WAKA KOTAHI NZ TRANSPORT AGENCY

MEMO

To: Tim Christensen, s 9(2)(a) [redacted]

From: s 9(2)(a) [redacted]

Copy:

Date: 18/06/2021

Subject: Draft AHB walking & cycling options – structural review

INTRODUCTION

Resolve Group developed eleven walking and cycling options on the existing Auckland Harbour Bridge (AHB). High level feasibility of the options will be reviewed based on a range of disciplines including traffic operational impacts, public transport, health and safety and structural load-carrying capacity. Waka Kotahi requested Beca to conduct a high-level review and comment on the feasibility of the proposed options from a bridge structural point of view. The options are shown on a sketch produced by Resolve Group and included in Appendix 1.

The purpose of this memo is to summarise the structural review findings to Resolve Group to be considered as part of their options evaluation. This memo will also highlight some of the structural risks and issues related to the options.

REVIEW METHOD

This high-level structural review was carried out based on a load comparison approach. Loadings from traffic, shared use path, new barriers and new fences were determined for each option and compared against the available live load capacity of the bridge. The available live load capacities of the truss and extension bridges were determined from previous AHB assessments and strengthening works.

Traffic live loads used for this assessment were from previous load assessments. Shared use path loading was in accordance with standard BD37/01 which was used in previous AHB assessment works. Weights of the proposed new barriers were provided by Resolve Group for a 680kg/m concrete barrier and a 715kg/m SRTS barrier.

The assessment for each option is limited to the load effects on the bridge superstructure that is carrying the shared use path only. All options propose some re-arrangement of existing traffic lanes which will result in traffic loads in the other lanes increasing. This increased load effect on superstructures that do not carry the shared use path was not assessed as part of this work. The impacts of the changes in lane loading are discussed in this memo.

Effects of wind load were not considered as part of this review. It is assumed the pedestrian barriers on top of traffic barriers will be lightweight with high porosity so any increase in wind loading is minimised.

REVIEW OUTCOMES

The following Table 1 summarises the findings of the structural review. The table outlines where new loads exceed the available live load capacity and outlines potential options available to reduce new loads. The options available are considered from a bridge loading perspective, some of them might not be practical due to other reasons such as network operations and traffic impacts. Review findings for each option are discussed in more detail below.

Option #	Side	Arrangement	Load Capacity	Options available to bring loads within available capacity
1	East Box	Temporary 1 lane traffic + 4m SUP	Exceeded*	SUP arrangement: no heavy vehicles + limit bus numbers 2 lane traffic arrangement: no heavy vehicles both lanes + limit bus numbers
5	West Box	Temporary 1 lane traffic + 4m SUP	Exceeded*	SUP arrangement: no heavy vehicles + limit bus & ped/cyclists numbers 2 lane traffic arrangement: no heavy vehicles both lanes + limit bus numbers
3	East Box	Permanent 1 lane traffic + 4m SUP	Exceeded*	no heavy vehicles + limit bus numbers
7	West Box	Permanent 1 lane traffic + 4m SUP	Exceeded*	no heavy vehicles + limit bus & ped/cyclists numbers
2	East Box	Temporary 8.9m SUP, no traffic	Not Exceeded	
6	West Box	Temporary 8.9m SUP, no traffic	Not Exceeded	
4	East Box	Permanent 8.9m SUP, no traffic	Not Exceeded	
8	West Box	Permanent 8.9m SUP, no traffic	Not Exceeded	
9	Central truss	Permanent 3 lane traffic + 2.75m SUP	Exceeded*	traffic restrictions on truss bridge + limit bus & ped/cyclist numbers
10	Central truss	Permanent 2 lane traffic + 5.5m SUP	Exceeded*	limit ped/cyclist numbers
11	Both Boxes	Permanent 2 lane traffic + 2.5m SUP	Exceeded	None

Table 1 – Summary of structural review findings

Option 1 & 5 – temporary one lane traffic with shared use path on extension bridge

Options 1 and 5 propose temporarily converting the outer traffic lane into a shared use path, with a new barrier separating the shared use path and traffic in the inner lane. It is proposed to keep the new barrier on the bridge when both lanes are open to traffic.

It was found that the new loading from the shared use path, new barriers and one lane of traffic exceeded the available live load capacity of the extension bridges.

Load restrictions would be required to bring the new loads down to acceptable levels such as banning heavy vehicles from both lanes on the extension bridge carrying the shared use path. A limited number of buses would be permitted within the acceptable load limits with a minimum spacing requirement. In addition, for Option 5 on the west box girder, the number of users on the shared use path at any one time would need to be controlled to keep loads within the structural capacity.

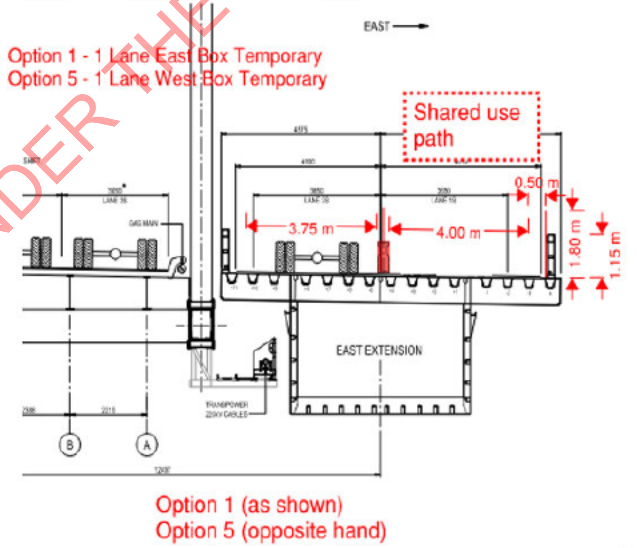


Figure 1 – Option 1 & 5 section

Option 3 & 7 – permanent one lane traffic with shared use path on extension bridge

Options 3 and 7 propose permanently converting the outer traffic lane into a shared use path, with a new barrier separating the shared use path and traffic in the inner lane.

It was found that the new loading from the shared use path, new barriers and one lane of traffic exceeded the available live load capacity of both extension bridges.

Load restrictions would be required such as banning heavy vehicles from the extension bridge carrying the shared use path. A limited number of buses would be permitted with acceptable load limits with a minimum spacing requirement. In addition, for Option 7 on the western box girder, the maximum number of users allowed on the shared use path at any one time would need to be controlled.

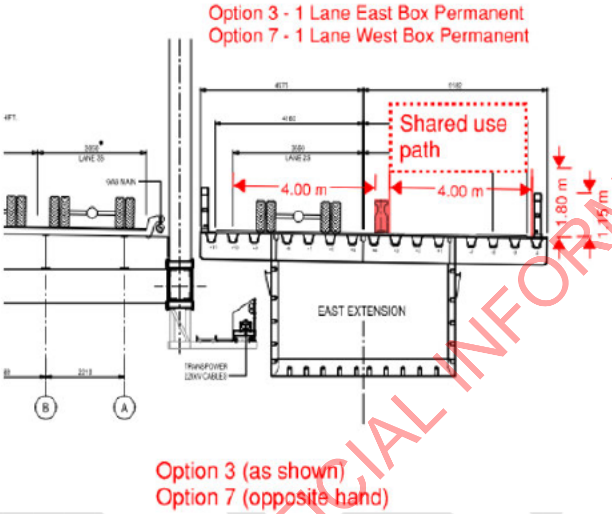


Figure 2 – Option 3 & 7 section

Option 2 & 6 – temporary shared use path on extension bridge with no traffic

Options 2 and 6 propose temporarily converting both traffic lanes on the extension bridges into a shared use path.

It was found the new loading from the shared use path and new fences would not exceed the available live load capacity of both extension bridges.

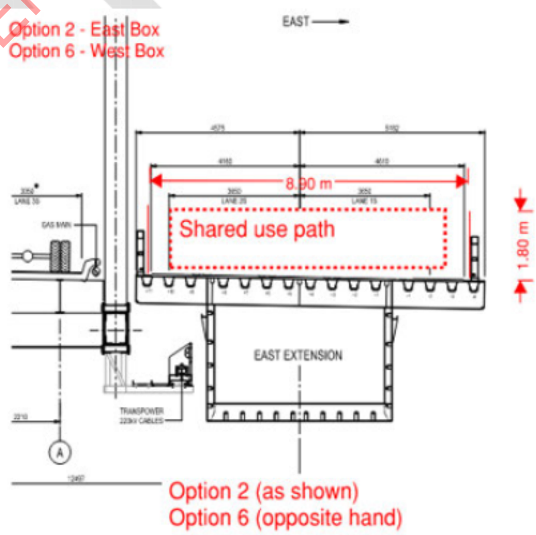


Figure 3 – Option 2 & 6 section

Option 4 & 8 – permanent shared use path on extension bridge with no traffic

Options 4 and 8 propose permanently converting both traffic lanes on the extension bridges into a shared use path.

It was found that the new loading from the shared use path and new fences would not exceed the available live load capacity of both extension bridges.

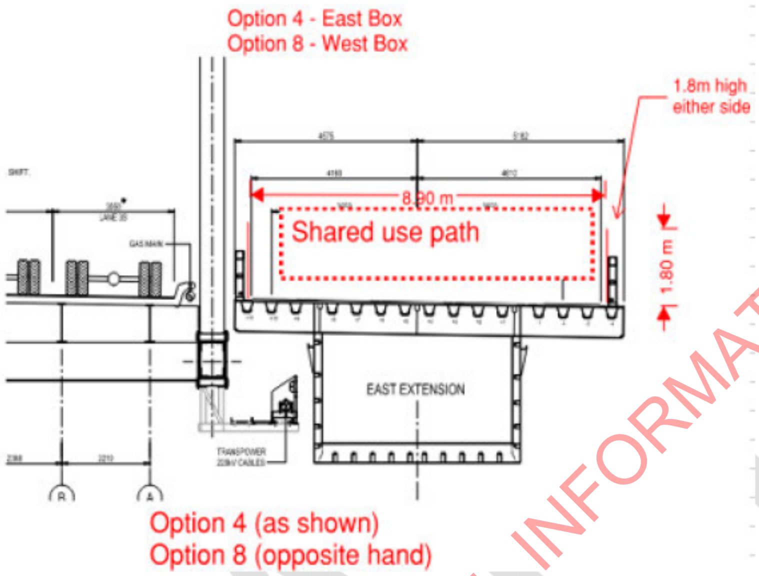


Figure 4 – Option 4 & 8 section

Option 9 – permanent shared use path with three lanes of traffic on truss bridge

Option 9 proposes to permanently convert one central lane on the truss bridge into a shared use path. New barriers are proposed at either side of the shared use path.

It was found that the new loading from the shared use path, new barriers, and three lanes of traffic exceeded the available live load capacity of the truss bridge. Load restrictions on all traffic lanes and pedestrian/cyclists would be required to bring the new loads down to acceptable levels.

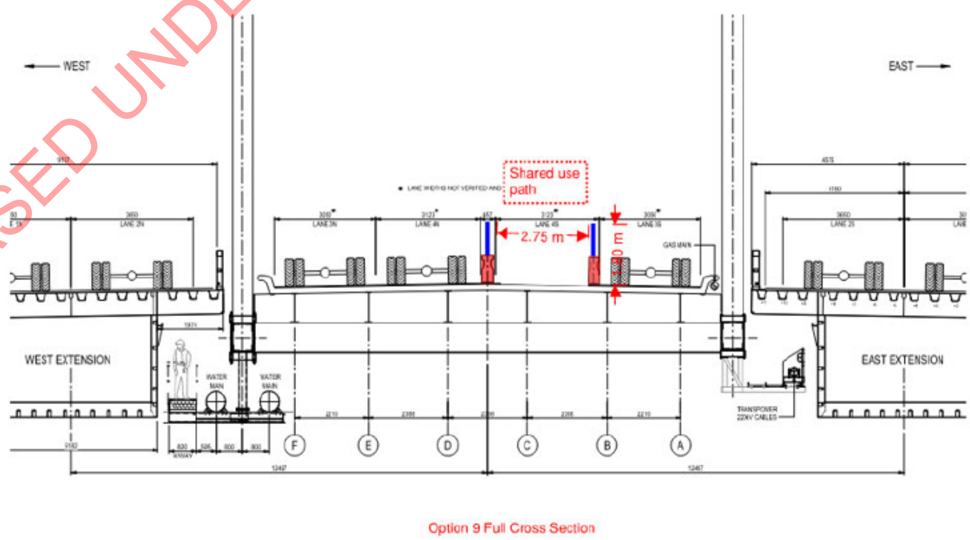


Figure 5 – Option 9 section, option 10 similar but with central two lanes into shared use path

Option 10 – permanent shared use path with two lanes of traffic on truss bridge

Option 10 proposes to permanently convert two central lanes on the truss bridge into a shared use path. New barriers are proposed at either side of the shared use path.

It was found that with the two central traffic lanes replaced by a shared use path and an extra traffic barrier, that the bridge would be able to carry a controlled pedestrian load on the shared use path without load restrictions on the traffic lanes.

Option 11 – permanent shared use path with two lanes of traffic on both extension bridges

Option 11 proposes narrowing the existing two traffic lanes on each extension bridge and adding a shared use path, with a new barrier separating the shared use path and traffic.

It was found the new loading from the shared use path, new barriers and two lanes of traffic exceeded the available live load capacity of both extension bridges. The new loads were found to exceed the available live load capacity of the box girders even with no heavy vehicles in both lanes.

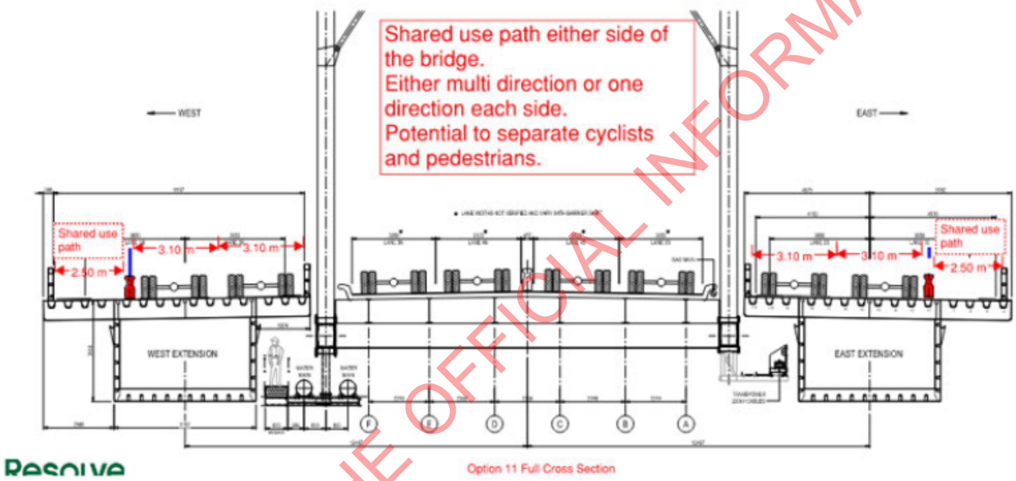


Figure 6 – Option 11 section

SHARED USE PATH LOADING

The shared use path loading used in this review is in accordance with the standard BD37/01 as applicable to the box girder structures. The load intensity varies with loaded length, width and concurrency with traffic loads.

For the critical Span 2 of the extension bridge, the unfactored equivalent distributed loads are

- 1.57 kPa for 2.5m wide shared use path concurrent with traffic
- 1.44 kPa for 4.0m wide shared use path concurrent with traffic
- 1.58 kPa for 8.9m wide shared use path without traffic

For the critical truss bridge Span 1, the unfactored equivalent distributed loads are

- 1.2kPa for 2.75m wide shared use path concurrent with traffic
- 1.1kPa for 5.5m wide shared use path concurrent with traffic

For all options, the new loads exceed the available capacity with crowd loading on the shared use path.

Crowd loading is defined in BD37/01 as 5kPa over the shared use path.

BARRIER MACHINE ON EXTENSION BRIDGE

Option 1, 3, 5, 7, 11 all require the use of a barrier moving machine on the extension bridges. Currently the barrier moving machine is only allowed to operate over the truss bridge. The barrier machine has two heavy axles.

The review concluded that using the barrier moving machine on the extension bridges is feasible from a global capacity point of view. However, there would be increased fatigue damage with effects depending on the position of the machine and the frequency of operation, which would result in more weld repair works.

RISKS AND ISSUES

In addition to the load assessment findings discussed in previous sections, the proposed options have some risks and issues which affect the overall feasibility of the options. The risks and consequences have not been quantified at this stage. Further traffic load study and structural assessment are required to understand the risks and consequences in more detail. Some of the risks and issues are discussed in this section.

a. Increase of traffic lane loads

When one or more lanes of traffic is removed from the bridge, the traffic loads in the remaining lanes are expected to increase due to more vehicles using the remaining lanes. Restricting heavy vehicles in some lanes will also result in an increased traffic live load in the remaining lanes.

Increased traffic loading may cause global live load and fatigue issues. This may result in traffic restrictions and increased fatigue repair requirements on the bridge structures.

b. Shifting vehicle wheel tracks

For options proposing a change of traffic lane position or width, the vehicle wheel tracks on the bridge deck will be shifted. This will increase the fatigue damage of the elements under the new wheel track positions which is likely to lead to more fatigue repair work.

c. Overweight permits

Changing the lane width and lane arrangement will affect overweight or over-dimensional vehicles using the bridge. The introduction of new barriers and shared used path will also affect the ability of the bridge to carry overweight vehicles. The existing overweight permits will need to be revoked then re-assessed with outcomes that may require increased restriction levels such as time restrictions and escorts for low speed restrictions, or a no-go assessment.

d. Impact on truss bridge members

Changing lane arrangements on the truss bridge may result in vehicles travelling closer to the edge, increasing the risk of vehicle impact on the truss members.

e. Vibrations due to synchronous pedestrian excitation

It is known that the box girder structures have a resonant natural frequency that is susceptible to excitation by groups of pedestrians walking in step. Dampers would likely be required for all shared use path options on the extension bridges to control pedestrian-induced vibrations. Vehicles also cause vibrations and deflections of the box girders which may cause discomfort to pedestrians.

f. Vehicle weight limit compliance

There are some vehicle weight limits currently in place on the AHB and regular non-compliance with the restrictions has been recorded. Enforcement of traffic load restrictions such as banning heavy vehicles from lanes to accommodate walking and cycling loads would need to be carried out by the police.

g. Light weight metal traffic barrier

Light weight metal traffic barrier requires fixings to the deck slab. It is structurally not feasible to fix a traffic barrier onto the bridge deck at the position proposed, because the deck is unable to sustain the impact load from a traffic barrier.

h. Wind loads

The porosity of the new fences needs to be high to minimise additional wind loading. Wind loading could be significant if a solid fence or screen is required. Further assessment or wind tunnel testing may be required to quantify the effect.

i. Controlling pedestrian and cyclist numbers

For some options, practical and effective measures are required to control the number of pedestrians and cyclists using the bridge. An effective monitoring scheme may also be required.

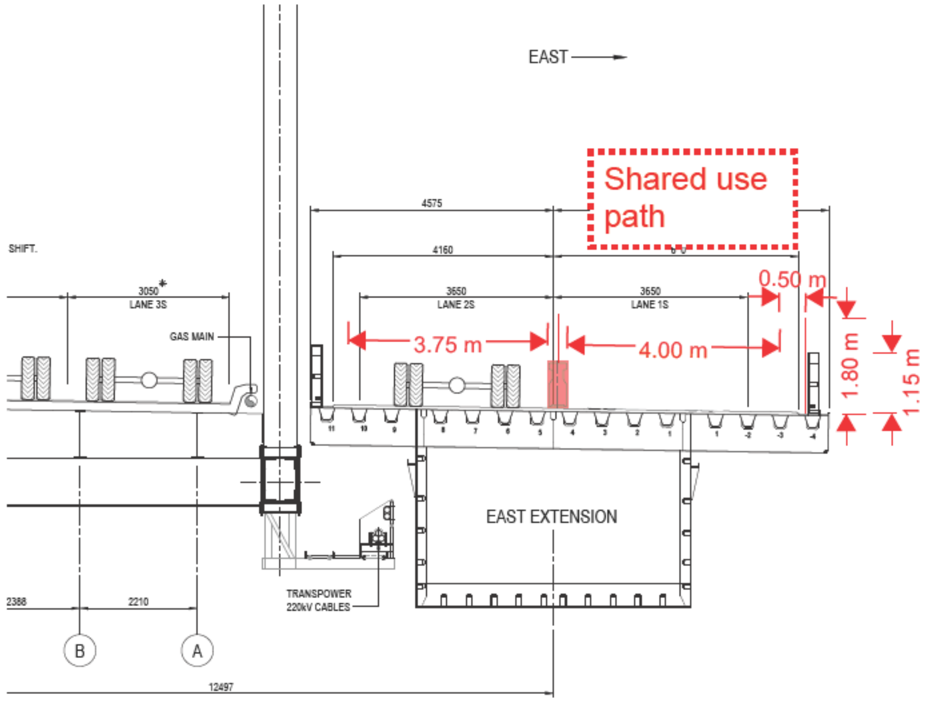
APPENDIX 1 – OPTIONS SKETCH FROM RESOLVE GROUP

Auckland Harbour Bridge Shared Path Options List

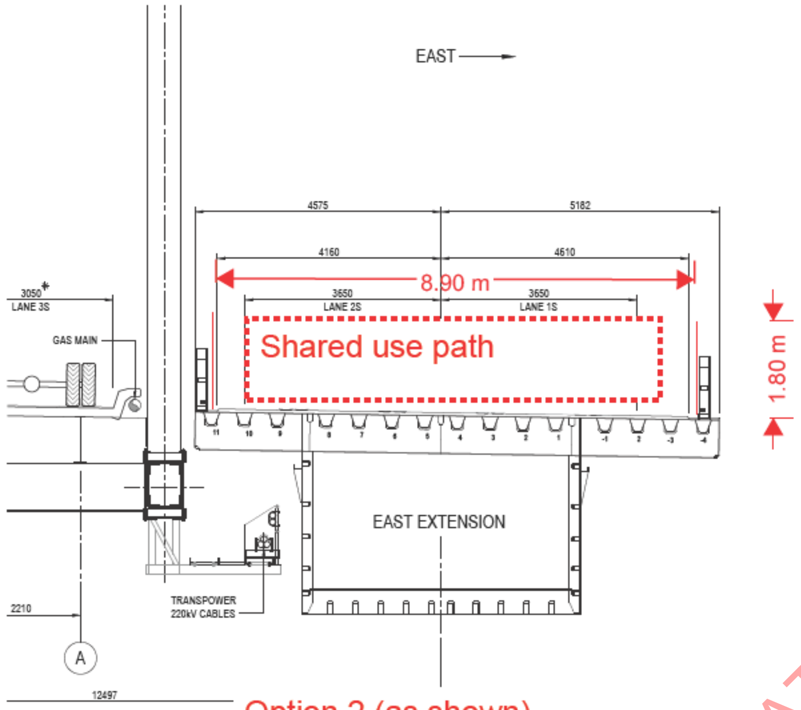
Option	Description	Temporary/ Permanent	Ramp Closures/ Modification	Traffic Configuration	Tidal Flow	Access North	Access South	Shared Path Width
1	East - 1 Lane	Temporary	Shelly Beach	4/3 (5/2)	Tidal	Sulphur Beach Road/Underpass	Shelly Beach Offramp	4m
2	East - 2 Lane	Temporary	Shelly Beach	3/3	None	Sulphur Beach Road/Underpass	Shelly Beach Offramp	8m
3	East - 1 Lane	Permanent	Shelly Beach	4/3 (5/2)	Tidal	Sulphur Beach Road/Underpass	Shelly Beach Offramp	4m
4	East - 2 Lane	Permanent	Shelly Beach	3/3	None	Sulphur Beach Road/Underpass	Shelly Beach Offramp	8m
5	West - 1 Lane	Temporary	Curran Street	4/3 (5/2)	Tidal	Sulphur Beach Road/Underpass	Curran Street	4m
6	West - 2 Lane	Temporary	Curran Street	3/3	None	Sulphur Beach Road/Underpass	Curran Street	8m
7	West - 1 Lane	Permanent	Curran Street	4/3 (5/2)	Tidal	Sulphur Beach Road/Underpass	Curran Street	4m
8	West - 2 Lane	Permanent	Curran Street	3/3	None	Sulphur Beach Road/Underpass	Curran Street	8m
9	Centre -1 Lane	Permanent	None	4N/3S	None	Sulphur Beach Underpass	Fanshawe Street	3m
10	Centre - 2 Lane	Permanent	None	3/3	None	Sulphur Beach Underpass	Fanshawe Street	6m
11	Both Sides	Permanent	Shelly Beach/ Curran Street	5/3	Tidal	Sulphur Beach Road/Underpass	Shelly Beach Offramp/ Curran Street	2.5m/2.5m

Temporary = Weekend
Permanent = 24/7

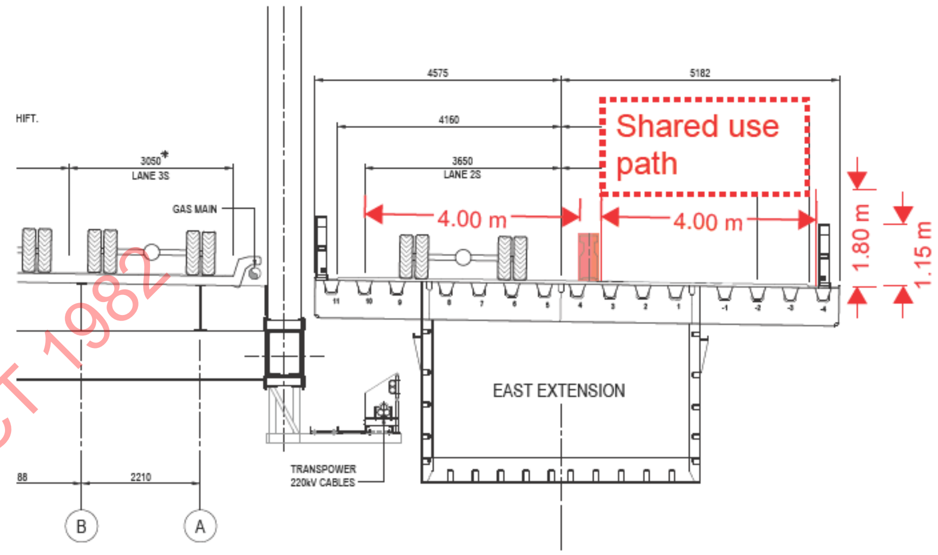
Resolve GROUP



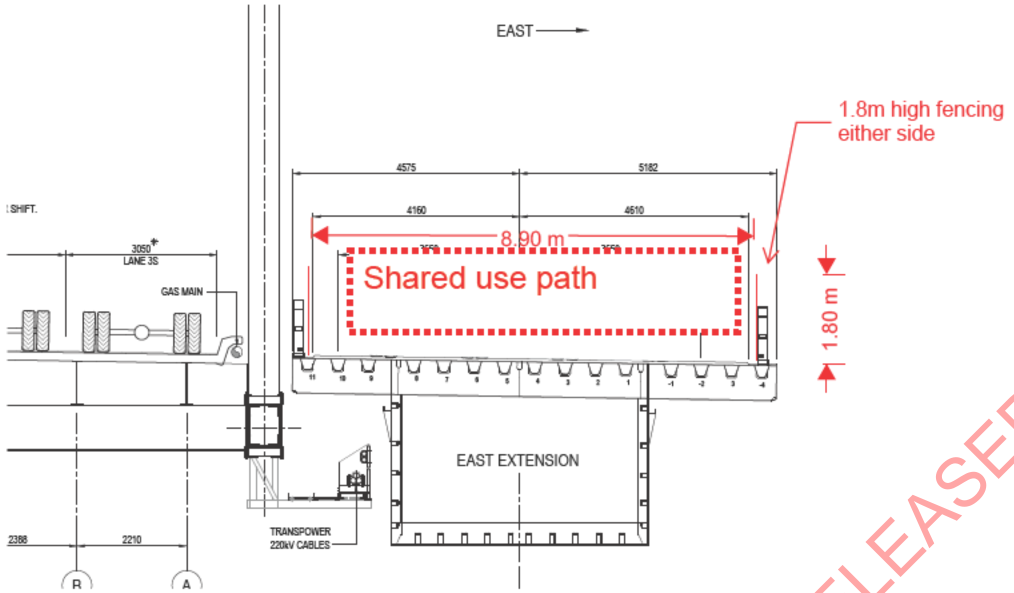
Option 1 (as shown)
Option 5 (opposite hand)



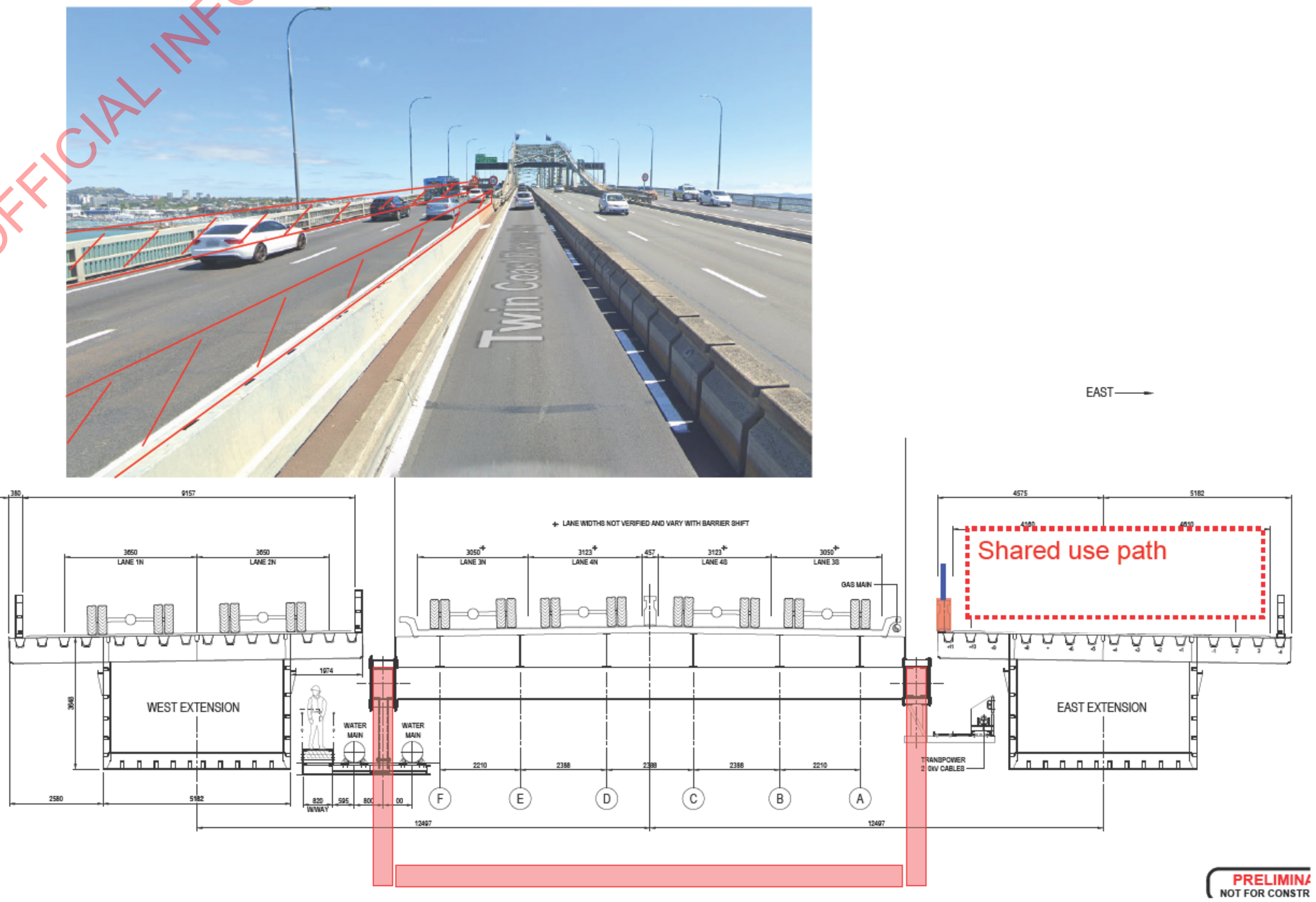
Option 2 (as shown)
Option 6 (opposite hand)



Option 3 (as shown)
Option 7 (opposite hand)

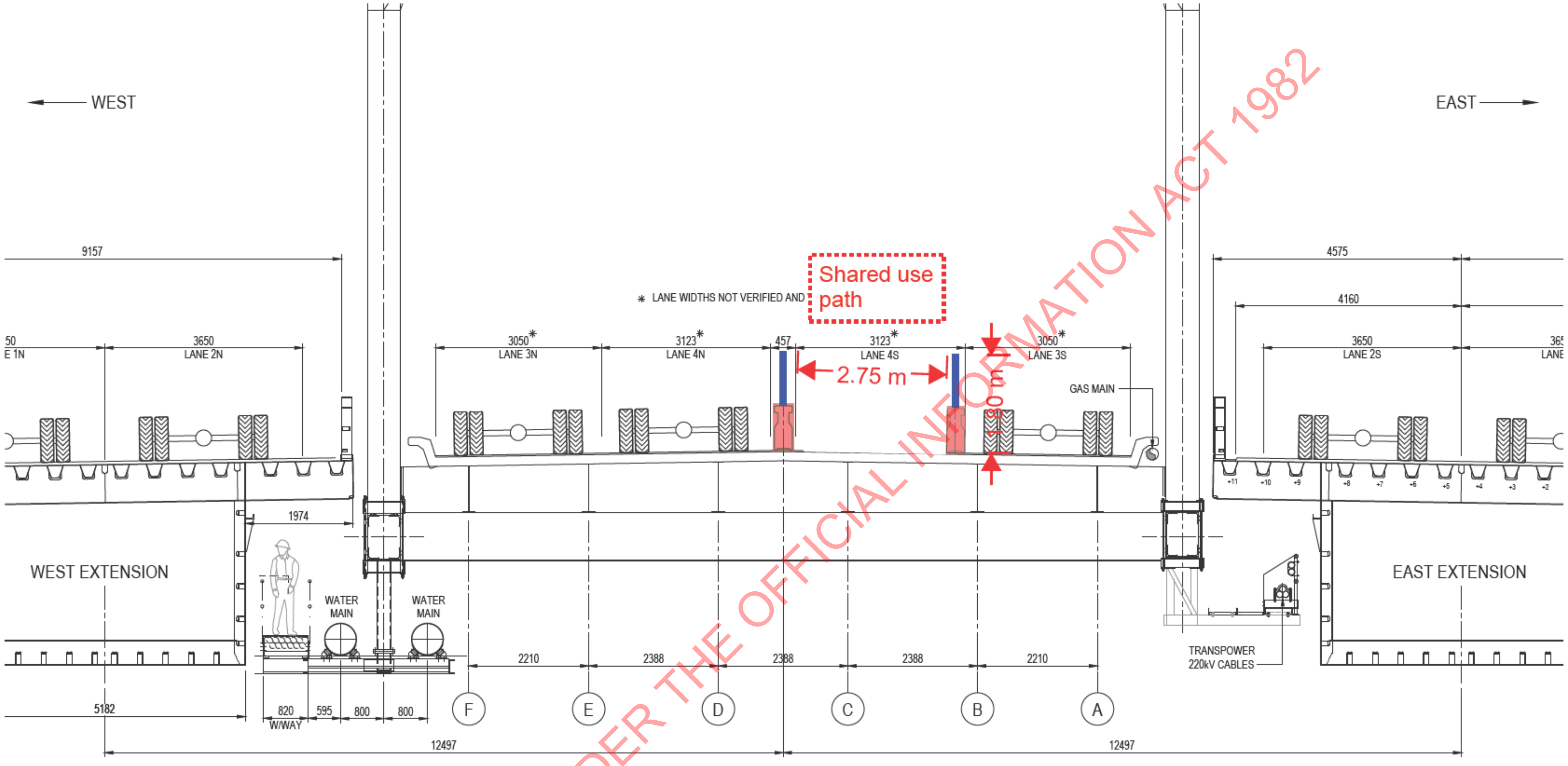


Option 4 (as shown)
Option 8 (opposite hand)



Option 4 Full Cross Section

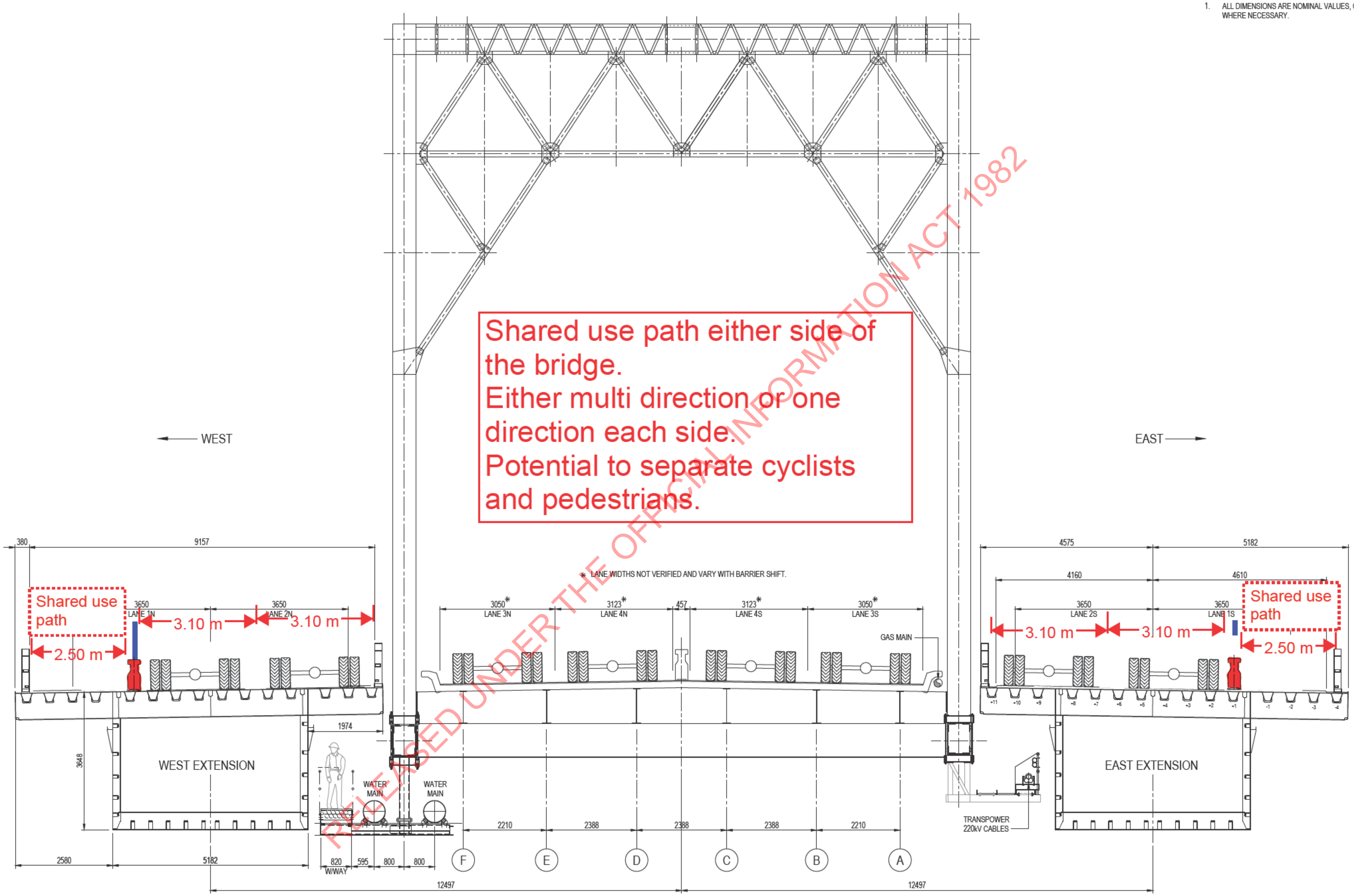
Resolve GROUP



Option 9 Full Cross Section

NOTES

1. ALL DIMENSIONS ARE NOMINAL VALUES, CHECK ON SITE WHERE NECESSARY.



Option 11 Full Cross Section

Resolve GROUP

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	By	Chk	Appd	Date
A	PRELIMINARY	PN			

Drawing Originator: NZ TRANSPORT AGENCY WAKA KOTAHI; Auckland Harbour Bridge — PART OF THE AUCKLAND MOTORWAY ALLIANCE

Original Scale (A1) 1:50; Reduced Scale (A3) 1:100

Design	MB	19.10.15
Drawn	PN	19.10.15
Dsg Verifier		
Dwg Check		

Approved For Construction* — Date

* Refer to Revision 1 for Original Signature

Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: AHB ALLIANCE

Title: AUCKLAND HARBOUR BRIDGE NAVIGATION SPAN CROSS SECTION

Discipline: STRUCTURAL ENGINEERING

Drawing No. 3910806-S-110 — Rev. A

Document No. 3910806-S-110.DWG

DO NOT SCALE

IF IN DOUBT ASK.