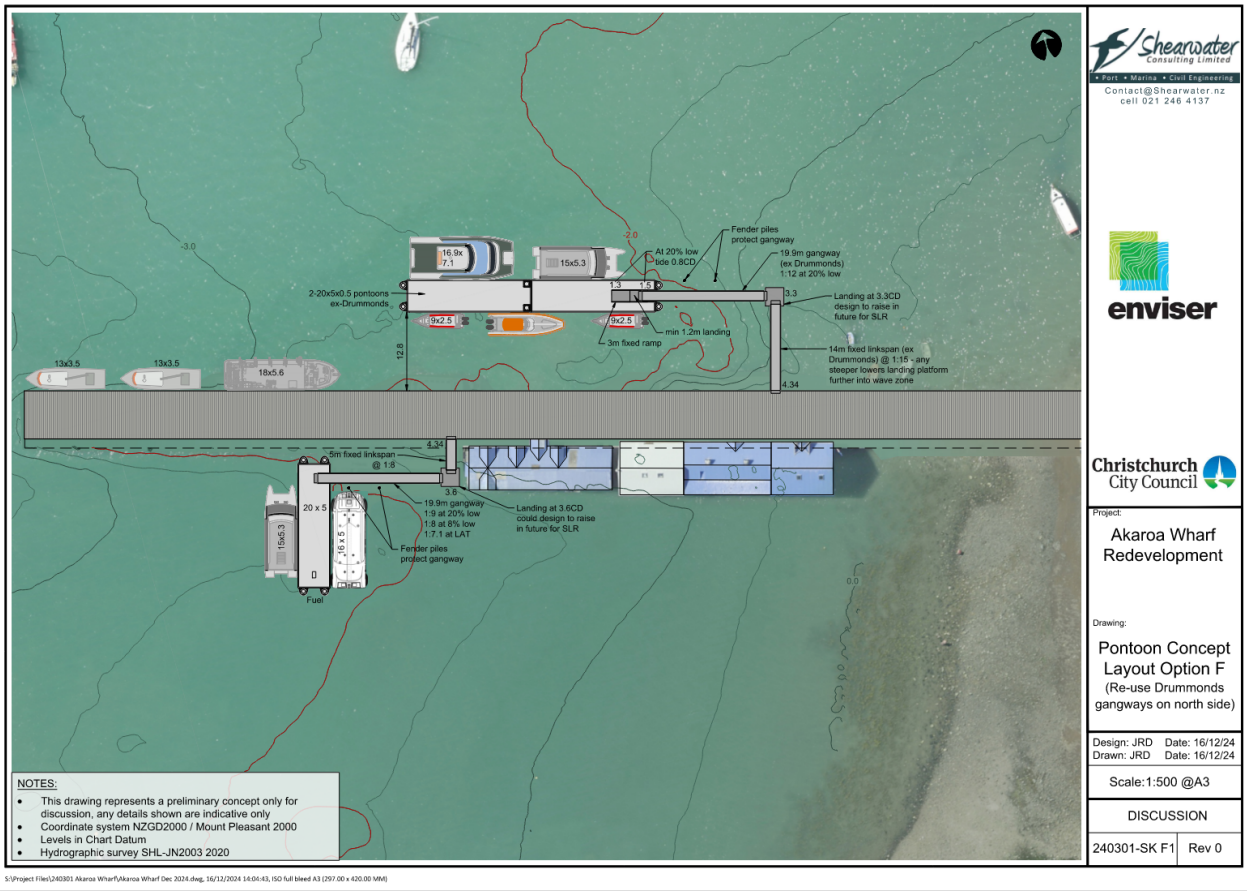


Figure 10 - Pontoon Concept Layout Option F Rev 0 (Enviser)

5.8 Snow and Ice Loads

The elevation of the wharf is essentially at sea level and therefore snow loading is not considered significant for this structure.

5.9 Wind Loads

Wind loading is not considered significant for this structure. Wind loading on secondary/architectural elements will be considered during the next stages of design.

5.10 Time Dependant and Temperature Effects

Temperature and time dependent effects such as creep and shrinkage will be considered during the next stages of design.

5.11 Retaining Loads

Soil retaining loads will be provided in the geotechnical report. Initial parameters used for the design are outlined below but will be developed further during Detailed Design.

- Fill
  γ = 18 kN/m^3
  θ = 35 degrees
  Kp = 1+sinθ / 1-sin θ = 3.69

5.12 Sea Level Rise Considerations

The wharf will be designed for any increased loading anticipated because of sea level rise e.g. wave, berthing and mooring etc.

It is considered impractical to design the wharf structure to be lifted in future to cater for sea level rise. Instead, it is proposed that a 2.5 kPa superimposed deadload allowance over the full deck area is included for future raising of the deck level by means of a lightweight timber deck constructed on top of the concrete deck.

5.13 Tsunami Loading

The wharf has not been designed to for any specific tsunami loading.

5.14 Construction Loading

The following construction loads have been considered:

- The 800 mm deep x 1100 mm precast pier caps have been sized to be able to support the full weight of the 500 mm thick deck (250 mm precast deck planks and 250 mm in-situ topping with falls) and a 1.5 kPa construction live load prior to being integral with the deck.
- Refer to Sections 5.5 and 8.1 for designed live load allowance on the completed structure.

5.15 Load Combinations

The following tables summarises the load combinations that will be considered for the serviceability limit state and the ultimate limit state design of the wharf. Load combinations are generally in accordance with AS/NZS1170 and AS4997:2005, except for the seismic load combination, which is influenced by ASCE61-14.

Table 8 - Serviceability limit state load combinations

Load cases	Load combinations							
	A	B	C	D	E	F	G	H
Earth Pressure	1.0	1.0	1.0	1.0	1.0		1.0	
Seismic Earth Pressure						1.0		1.0
Dead Load (incl. SDL)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Distributed Live Load	1.0		0.6	0.6				0.1
Concentrated Live Load		1.0						
Berthing Loads			1.0		1.0			
Mooring Loads				1.0		1.0		
Wave Loads			1.0/0.7	1.0/0.7			1.0/0.7	
Wind and Current Loads			0.7/1.0	0.7/1.0			0.7/1.0	
Temperature					1.0	1.0	1.0	
Shrinkage & Creep					1.0	1.0	1.0	1.0
Earthquake								1.0

Table 9 - Ultimate limit state load combinations

Load cases	Load combinations						
	I	J	K	L	M	N	O
Earth Pressure				1.5	1.5	1.5	
Seismic Earth Pressure							1.0
Dead Load (incl. SDL)	1.35	1.2	1.2	1.2	1.2	1.0	1.0
Distributed Live Load		1.5		0.6	0.6	0.6	0.1
Concentrated Live Load			1.5				
Berthing Loads					1.0		
Mooring Loads						1.0	
Wave Loads					1.0/0.7	1.0/0.7	
Wind and Current Loads					0.7/1.0	0.7/1.0	
Earthquake							1.0

6 GEOTECHNICAL CONDITIONS

6.1 Description of Geotechnical Design Considerations

Factual and Interpretive Geotechnical reports have been prepared for the new Akaroa Wharf by PDP and Holmes NZ LP respectively. The Interpretive Report outlines the geotechnical design considerations and parameters used in the design to date.

The geotechnical and structural designs will be developed in parallel through the next stages of design. Initial discussions with the Geotechnical Engineer are that the following assumptions are reasonable:

- Pile base shear takeout at the bottom of the piles is achievable through keying sufficiently into the basalt layer.
- Pile axial compression loads can be adequately resisted through end bearing of the piles.

Design of the abutment and retaining wall will be developed during the next stages of design.

Additional site investigations including boreholes and SPTs were undertaken early in 2025. It was found that the founding basalt was less competent and in areas thinner than previously understood such that a bored pile solution was unlikely to be feasible (would require deeper drilling to a more competent layer and sleeving to remove kinematic effects of upper layers). As a result of these findings it was decided to switch from a bored pile to a driven pile strategy. This will be developed with the Geotechnical Engineer and ECI Contractor during detailed design.

7 WHARF STRUCTURAL DESIGN

7.1 Gravity Structure

The deck comprises of precast concrete prestressed panels with an in-situ concrete topping. During construction, the precast deck panels will span simply supported between the precast capping beams and will act as formwork for the in-situ topping. Once poured, the panels and topping will form a composite member creating continuity between adjacent panels and over the capping beam supports. The relative thickness of the precast panels and in-situ topping will be chosen considering aspects such as performance, transportation and handling, buildability, and efficiency. The capping beams are supported by 710mm diameter reinforced concrete piles, which will be installed using sacrificial steel casings driven into the basalt below the seabed. The deck and capping beam will be connected to the piles with an in-situ reinforced concrete stitch.

7.2 Lateral Load Resisting Structure

The concrete deck acts as a diaphragm to distribute load to the capping beams and piles below.

In the transverse direction, the piles and capping beam act as a frame. Moment fixity at the top of the piles will be provided through detailing with the capping beam. Base shear takeout will be provided by keying of the pile into the basalt. Under non-seismic loading and prior to liquefaction of the marine deposits, some amount of base fixity may be provided through embedment in the marine sediments.

The lateral load resisting system in the longitudinal direction is similar to the transverse direction but top fixity will be provided through detailing with the deck.

7.3 Secondary Structure

Horizontal berthing loads will be resisted by extruded rubber fenders attached to hardwood timber piles. The piles will act as propped cantilevers with fixity at the base provided by embedment into the marine deposits and supported at the top by a connection to the wharf deck.

Vertical berthing loads will be resisted by piles alone through a combination of end bearing and skin friction within the marine deposit layers. If the suitability of the marine deposits to support vertical loads is not sufficient then end bearing on top of the basalt layers is a feasible alternative.

Mooring loads will be resisted by the wharf structure via bollards and fender piles extended above deck level.

Due to the misalignment between the new wharf and the existing abutment, it is proposed that a new seawall is constructed using reinforced concrete ‘L’ panels along the northern edge of the abutment in front of the existing seawall. Further development of this area will be undertaken during the next stages of design with input from the project team and ECI Contractor.

A retaining wall is required at the abutment to retain the soil behind and to tie into the seawalls on either side. The current design uses precast panels laying horizontal against the piles. This will be developed further during the next design stage in conjunction with the development of the abutment area.

7.4 Software

Table 10 summarises the computer applications used for structural aspects of the project.

Table 10. Computer applications used for the project

Analysis Type	Software Used
General Spreadsheet Design	HCG Design
2D/3D Frame Analysis	Microstran v10.1 & LUSAS V20

Analysis Type	Software Used
Moment curvature analysis of concrete sections	Response 2000

7.5 Methods of Analysis

2D and 3D models of the wharf have been created for the purpose of determining the vertical and lateral demands on the primary structural elements. Initial checks on the lateral load resisting systems were carried out in Microstran, with a shift made to Lusas due its superiority in capturing the effects of soil structure interaction and structure non-linearity. Line elements are used to represent the wharf structure, with joint elements used to model the soil springs and flexural hinges in the piles.

Material and geometric properties are assigned to the elements appropriate to their design. Plastic hinge properties are assigned to the piles based on a moment curvature analysis of the pile cross sections in Response 2000 with the use of probable material strengths.

Soil-structure interaction is modelled with non-linear p-y springs provided by the Geotechnical Engineer. A sensitivity analysis of the soil springs stiffness will be carried out by using 50% and 200% of the stiffness values. This will be done by halving and doubling the force component (p) of the p-y spring. Sensitivity checks will be done on the distribution of soils springs to the piles to account for possible variation in the marine deposits and basalt depth along the length of the wharf. At current, the soil profile and layer depths have been inferred from six bore holes spread along the length of the wharf footprint. Appropriate assumptions will be made to make allowance for the uncertainty with this approximation. Additional site investigations are expected to be completed at the start of Detailed Design and will feed into this analysis. Kinematic soil displacements will be assessed in collaboration with the Geotechnical Engineer.

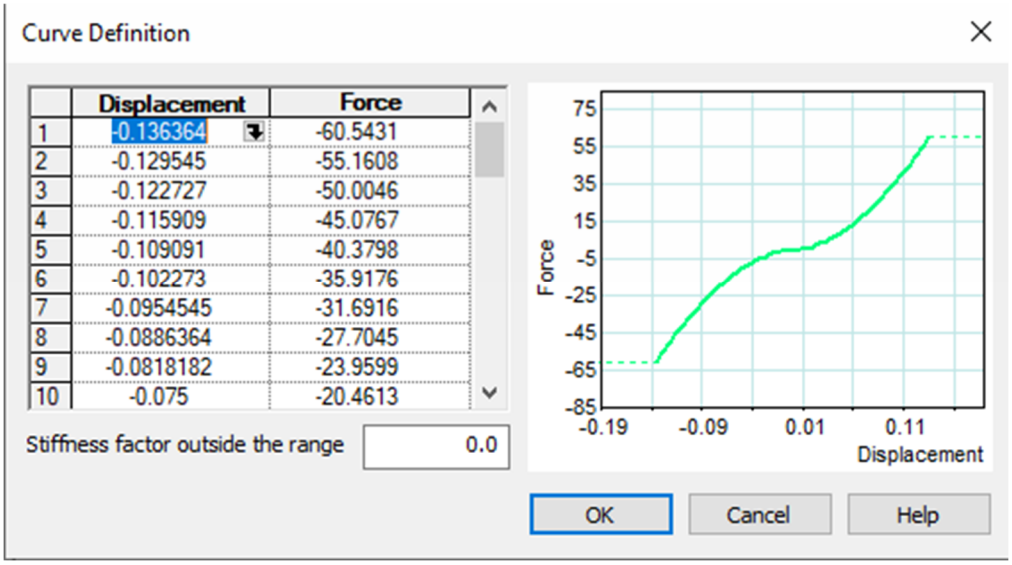


Figure 11 - Non-linear P-Y curve data at a single node used in the model based on outputs from the Geotechnical Engineer

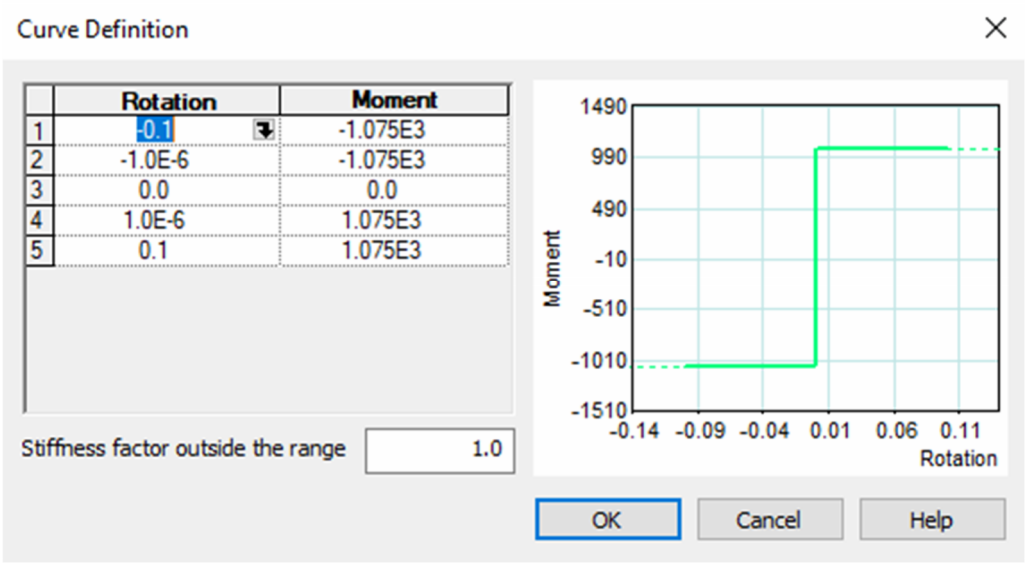


Figure 12 - Pile plastic hinges properties incorporated into the Lusas modelling

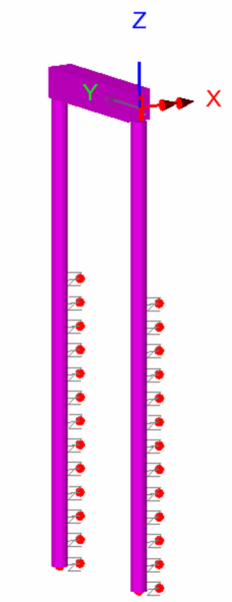


Figure 13 - Lusas 2D frame model of a single wharf bent for transverse loading

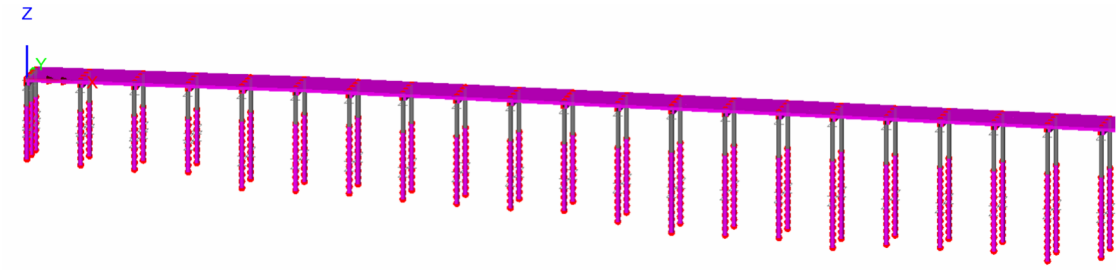


Figure 14 - Lusas 3D model of the wharf used for longitudinal seismic loading

7.5.1 Seismic Design

The seismic design of the wharf is being done using a displacement-based design approach. Pushover analysis in both the longitudinal and transverse directions are used to understand the wharf lateral behaviour.

This process involves applying an increasing horizontal force at the centreline of the deck and plotting this against the wharf displacement. The model captures the effects of material and geometric non-linearity through this process. The pushover curves for the wharf can be plotted over the Acceleration Displacement Response Spectrum (ADRS) curves for SLS, ULS and MCE seismic events with the design displacements for each event determined by where the pushover curve intersects with the respective ADRS curve. Bending moments in the piles at the design displacement are then evaluated to determine if plastic hinges have formed within the piles. If hinges have formed, pile rotations can be taken from the model and converted to strains using the plastic hinge lengths. These strains can then be checked to ensure that they are below the limits in ASCE 61-14.

To ensure that hinging only occurs in the piles, the capping beams and deck are designed for the overstrength actions from the piles. To obtain the overstrength demands the pushovers are rerun with the upper bound material properties and pile overstrength capacities.

7.5.2 Non-seismic Design

Non-seismic loading on the wharf will be checked using the same models but using non-liquified soil springs.

8 DURABILITY

8.1 Serviceability Criteria

Serviceability limit state checks will be performed to ensure that crack widths and steel reinforcement stress range under live loading is within the acceptable limits specified in the design standards. Crack width limits applied to the Class 15 live loads may be reviewed with Council during Detailed Design to make sure that it they are appropriate.

Under SLS seismic loading, steel and concrete strains will be kept below the limits given in Table 3-1 of ASCE16-14.

Horizontal displacements under berthing and mooring loading will be limited to l/150, as per Clause 4.2.2 of AS4997:2005, where l is the distance between the underside of the deck and the point of fixity in the seabed.

8.1.1 Reinforced Concrete Members

The table below shows the minimum concrete grade and cover required to achieve a 100-year durability life, in accordance with NZS 3101:2006. Class C concrete shall also include supplementary cementitious materials such as fly ash, micro silica or slag in accordance with Table 3.7 of this standard.

Table 11. Reinforced concrete exposure classification, grade, and cover

Surface and Exposure Environment	Exposure classification	Concrete Grade	Min cover
Members exposed to sea water, or in a splash/spray zone	C	50 MPa	60 mm
Piles and members cast directly against ground	C	50 MPa	75 mm

8.2 Timber Elements

It is proposed that any structural timber elements used on the wharf will be Australian Hardwood. This will be developed further during Detailed Design.

8.3 Structural Steel Elements

The steel casings are considered non-structural sacrificial elements, used as permanent formwork to construct the concrete piles. As such, durability requirements do not apply to these members. Corrosion protection to minimise the visual impact of any corrosion staining is still under development with Isthmus and Council.

Performance requirements for all other exposed steel to be developed with Isthmus, Council, and other stakeholders during Detailed Design.

9 MATERIAL PROPERTIES

9.1 Concrete

Piles	50 MPa
Capping beams	50 MPa
Deck panels and topping	50 MPa
Wall panels	50 MPa

9.2 Reinforcing Steel

Longitudinal reinforcing steel	500 MPa (Seismic Grade)
Transverse reinforcing steel	500 MPa (Seismic Grade)

9.3 Structural Steel

Mild steel pile casings	300 MPa
Bolts	Stainless G316 (A4-70)

9.4 Structural Timber

Hardwood timber fender posts	Grade F22

9.5 Proprietary Systems

The following proprietary systems are being considered in the design;

- 10 tonne tee and pillar bollards, or similar.
- Extruded DD fenders, or similar.

10 STATUTORY REQUIREMENTS AND PLANNING

10.1 Resource Consent

Preparation of the Resource Consent and regulatory approvals are being led by Enviser.

10.2 Building Consent

The Building Act allows under Schedule 1, Clause 2 for complex engineered building projects designed and supervised by Chartered Professional Engineers, such as infrastructure projects, to be exempted from obtaining a Building Consent. This will be discussed and agreed with Council, as acting territorial authority, during the next stages of design.

11 DESIGN AND CONSTRUCTION REVIEW

11.1 Design Review

As part of Detailed Design of the wharf, Council require a Producer Statement PS1 -Design for structural and geotechnical aspects.

Council will be engaging a Peer Reviewer to undertake an independent design review of the structural design and provide a PS2.

12 LIMITATIONS

Findings presented as a part of this report are for the sole use of the Client's and their Consultants use in its evaluation of the site as defined by the scope of services agreed between Holmes and the Client. The findings are not intended for use by other parties and may not contain sufficient information for the purposes of other parties or other uses. This report may not be relied upon by any third party or for any other purpose without the express written agreement of Holmes.

Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report.

This report has been prepared on the basis of various sources of information described in this report, which have not been independently verified and has relied upon it being accurate and sufficient for use in preparing the report. Holmes accepts no responsibility for errors or omissions in the provided information.

The recommendations in this report are based on the ground conditions indicated from published sources, site assessments and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it should be appreciated that actual conditions could vary from the assumed model.