AHB Alliance

SkyPath Concept Structural Assessment Technical Report

NZ TRANSPORT AGENCY

Auckland Harbour Bridge

Part of Auckland Motorways

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Auckland Harbour Bridge Alliance Confidential Report 2014.

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Executive Summary

The AHB Pathway Trust has developed a revised concept design of a cycleway / walkway on the eastern side of the AHB. It is proposed that a cycleway / walkway facility be suspended beneath the overhanging deck of the eastern box girder extension bridge. The current design is for a 4.0 m wide facility with viewing platforms over piers to be constructed using carbon fibre reinforced polymer (FRP) materials. It is proposed that the SkyPath utilises the full available capacity of the box girder structure on the south-bound extension bridge.

The SkyPath facility has been designed by Reset Urban, Gurit and Airey Consultants Ltd. SkyPath loadings were provided by Gurit / Airey Consultants and used to assess the load effects on the extension bridge structure by Beca using NZ Transport Agency standards. For the current 4.0 m wide SkyPath with 6.0 m wide observation decks at the piers it was found that with unrestricted access for pedestrians and cyclists assessment loadings exceed the structural capacity of the bridge. The Pathway Trust has proposed that pedestrian / cyclist loading could be reduced by installing a control gate system to limit people numbers. As no such system can be found in operation in New Zealand the Pathway Trust is investigating reliable fail-safe gate systems to monitor people numbers.

The Transport Agency has indicated that a minimum 20 years of unrestricted traffic on the south-bound extension bridge must be allowed for to meet its operational requirements for the AHB. This aligns with the anticipated timeframe for delivery of the Additional Waitemata Harbour Crossing. This assessment found that in order to meet the Transport Agency’s requirements it would be necessary to reduce pedestrian / cyclist loading below design standards and limit the number of people accessing SkyPath at any one time.

In this study the existing extension bridge was assessed to find out the critical pedestrian / cyclist loading in combination with peak traffic and temperature loads that would use up the available bridge capacity. The resulting load was converted into a critical number of individuals using the SkyPath at one time. Considering the assessment traffic loading on the extension bridge together with SkyPath loads it was found that up to approximately 600 people could be carried. Pier brackets, box girder webs and some critical span locations would need to be strengthened for the SkyPath. With increasing traffic load intensity, representing estimated traffic growth occurring in about 20 years’ time, it was found that the SkyPath could be used by up to approximately 300 people.

The risks associated with the SkyPath user control system, with the variability of future AHB traffic loading and with the potential for variation in SkyPath dead loads will need to be considered by the Transport Agency. The issues associated with safety, security, operation and maintenance, consent compliance, finance and management of the SkyPath are to be assessed by NZ Transport Agency and Auckland Council. Such issues have not been addressed in this technical assessment and require further studies.

The SkyPath affects wind loading on the bridge and only preliminary assessments can be carried out until wind tunnel testing is completed.

It is concluded from this assessment that;

- Further investigation including a wind load study on the effects of the SkyPath has on the bridge using wind tunnel testing will need to be carried out to confirm the feasibility of the proposed SkyPath facility.
- The final SkyPath people limitations can be determined at the next stage of the project when developed design, wind tunnel test results and information on the user load control system are available, and a departure from standards has been agreed by the Transport Agency.

1 Introduction

1.1 Background

The feasibility of a range of options for a cycleway / walkway on the AHB extension bridges has been assessed by NZ Transport Agency in the past. The most recent assessment of the load effects of the SkyPath on the AHB were reported in Beca's Auckland Harbour Bridge Pathway Concept Structural Assessment Technical Report, Revision C (July 2012). The current assessment has been carried out to compare load effects of the latest FRP structure with previous assessment findings. The basis of the load assessment was to apply the same methodology and AHB loadings as used in the 2011/2012 study, but with updated lighter SkyPath loads.

The box girders were strengthened in 2010 to achieve the maximum load-carrying capacity to allow for future traffic load growth. Traffic in north-bound lanes 1 and 2 had been found to have the highest loading and a 10 % traffic load growth margin was applied in the design of strengthening works. Peak traffic loading on the south-bound extension bridge has been found to be approximately 15 - 25 % lower than in the north-bound lanes 1 and 2. The SkyPath has been proposed to utilise the spare capacity of the box girder structure to support the cycleway / walkway.

The previous Pathway assessment issued in September 2011 addressed six options of an under slung cycleway / walkway structure of varying width. The basis of the assessment was to allow for the full pedestrian / cyclist loading according to NZ Transport Agency standards and predict the timeline when load restrictions would have to be in place due to steady traffic load growth. As the assessment found that the box girder did not have sufficient load-carrying capacity to support the preferred 4m Pathway width or the traffic growth margin, a new approach was proposed by the Pathway Trust to utilise a lightweight FRP composite structure and limiting user loads on the facility.

1.2 Scope of this Report

In the most recent study the Pathway Trust has proposed a number of revised options for the shared use path with lighter dead loads but with 6 m wide viewing platforms added at pier locations (see drawings attached in Appendix A). Beca has carried out a structural assessment of the proposals to determine if both local and global box girder capacities are adequate to support the revised SkyPath loads in combination with traffic and temperature loading.

Traffic live loads on the AHB are evaluated using data from weigh-in-motion (WIM) equipment installed in the bridge. The bridge-specific live loads derived in this way for long-span bridges allow lane loadings based on actual traffic. In order to maintain the safety of the bridge the bridge-specific assessment live loads must be monitored and account taken of future traffic load growth. The most recent load model available for the south-bound extension bridges at the time of the assessment was derived from a 2005 load study and updated based on measured increases in vehicle weights and numbers from 2014. The updated 2005 traffic load model was used for the previous SkyPath assessment and is also used for the current study.

In order to allow for future load growth, estimates of changes in the south-bound loading were also made and applied in the load assessment. Future load growth due to increases in heavy vehicle numbers and weights has been determined by projecting growth curves using loads measured over the past decade. These estimates of future traffic load growth have been used to predict approximate numbers of people that could be allowed on the SkyPath in 20 years' time.

1.3 Exclusions

Due to the conceptual nature of the SkyPath design to date a process of design development, feasibility studies, detailed bridge assessment and design of strengthening works to the existing structure will be required in future to fully assess the impacts on the AHB.

A wind load study of the effects of the suspended cycleway / walkway on the box girder structure including wind tunnel testing of scaled models of the modified bridge will be required to confirm the effects on the AHB and the feasibility of the SkyPath.

In order to establish the feasibility of such a facility several broader issues in addition to the structural implications of the proposal are to be addressed by the SkyPath group including security, safety, operation and maintenance issues, resource consents and stakeholder consultation. The risks associated with design, implementation and operation of the proposed facility have not been addressed by Beca at this stage. This assessment is a technical structural assessment and the broader issues will need to be addressed before acceptance of any proposal can be given.

Additionally, the following elements are excluded from this technical assessment;

- SkyPath approach ramps at the north and south ends of the bridge.
- Replacement of the existing maintenance gantry and feasibility of the gantry running arrangement and location.

The SkyPath structure has been designed by Gurit. There has been no peer review of the structural design of the SkyPath to date. Beca's role has been limited to assessing the effects of the proposal on the AHB and has carried out no structural check on the adequacy of the proposed FRP structure.

2 Assessments Standards

The assessment of bridges in New Zealand is covered by the NZ Transport Agency Bridge Manual. For the design of steel box girder structures the Bridge Manual refers to BS 5400 Part 3. Loadings must be compatible with the design standards and so BD 37/01 Loads for Highway Bridges is used to define appropriate load factors, combinations and the method of application of loads to the AHB box girder.

The traffic loading standards set out in the Bridge Manual are considered appropriate for bridge loaded lengths up to 50 m. For long-span bridges it is widely recognised that the maximum traffic loading occurs when a traffic incident results in a closely packed stream of slow moving vehicles. To allow such loads to be assessed a traffic load study has been carried out to develop a bridge-specific loading for the AHB. The approach developed by the UK Highways Agency for the assessment of bridges as set out in BD 21. The Assessment of Highway Bridges and Structures and BD 50 has been applied in the assessment of the AHB. It provides guidelines for the assessments of ultimate limit state traffic loading required to maintain appropriate safety levels for major bridges. BD 50 specifically covers the requirements for long-span bridges.

The ultimate limit state live loads derived from BD 21 and BD 50 are used with the load factors supplied in those standards and the material partial safety factors in BS 5400 Part 3.

Common practice is to apply an additional margin to allow for growth in traffic loads. As noted above this assessment is based on assessment traffic loadings and appropriate allowance for the traffic load growth on the AHB must be included in the study. Furthermore BD 50 requires 2 yearly reviews of the traffic loadings when bridge specific loads are adopted for assessment and strengthening.

3 SkyPath Arrangement

It is proposed that an under slung carbon fibre reinforced polymer (FRP) composite structure, will be fixed to the AHB east box girder facing downtown Auckland. The shared use cycleway / walkway runs from box 1 at the northern bridge end to box 74, immediately north of Westhaven Drive. The landings at both ends of the SkyPath have been planned with separate substructures having no load effect on the existing AHB structure.

The deck width of the SkyPath structure attached to AHB is 4.0 m uniformly, except at piers 1, 2, 3, 4 and 5 where observation decks of 6.0 m width are planned. The clear height between SkyPath deck and AHB cross girder is 2.6 m constant.

The composite ribs are proposed to be supported at the top with a pinned connection to the AHB cross girders and at the bottom with a bolted connection to the outer web of AHB. At the observation decks, projecting out 2.0 m further, additional supports (beams, props) to the AHB box girder bottom flange are proposed.

Elevation, plan view and cross sections showing the proposed SkyPath are shown on the figures below. A full set of drawings showing the facility are included in Appendix A.

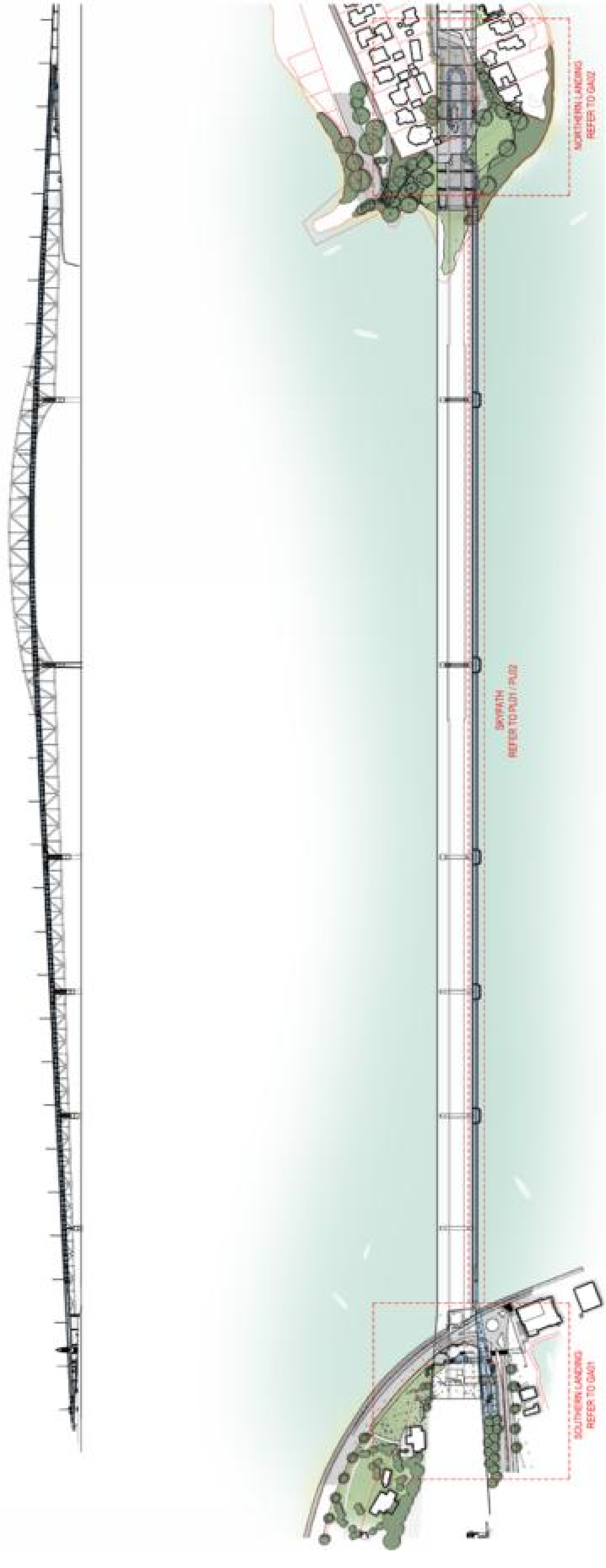


Figure 1: Elevation and Plan View of SkyPath

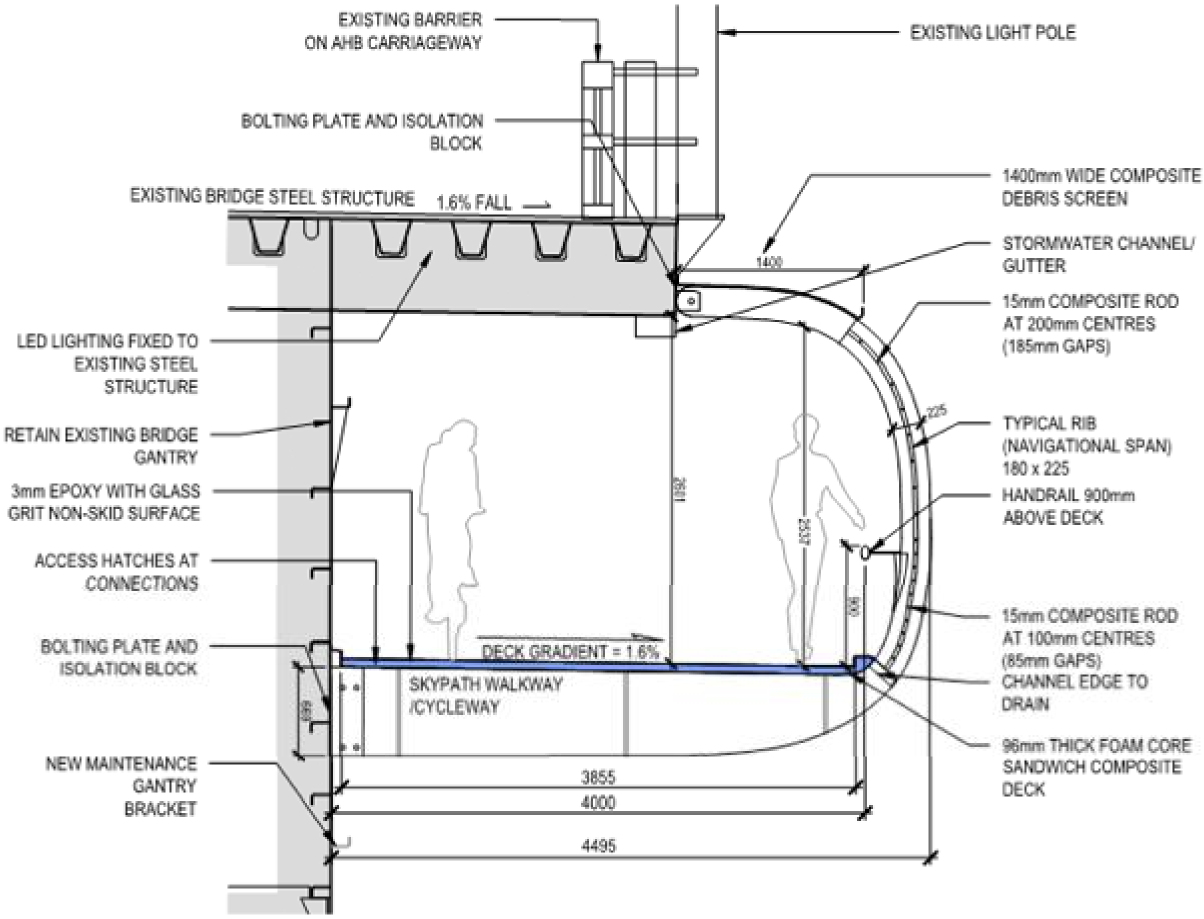


Figure 2: Typical Cross Section of SkyPath

4 Loading

The AHB extension bridges have been subject to rigorous load assessment in 2006 and detailed design of strengthening was completed in 2008. Bridge dead loads from previous assessments have been used along with dead and live loading specific to this assessment.

SkyPath loadings provided by Airey Consultants and Gurit for the self-weight of the facility and pedestrian / cyclist loads on the suspended cycleway / walkway have been applied to the box girder sections. Existing bridge dead and superimposed dead loads have not been considered in detail since the assessment has been carried out as a comparison between the north-bound traffic loads and the south-bound traffic combined with SkyPath loads. The critical combinations of south-bound traffic loads, wind load, temperature, SkyPath self-weight and pedestrian / cyclist loads have been assessed. The main components of the assessment loading are described below.

4.1 Live Loading

The loadings used for the previous assessments and the method of application of loadings are described in detail in Beca's Auckland Harbour Bridge Pathway Concept Structural Assessment Technical Report. A similar approach has been taken to the load assessment for the current study.

4.2 Wind Loads

The basis of the wind load application is as determined in the wind tunnel testing undertaken by MEL Consultants during the box girder strengthening design; refer MEL Consultants Report 17/08 - Wind Tunnel Tests on a Sectional Model of the Auckland Harbour Bridge, Auckland. The test results were obtained for the current bridge and for the addition of a pathway on each extension bridge with 1.2m extensions to the deck. The current SkyPath bridge assessment has used these test results to assess additional wind loadings applied to represent wind on the new 4m wide SkyPath structure.

The assumption is made to consider similar vertical area wind loadings on the SkyPath deck as applied to the bridge deck, acting in the same direction with equal intensity. The offset between the cross sectional centre of gravity of the box girder and the centre line of the cycleway / walkway is included in analysis. Lateral wind effects generated by the SkyPath structure are ignored.

The wind loading applied to the structural model for this assessment is considered a reasonable estimate of the wind load effects of the SkyPath structure. However, it is essential for the detailed design stage to investigate the behaviour of the bridge in conjunction with the SkyPath structure in a new wind tunnel test to establish the actual loadings. The wind effects could differ significantly due to the SkyPath position being under slung rather than at deck level.

4.3 Temperature

Temperature effects are applied to the structural model according BS 5400-2:2006 – Steel, concrete and composite bridges – Part 2: Specification for loads. This standard has been adopted for the temperature cases as it is more recent than BD 37/01 – Loads for Highway Bridges (May 2002).

Both overall and differential temperature change effects are considered in the bridge assessment model. Positive and negative temperature variations are applied.

A coefficient of thermal expansion for structural steel members of 12×10^{-6} /°C is used in the structural model of the extension bridge.

4.4 SkyPath Structure Loads

The superimposed dead loads from the cycleway / walkway structure were taken from loadings provided by Airey Consultants / Gurit. A summary of weight and reaction loads of the SkyPath structure is included in Appendix B. Loads are applied as point loads at every single SkyPath rib location along the longitudinal bridge sections.

The final dead load of the SkyPath structure must not exceed the design dead load. Any increase in structure weights above those supplied will have the effect of reducing the limitation on people using the SkyPath even further.

Additional physical work is required to enable the attachment of the SkyPath to the existing bridge structure, including further strengthening and installation of tuned liquid dampers. Allowance is made by adding superimposed dead load representing both strengthening and dampers.

4.5 Pedestrian / Cyclist Loads

The pedestrian / cyclist loading on the cycleway / walkway is in accordance with BD 37/01. The nominal pedestrian live load (including cyclists and pedestrians), to be used for elements carrying footways or cycle tracks only, is 5 kN/m^2 for loaded lengths of 36 m and under. For longer loaded lengths the nominal load is reduced in accordance with Clause 6.5.1 of BD 37/01.

For elements of the bridge which support carriageway loadings together with SkyPath footway or cycle track loading a reduction of 0.8 to the nominal load is applied together with specific reductions due to the width of the facility. Accordingly for the local analysis of the secondary cross girders a reduction factor to the nominal pedestrian / cyclist loading of 0.71 (for 4 m plus width) is applied.

For main structural members of the extension bridges, supporting at least two lanes of notional traffic, a reduction of 0.5 to the nominal pedestrian / cyclist load is applied. Hence for the global analysis of the main box girder structure and the substructures the loading is reduced to 0.5 of nominal pedestrian / cyclist load. The table below indicates the intensity of pedestrian / cyclist loading applied for a SkyPath deck width of 4 m and over for local analysis of secondary cross girders and for global analysis of the primary box girder structure and substructures for a range of loaded lengths. An overview of the pedestrian / cyclist load cases that have been considered for the assessment are included in Appendix C.

Table 1: Pedestrian / Cyclist Loading in kN/m^2

Pedestrian / Cyclist Loading cross girders* (kN/m^2)	Pedestrian / Cyclist Loading for Global Analysis (kN/m^2)**								
	Loaded Length (m)								
	<36	50	100	150	200	250	300	350	>400
3.55	2.50	1.91	1.53	1.30	1.13	1.00	0.89	0.81	0.74

Notes:

* according to BD 37/01 6.5.1 for loaded length, L=4.57 m (cross girder)

** according to BD 37/01 6.5.1 for main members at different loaded lengths

The pedestrian / cyclist loads for the SkyPath structure were obtained from loadings provided by Airey Consultants / Gurit. A summary of weight and reaction loads of the SkyPath loads is included in Appendix B. The provided reactions refer exclusively to 5 kN/m^2 pedestrian / cyclist loading and were scaled down to match the above conditions in this assessment. Loads are applied as point loads at every single SkyPath rib location along the longitudinal bridge members.

Where load effects were found to exceed assessment standards a further analysis to calculate approximate maximum people numbers was carried out for the critical main span, Span 2. In this analysis an allowance for pedestrian / cyclist crowd load is made by using a patch load of 2.5 kN/m^2 distributed over a width of 4 m and a critical length. The critical length varies with the intensity of the south-bound traffic loading for the span being assessed and refers to a Demand /Capacity ratio of 1.0 at the most critical location along the longitudinal members. No reduction of patch loading is applied. This patch load is applied as a moving load running along the centre line of the SkyPath deck. The effects of the deck widening (6 m) at the viewing platforms at the piers of the bridge are neglected for the moving load application, since these only marginally contribute to the moment around the major axis of the box section.

5 Analysis Methods

Structural analysis models of the bridge used in previous assessments and design of strengthening were utilised with modifications for the SkyPath assessment. No stiffening effects of the SkyPath structure were included in the analysis. It was assumed that the cycleway / walkway supporting structure will be detailed to deflect in unison with the box girder structure.

The global analysis of the structure to determine the effects of loadings defined in Section 4 Loading was carried out using a continuous beam model including varying geometric properties for box girder sections along the bridge.

A separate local deck grillage model was used to analyse the local bending effects of traffic loading on cross girders.

Previous strengthening design calculations were used to assess the critical members in the pier brackets.

6 Assessment Methods

6.1 Global Box Girder Assessment

The results of global structural analysis for the box girder supporting the SkyPath were compared with the previous analysis results for the box girder strengthening. The box girders have been strengthened to their maximum feasible capacity for the critical span 2 and at Piers 1 and 2. The ultimate design forces were therefore deemed to be the maximum limit for the south-bound box girder supporting the SkyPath. In this assessment the traffic and SkyPath loading was compared with ultimate design forces for the strengthened box girder.

This assessment is based on a moment comparison for the major bending moment of the box section. Previous assessments indicated the major bending moment is the predominant and critical component for a detailed stress evaluation of the box.

Where the assessment major bending moment exceeded the strengthening major moment at a location along the box girder a detailed stress evaluation was carried out. Where capacity of the box section was found to be exceeded the proposal was re-assessed with reduced pedestrian / cyclist loadings on the SkyPath.

6.2 Local Deck Assessment

The load effects of the traffic plus SkyPath load combinations described above were compared with ultimate cross girder capacities evaluated in the previous assessment.

Local Space Gass deck grillage models used in previous box girder assessments were used to analyse the local bending effects of the SkyPath loading on the cross girders. Local vertical reactions on the deck cantilever girders from SkyPath loading were obtained from loadings provided by Airey Consultants / Gurit (included in Appendix B) and were applied as vertical forces at the tip of the cantilever.

The cross girders were also checked for 150 % local vertical reactions from SkyPath loads concurrent with 100 % full design traffic load on the bridge, to represent effects of breakage of a rib attachment to cross girder load case.

6.3 Pier Bracket Assessment

The load effects of the SkyPath plus traffic loading combinations described above were compared with previous design forces for the strengthened brackets.

7 Assessment Findings

The SkyPath load assessment was undertaken for the global effects on the box girder and the pier brackets and the local effects on the cross girders.

7.1 Global Box Girder Load Assessment

A global moment comparison has been made between the assessment peak south-bound daytime traffic (which is more critical than night time loading) in combination with SkyPath loading plus temperature effects and the ultimate design forces for the strengthened box determined during the previous Box Girder Strengthening (BGS) project. Temperature effects have been investigated in a specific load combination and compared with the strengthened box capacity at critical locations. The load combination including traffic load and temperature effects were found to govern the assessment findings.

As Pier 1, Pier 2 and Span 2 have been strengthened to their maximum feasible capacity the comparison is governed by these critical areas of the box girder. It was found that the assessment loadings exceeded box girder capacities in the critical Span 2. This does not include any allowance for future traffic load growth. Other areas were generally found to have loadings less than the previous box girder strengthening loads. However, the assessment indicated that when applying the critical loadings at spans 4 to 7 load effects were found to exceed the current box girder capacity at some locations. It is assumed that minor box girder strengthening works tailored to accommodate the new cycleway / walkway will be carried out in this region before applying SkyPath to the AHB. Omission of the strengthening work at spans 4 to 7 would result in a significant drop in people numbers.

Because the structure was found not to satisfy assessment standards it was necessary to carry out further analysis to estimate potential numbers of people that could be carried on the critical Span 2 while utilising the full capacity of the box girders. Specific lengths of pedestrian / cyclist loading applied to the SkyPath were found to govern the assessment and limit the allowable number of people using the bridge at any time. A summary of the results of the moment comparison between SkyPath assessment load combination, applying current assessment (100 %) south-bound traffic and full pedestrian / cyclist loading (BD 37/01), with north-bound strengthening loading is included in Appendix D.

The people/user limitation is a global limit of individuals (cyclists or pedestrians) for the proposed SkyPath structure attached to the existing AHB. It is assumed that a reliable system to monitor and control the limit will be put in place when the facility is installed.

A range of potential south-bound traffic growth margins have been considered. During the current assessment (100 %) traffic load, 105 % and 110 % traffic growth margins and the correlating allowable pedestrian / cyclist loading (assuming the average weight of a person to be 0.75 kN) have been investigated and are summarised in the table below.

Table 2: Comparison of South-bound Traffic Growth Margins and People Number Limits

South-bound Traffic Growth Margin	Current (100 %)	105 %	110 %	120 %
Pedestrian / Cyclist Limitation	600 people	450 people	300 people	No capacity for pedestrian/cyclist load remaining

7.2 Local Deck Load Assessment

Cross girders were found to satisfy assessment standards for flexural strength under combined local vehicle and global effects described in Section 7.2 above.

A summary of the results of the assessment of cross girders is attached in Appendix E.

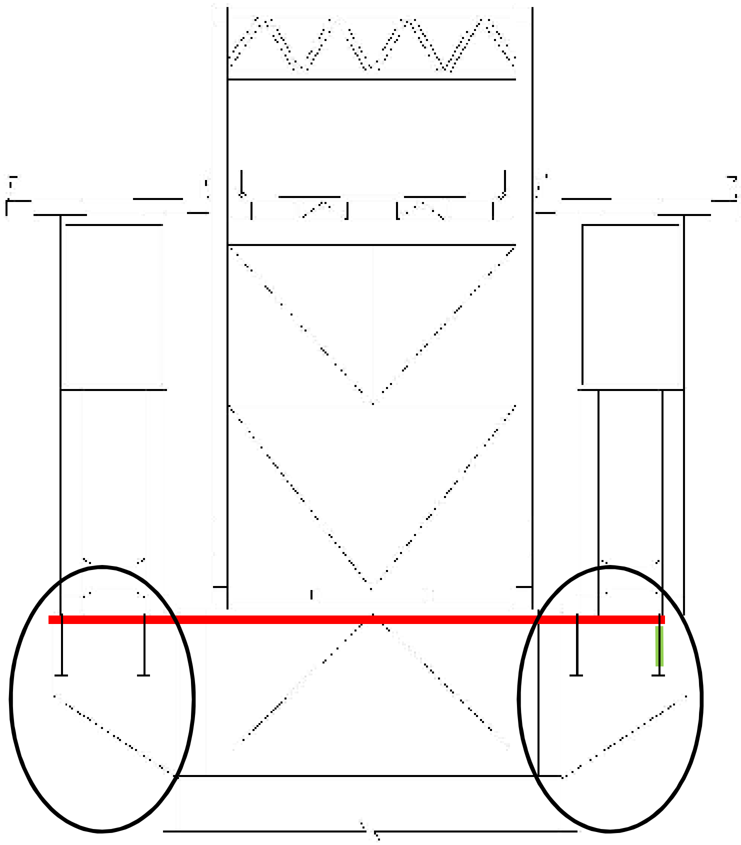
7.3 Pier Brackets

The substructure supporting the box girders was assessed and retrofitted between 1998 and 2000 and again between 2007 and 2010.

Based on a comparison of assessment loads with previous strengthening loads, additional pier bracket strengthening required would include;

- Additional stress bars at Piers 4 and 6
- Outer diaphragm beam web plating at pier 4 east

Figure 6 below shows indicatively the types of pier bracket strengthening that would be necessary to support the proposed SkyPath.



Stress (Sumitomo) Bars

Diaphragm Beam Web Plating

Pier brackets

Figure 6: Cross Section of AHB Showing Pier Brackets and Items Requiring Strengthening (Pier 1 and 2 Brackets Shown)

8 Discussion of Assessment Findings

As previously noted the critical areas of the bridge including the navigation span, Span 2, and adjacent piers, Pier 1 and Pier 2, cannot be feasibly strengthened further beyond their current capacity. It is anticipated that some strengthening in spans 4, 5, 6 and 7 is required in order to cater for increased loading.

Traffic loading applied in the assessment is based upon measured vehicle numbers and weights. In order to allow for future growth in heavy vehicles a load growth margin must be included for the safety of the bridge and its users. NZ Transport Agency has indicated that a minimum 20 years of unrestricted traffic on the south-bound extension bridge must be allowed for to meet its operational requirements for the AHB. As described in Beca's previous Auckland Harbour Bridge Pathway Concept Structural Assessment Technical Report, Revision C (July 2012), in order to provide for at least 20 years of traffic load growth, an estimated 10 % growth margin above the assessment traffic live load was found to be necessary.

The critical area where assessment standards were not satisfied was found in Span 2. Span 2 is governed by the load combination that includes differential temperature effects. Span 2 is therefore deemed to be the limiting element, provided that minor box strengthening will be carried out at spans 4 to 7.

The assessment findings described above show a range of traffic load growth margins and corresponding allowable people number limits on the proposed SkyPath structure.

A discussion of the implications of the assessment findings follows with reference to critical areas of the bridge.

8.1 Global Box Girder Load Limits

Assessment found the box girder capacity to be less than assessment traffic plus SkyPath loads in Span 2. Span 2 has been strengthened to its maximum feasible capacity. The effects of the proposed SkyPath on the AHB do not meet current loading standards. Traffic load restrictions or pedestrian / cyclist load reductions as suggested by the Pathway Trust, would be required on opening.

The assessment indicated that areas of spans 4 to 7 may need to be strengthened to increase the box girder capacity to carry the applied loads.

8.2 Local Deck Load Limits

The assessment findings show that the demand / capacity ratios for all local effects to be less than 1.0 for critical cross girders.

Cross girder loading is determined by local vehicle axle loads and no allowance was made for future traffic axle load growth. Any change to the current legal vehicle axle loads in future would have the effect of increasing demands on cross girders and would alter the findings of this assessment.

8.3 Pier Bracket Strengthening

The combination of vertical load and torsional effects from the box girder plus SkyPath impose loads through the trestle legs and onto the pier brackets. This load is greater than the previous loads considered in the recent AHB Box Girder Strengthening (BGS) project because the SkyPath is much wider.

The assessment shows that further strengthening would be required for a number of pier bracket elements. Additional stress bars were added to the Pier 4 brackets during the BGS project in 2010. With the SkyPath loads increasing effects from those considered in the BGS, the current capacity of the stress bars is close to being exceeded. Further work is required to assess the load effects of the SkyPath live and wind load on pier brackets in more detail. There is a risk that additional bars or replacement of the existing bars may not be feasible for Pier 4. The Pier 4 stress bars may then become the limiting factor governing the limit on people numbers.

Additional stress bars would also be required at pier 6. These would be similar to those installed as part of the recent BGS works. Further strengthening of this pier bracket would also be necessary to resist the extra load imposed through the new stress bars.

8.4 Pedestrian / Cyclist Load Reductions

The assessment of load effects on the extension bridge was carried out to the standards described in section 2. As the previous Pathway assessment indicated the AHB is not capable of carrying full pedestrian / cyclist loading for a 4 m wide shared path according to standards, the Pathway Trust has suggested that pedestrian / cyclist loading on the bridge could be reduced below NZ Transport Agency bridge standards by limiting the numbers of individuals accessing the bridge through the use of control gates and security personnel. By reducing pedestrian / cyclist loading in this way it is required that the utilisation of SkyPath is constantly monitored and effectively controlled to ensure that the bridge is not overloaded.

Because a reduction in pedestrian / cyclist loading below recognised code levels is a departure from standards this would require approval by the NZ Transport Agency Value Assurance Committee (VAC).

NZ Transport Agency has stated that since it will not be operating the SkyPath there would need to be appropriate control measures that would ensure the allowable loads were not exceeded. The Transport Agency would thus need details of the proposal for limiting pedestrian / cyclist loading to be presented to its VAC for their approval.

9 Additional Physical Work Required to Facilitate SkyPath

Additional work is required to enable fixing of the SkyPath to the existing bridge structure, including extension bridge strengthening and tuned liquid dampers as described in Beca's Auckland Harbour Bridge Pathway Concept Structural Assessment Technical Report, Revision C (July 2012). It is also required to strengthen spans 4, 5, 6 and 7 to allow for greater people/user limits.

10 Risks

A risk assessment has not been carried out to date for this project, however in the process of evaluation a number of issues requiring further studies have been noted. The risks and opportunities that affect the SkyPath from a bridge structural and operational performance perspective are summarised below.

10.1 Dead Loads

The assessment carried out to date is based on conceptual information and sizing. Possible variations to dead loads could occur in the following items:

- SkyPath

  The SkyPath is a very lightweight composite structure. It has not yet been peer reviewed and there could be changes to its dead load when the design is developed. For example, changes to structural weights, surfacing requirements, services or security equipment could lead to increased dead load.

- Box Girder Strengthening

  The additional strengthening steelwork required inside the box girder to support the SkyPath has not been designed and could increase (or decrease) when the design is developed.

- Tuned Liquid Dampers

  These are based on conceptual design only and will be subject to changes (increase or decrease) in weight when their design is further developed.

There is a risk that dead loads could vary as the design develops. Dead load changes are important because the margin for pedestrian / cyclist load is small and sensitive to any variation in dead load.

10.2 Traffic Loading

The intensity of traffic loading is governed primarily by the percentage and weights of heavy vehicles using the bridge. The current peak loading of heavy vehicles crossing the south-bound extension bridge is less than those using the north-bound extension bridge. It is proposed that the SkyPath loads take up this difference between the north-bound and south-bound traffic loads. There is significant uncertainty in predicting the future growth in heavy vehicle numbers and weights. A change in the proportion of heavy vehicles on the south-bound extension bridge could happen relatively quickly. These rapid changes have been experienced recently with the change in heavy vehicle behaviours during and following the recent BGS project. A suitable margin to cater for this uncertainty is necessary for the on-going safety of the bridge.

The traffic load on the extension bridge needs to be monitored as the people limitations on SkyPath are dependent on its intensity. The limitations need to be reduced when traffic load increases accordingly.

Cross girder loading is determined by local vehicle axle loads and no allowance was made for future traffic axle load growth. Any change to the current legal vehicle axle loads in the future would have the effect of increasing demands on cross girders and would alter the findings of this assessment. The risk for the NZ Transport Agency posed by traffic load changes is that of restrictions on heavy vehicles using the bridge having to be implemented.

10.3 SkyPath Loading

Pedestrian / cyclist management is proposed through the use of continuously manned access gates and admission fares. NZ Transport Agency must be satisfied that a suitably robust and reliable user management system can be implemented and maintained continuously throughout the life of the SkyPath. If the system was unable to perform satisfactorily there is a risk that restrictions on bridge traffic loading or closure of the SkyPath would be required.

The Pathway Trust is researching and investigating a suitable and reliable fail safe gate system to monitor people numbers. As no such system can be found in operation in New Zealand examples of user number controls and performance in operation overseas are to be reviewed.

10.4 Wind Loading

Assumptions have been made in this assessment on the effect of the SkyPath extension on the lift and drag coefficients for the south-bound extension bridge. Wind tunnel testing will be required to confirm the adopted wind loading. The risk is that the wind tunnel testing shows significantly higher wind loads and then governs the assessment loading, reducing the numbers of people the SkyPath can carry.

10.5 Other Risks / Hazards

The stress bars at Pier 4 were strengthened during the previous BGS project. Should the demands require further strengthening, there is a potential that this strengthening is not feasible. This may result in the capacity of the Pier 4 stress bars governing the bridge capacity, reducing the available pedestrian / cyclist load margin.

In the event of a bridge ship strike, the lightweight SkyPath structure could be struck before the more robust box girder. A suitable strategy will need to be determined to mitigate the risk to the SkyPath and users.

In the event that an errant vehicle hits or penetrates the existing extension bridge traffic barrier, debris may cause damage to the SkyPath and cause injury to SkyPath users. Suitable mitigation will need to be provided. Additionally, the capacity of the traffic barrier is less than current design standards. Further investigation into the suitability of the barrier and associated risks will be necessary.

In the event of a spillage of hazardous materials the SkyPath and users will be at risk and a mitigation strategy will be required. A flammable liquid spill or a fire will pose a significant risk.

There are significant safety and security issues associated with an under-deck cycleway / walkway (refer for example to the AHB Cycleway Feasibility Study Stage 1, July 2006) that are outside the scope of this study and will require further study.

11 Summary and Conclusions

Beca has assessed the load effects on the extension bridge structure to NZ Transport Agency standards using SkyPath loads provided by Airey Consultants / Gurit.

For the 4.0 m wide SkyPath with 6.0 m wide observation decks at the piers it was found unrestricted loadings exceed the structural capacity of the bridge. Therefore the existing extension bridge was investigated to find out the critical pedestrian / cyclist loading that would utilise the bridge's full load-carrying capacity. Finally the resulting load has been converted into a critical number of individuals using the SkyPath at a time.

Based on the assessment traffic loading on the extension bridge, the SkyPath was found to be able to carry up to approximately 600 pedestrians or cyclists at a time. Assuming increasing traffic load intensity, representing 110 % traffic growth occurring in about 20 years' time, the cycleway / walkway was found to be limited to approximately 300 people.

The key issues requiring further studies to be considered at this assessment stage are:

- that dead loads could vary as the project develops
- that wind loads derived following wind tunnel testing could increase from those currently assumed and govern the assessment loading
- that a suitable pedestrian/cyclist control system can be implemented.

If the dead load effects noted above increase then it will be necessary to reduce pedestrian / cyclist loading of the SkyPath further and conversely if the dead loads decrease pedestrian / cyclist loads could be increased. On this basis the final SkyPath people limits may best be determined in the next stage of the project when the developed design and wind tunnel results are available, together with information on the pedestrian / cyclist load control system.

Note that the reduction in pedestrian / cyclist loading is a departure from standards and will require approval from the NZ Transport Agency's Value Assurance Committee.

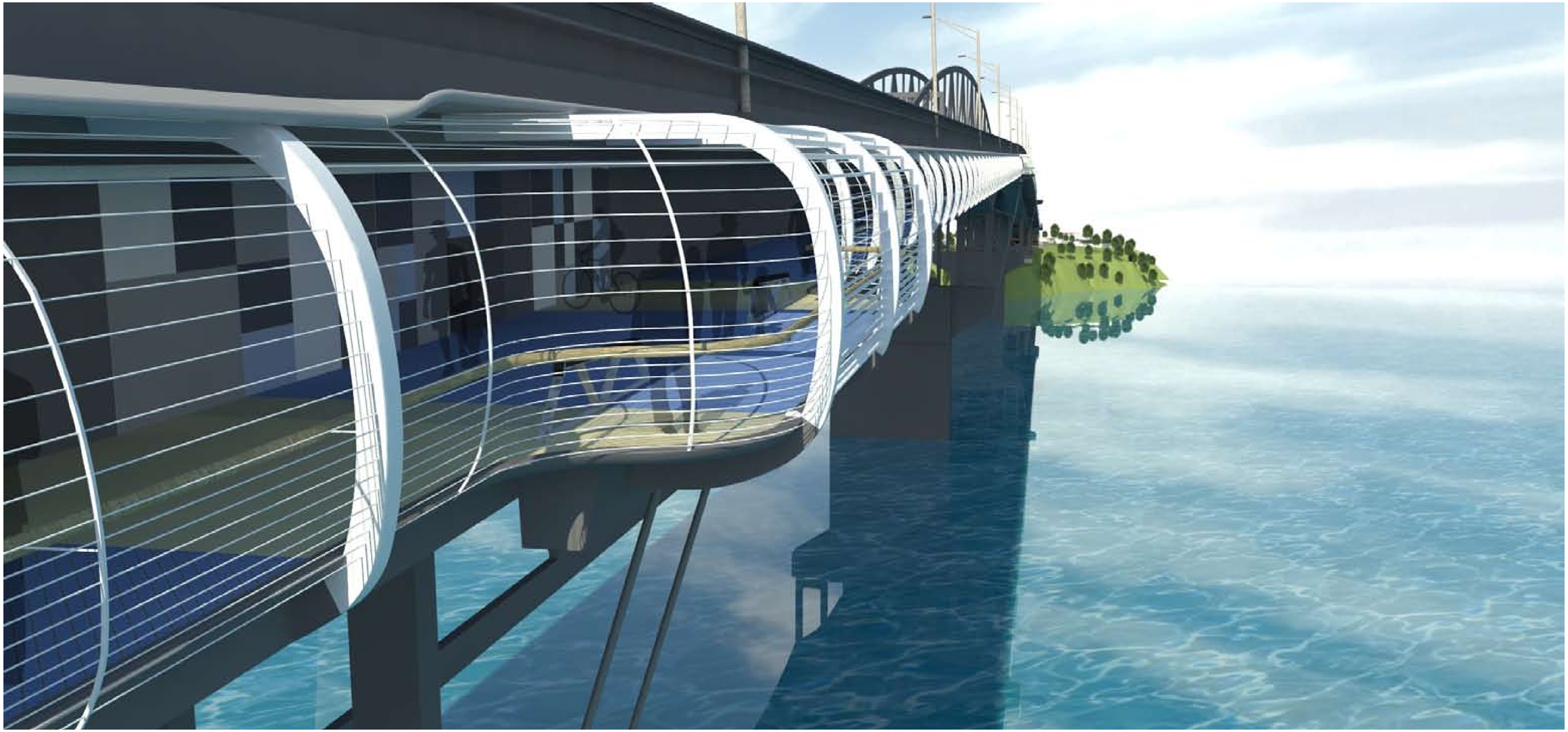
It is concluded from this assessment that:

- SkyPath could be used by up to 600 people at a time considering the assessment loading and up to 300 individuals in about 20 years' time depending on the growth of traffic load intensity.
- Further investigation including a wind load study on the effects of the SkyPath on the bridge using wind tunnel testing will need to be carried out to confirm the feasibility of the SkyPath.
- The final SkyPath people limit can be determined at the next stage of the project when developed design, wind tunnel test results and information on the pedestrian / cyclist load control system are available.

Appendix A
SkyPath
Resource Consent Drawing Package
(Draft)

SkyPath

draft



Resource Consent Drawing Package

15 JULY 2014

RESET URBAN DESIGN

SKYPATH

RESOURCE CONSENT DRAWING PACKAGE

PROJECT NUMBER: 2719

ISSUED: 15 JULY 2014

REVISION: -

STATUS: Draft

RESET URBAN DESIGN

SKYPATH

RESOURCE CONSENT DRAWING PACKAGE

DRAWINGS

DATE	PLAN NUMBER	DESCRIPTION	REVISION
CONTEXT PLANS			
30.06.2014	CP01	Southern Landing Context Plan	A
30.06.2014	CP02	Northern Landing Context Plan	A
MITIGATION PLANS			
01.07.2014	MP01	Southern Landing Mitigation Plan	A
01.07.2014	MP02	Northern Landing Mitigation Plan	A
AREA PLANS			
14.05.2014	DD KP01	Key Plan	A
10.06.2014	DD PL01	Southern Landing	A
10.06.2014	DD PL02	Northern Landing	A
GENERAL ARRANGEMENT PLANS			
30.06.2014	GA01	Southern Landing	D
30.06.2014	GA02	Northern Landing	C
SECTIONS / ELEVATIONS			
18.06.2014	DD EL01	Overall Bridge Elevation, Elevation 1 of 2	A
18.06.2014	DD EL02	Overall Bridge Elevation, Elevation 2 of 2	A
30.06.2014	DD SE01	Southern Landing Long Section	B
30.06.2014	DD SE02	Southern Landing Cross Section AA	A
30.06.2014	DD SE03	Southern Landing Viewing Platform BB	A
30.06.2014	DD SE04	Northern Landing Long Section	B
30.06.2014	DD SE05	Northern Landing Cross Section CC	B
30.06.2014	DD SE06	Northern Landing Detail Section	A

DATE	PLAN NUMBER	DESCRIPTION	REVISION
DESIGN ELEMENTS			
15.07.2014	DD KP02	Module Layout Key Plan	A
30.06.2014	T101	Type 1 Module	A
30.06.2014	T201	Type 2 Module	A
30.06.2014	T301	Type 3 Module	A
30.06.2014	T302	Type 3 Module Elevation	A
20.06.2014		Design Elements	
12.05.2014		Lighting	
30.06.2014	DE01	Handrail Detail	A
PHOTOMONTAGES			
16.06.2014	01	Bridge Span - Facing Northcote Point	
16.06.2014	02	Bridge Span - Facing Northcote Point	
16.06.2014	03	View on Path within Standard Span	
16.06.2014	04	View of Southern Landing	
04.07.2014	05	View of Southern Landing from Westhaven Drive	
16.06.2014	06	View of Southern Landing	
16.06.2014	07	View of Southern Landing	
16.06.2014	08	View of Northern Landing	
04.07.2014	09	View of Northern Landing	
14.07.2014	10	View of Northern Landing	

CONTEXT AND MITIGATION PLANS 01

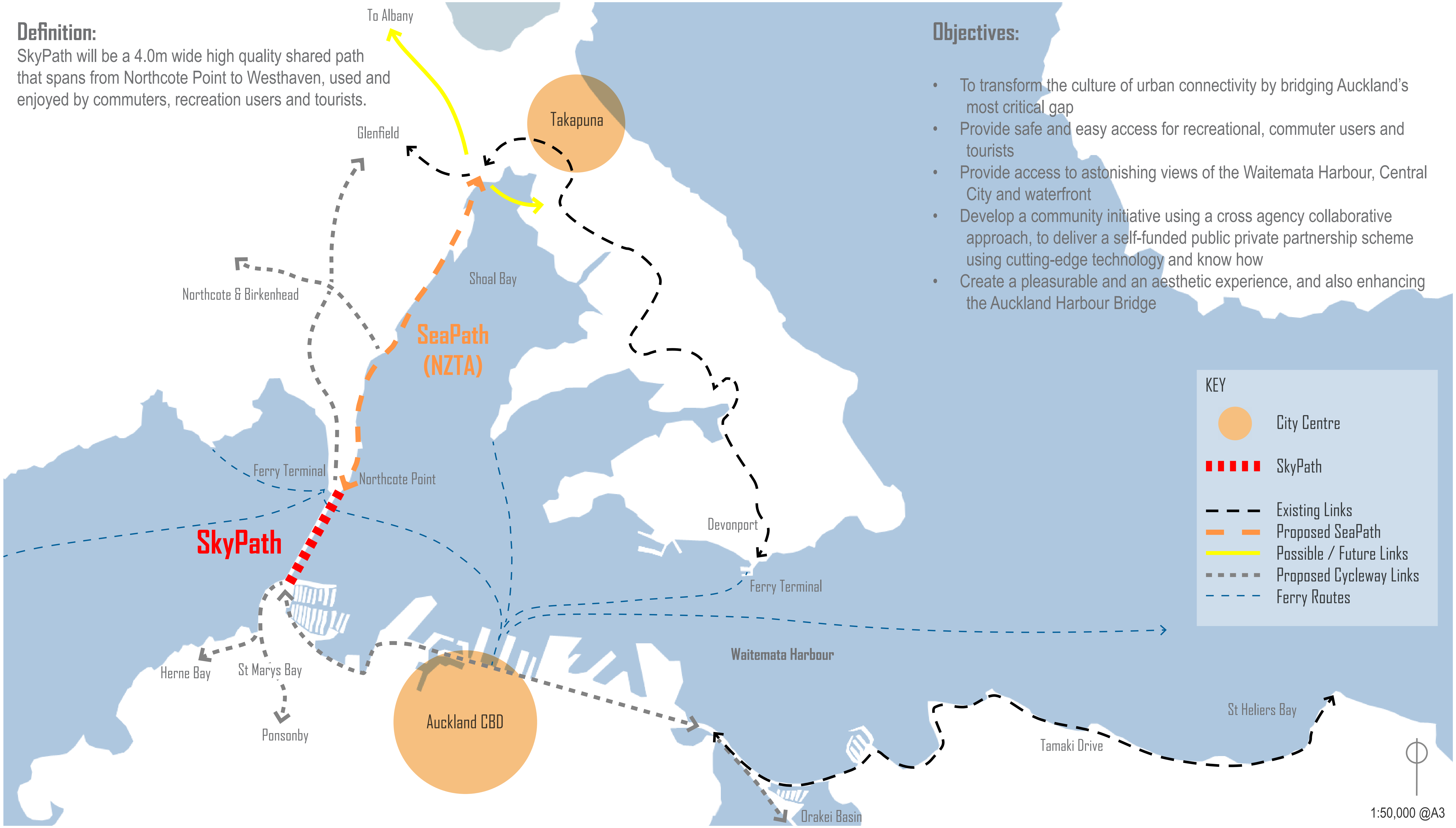
RESET URBAN DESIGN

SKYPATH

Project Vision: To have a world class walking and cycling facility on the Auckland Harbour Bridge, connecting the Central City to the North Shore

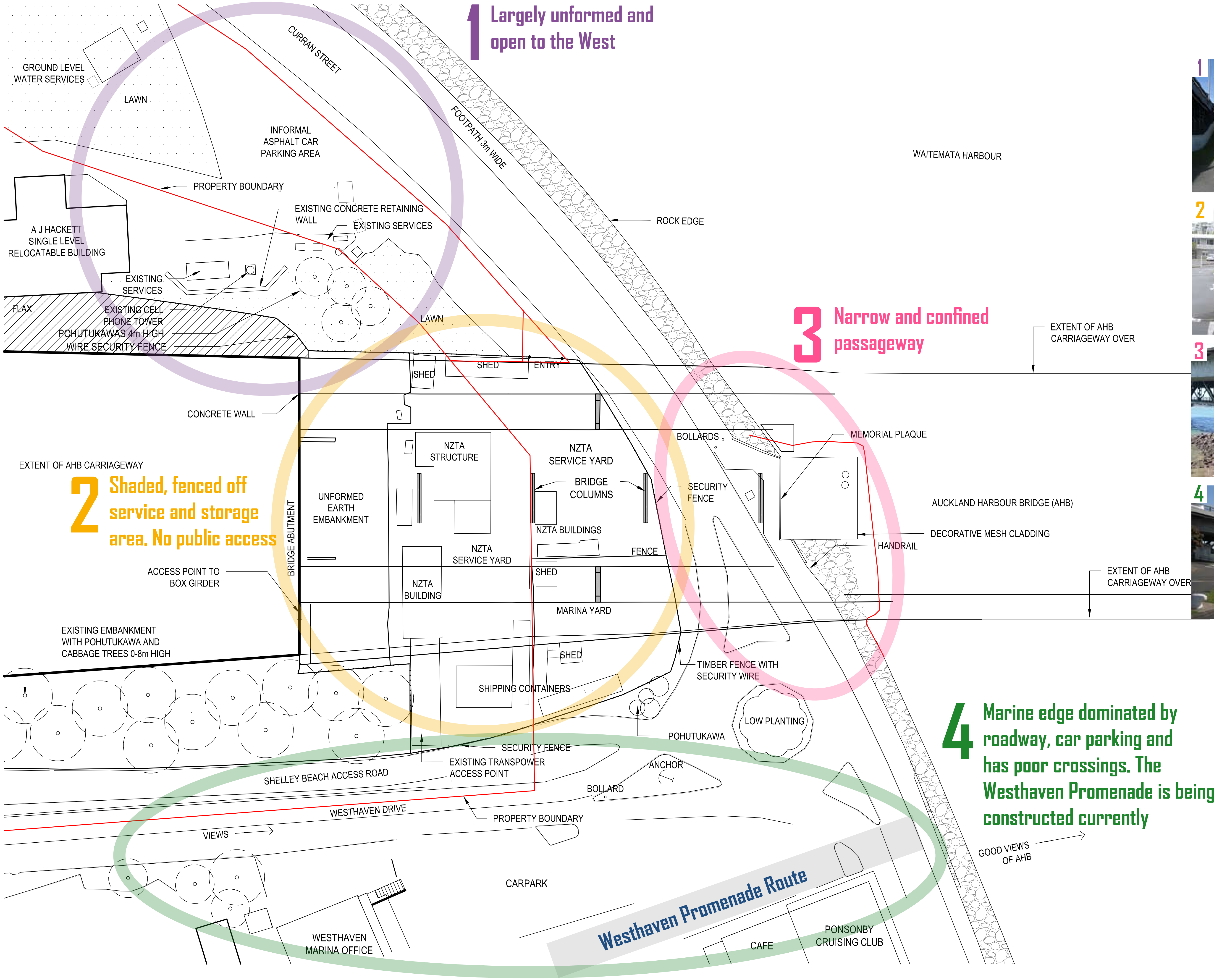
Definition:

SkyPath will be a 4.0m wide high quality shared path that spans from Northcote Point to Westhaven, used and enjoyed by commuters, recreation users and tourists.



Objectives:

- To transform the culture of urban connectivity by bridging Auckland's most critical gap
- Provide safe and easy access for recreational, commuter users and tourists
- Provide access to astonishing views of the Waitemata Harbour, Central City and waterfront
- Develop a community initiative using a cross agency collaborative approach, to deliver a self-funded public private partnership scheme using cutting-edge technology and know how
- Create a pleasurable and an aesthetic experience, and also enhancing the Auckland Harbour Bridge



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NORTH

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4

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No.	Revision	By	Chk	Appd	Date

CLIENT
SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

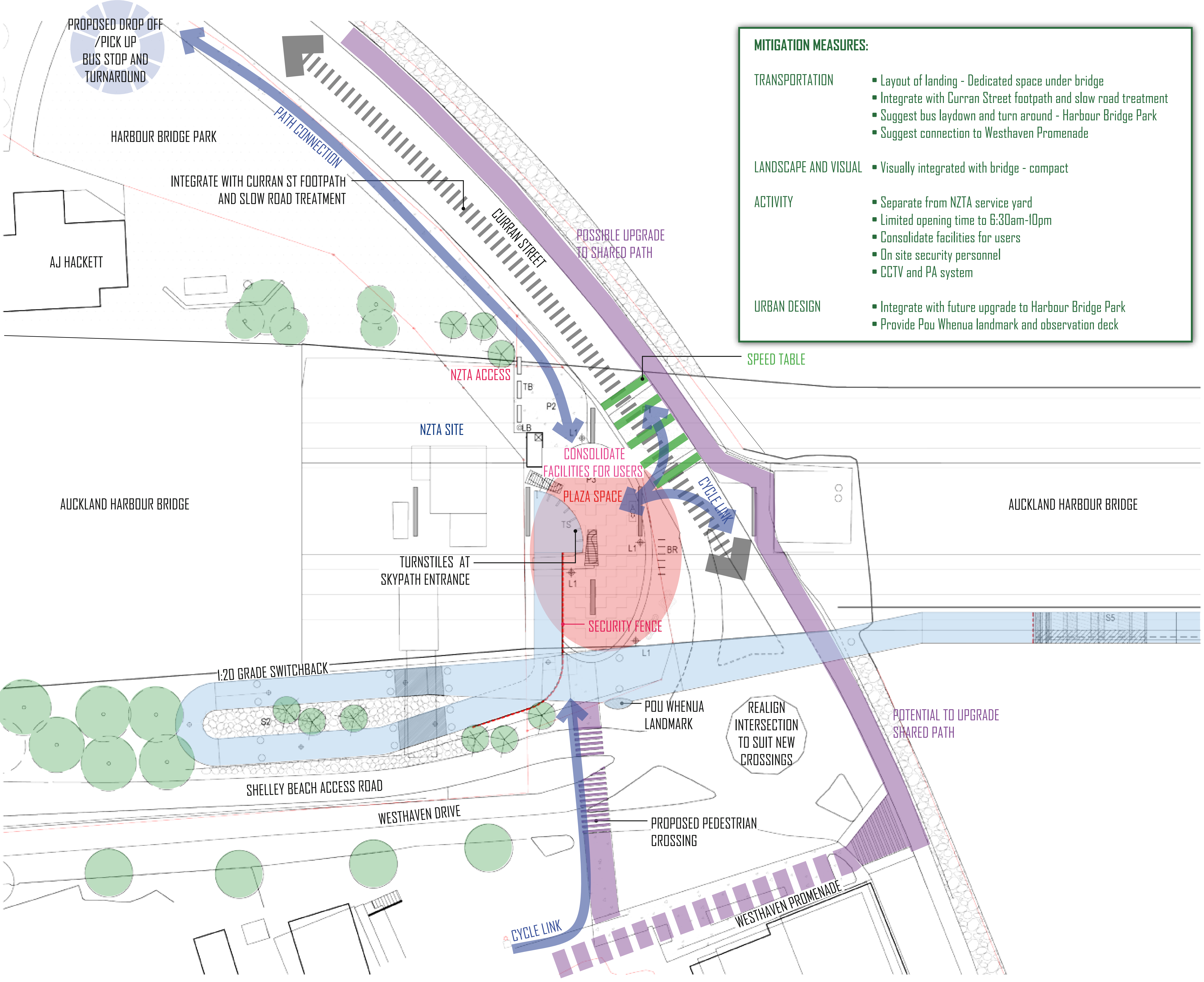
PROJECT
SKYPATH
SOUTHERN LANDING

RESET URBAN DESIGN

TITLE
EXISTING SITE CONTEXT 01
Southern Landing Plan

DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	EF		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	DRAWING NUMBER	REVISION	
2719	CP01	A	

FOR RESOURCE CONSENT



MITIGATION MEASURES:

TRANSPORTATION
- Layout of landing - Dedicated space under bridge
- Integrate with Curran Street footpath and slow road treatment
- Suggest bus laydown and turn around - Harbour Bridge Park
- Suggest connection to Westhaven Promenade

LANDSCAPE AND VISUAL
- Visually integrated with bridge - compact

ACTIVITY
- Separate from NZTA service yard
- Limited opening time to 6:30am-10pm
- Consolidate facilities for users
- On site security personnel
- CCTV and PA system

URBAN DESIGN
- Integrate with future upgrade to Harbour Bridge Park
- Provide Pou Whenua landmark and observation deck

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LEGEND:

SURFACES:
- P1 CONCRETE - TYP1
- P2 CONCRETE - TYP2
- P3 PLAZA PAVING
- S1 GRASS
- S2 FEATURE ROCKS
- S3 'SEFAR' FARBIC ENCLOSED CANOPY
- S4 MESH ENCASING
- S5 GLASS SCREEN

TREES:
- EXISTING TREE RETAINED
- PROPOSED TREE

FURNITURE:
- L1 PEDESTRIAN LIGHT POLE
- LB LITTER BIN
- IS INTERPRETIVE SIGNAGE
- BR BIKE RACKS
- TS TURNSTILES
- TB TIMBER BENCH
- DF DRINKING FOUNTAIN
- PS BIKE PUMP STATION
- PROPOSED SECURITY FENCE
- RELOCATED SERVICES

No	Revision	By	Chk	Appd	Date
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CLIENT
SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT
SKYPATH
SOUTHERN LANDING

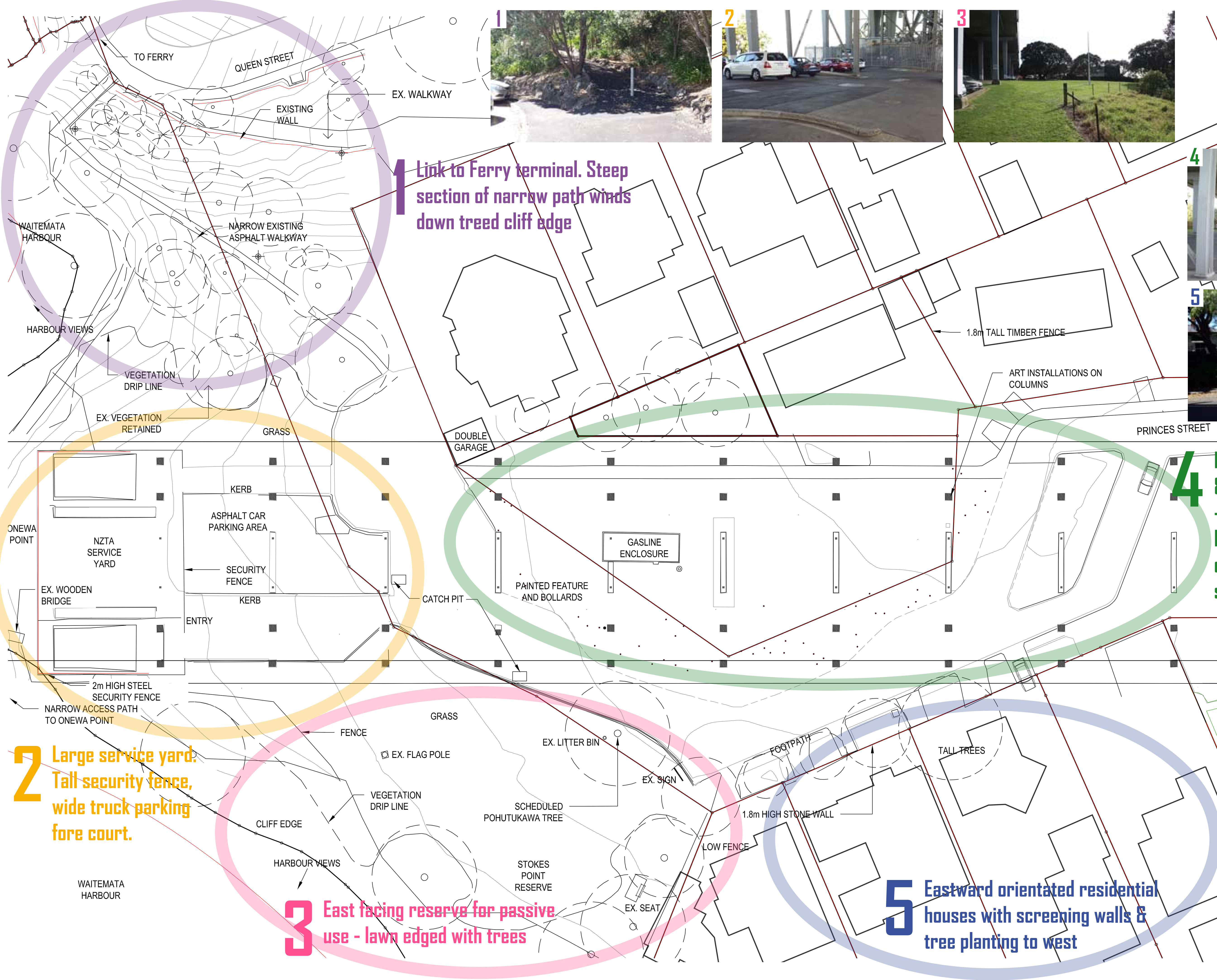
RESET URBAN DESIGN

TITLE
MITIGATION PLAN 01
Southern Landing

DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	AB		
APPROVED BY	GF	DATE	01.07.14

JOB NUMBER	DRAWING NUMBER	REVISION
2719	MP01	A

FOR RESOURCE CONSENT



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No.	Revision	By	Chk	Appd	Date

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
NORTHERN LANDING

RESET URBAN DESIGN

TITLE

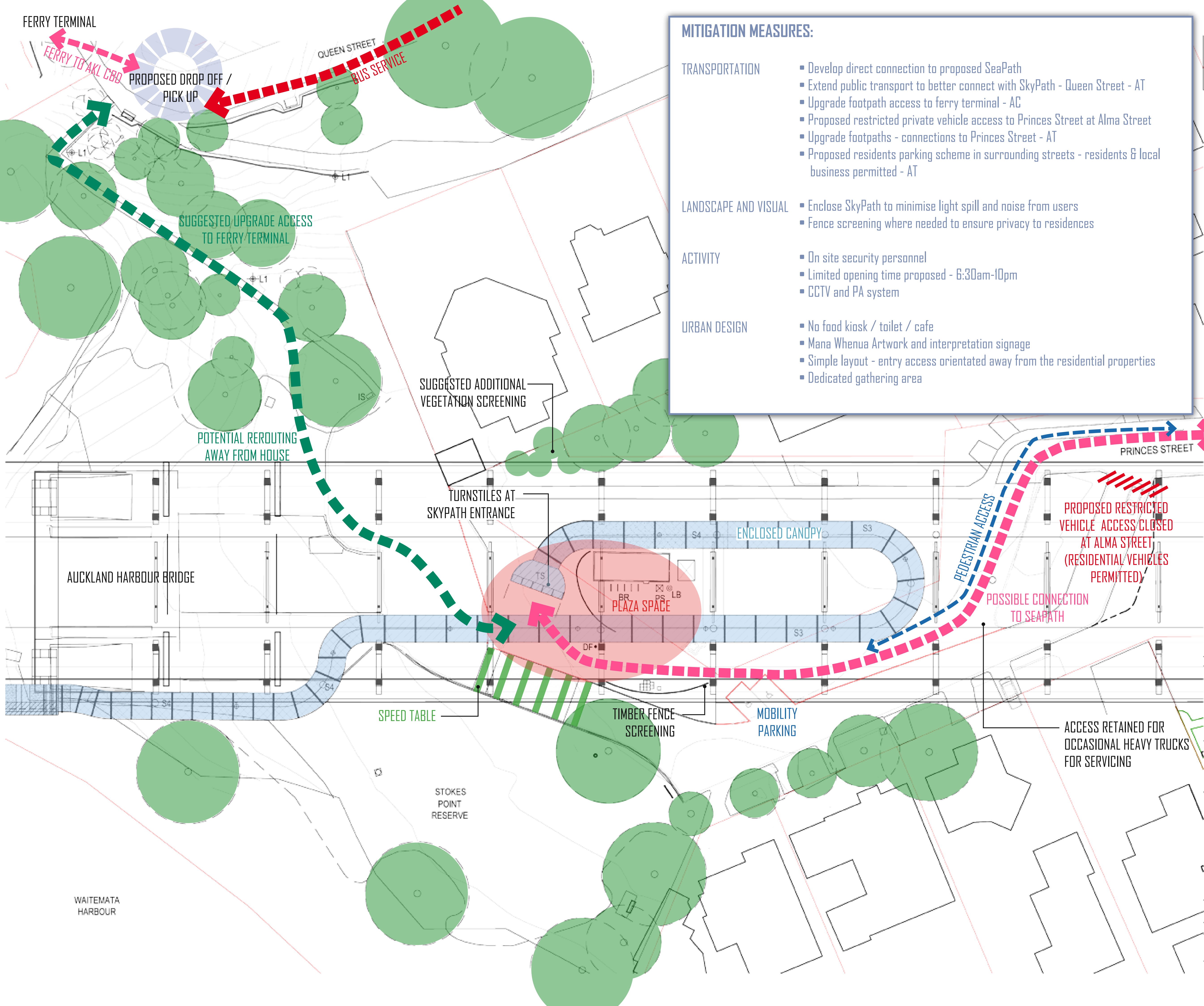
EXISTING SITE CONTEXT 02
Northern Landing Plan

DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	EF		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	DRAWING NUMBER	REVISION	
2719	CP02	A	

ISSUED FOR RESOURCE CONSENT

MITIGATION MEASURES:

TRANSPORTATION	▪ Develop direct connection to proposed SeaPath ▪ Extend public transport to better connect with SkyPath - Queen Street - AT ▪ Upgrade footpath access to ferry terminal - AC ▪ Proposed restricted private vehicle access to Princes Street at Alma Street ▪ Upgrade footpaths - connections to Princes Street - AT ▪ Proposed residents parking scheme in surrounding streets - residents & local business permitted - AT
LANDSCAPE AND VISUAL	▪ Enclose SkyPath to minimise light spill and noise from users ▪ Fence screening where needed to ensure privacy to residences
ACTIVITY	▪ On site security personnel ▪ Limited opening time proposed - 6:30am-10pm ▪ CCTV and PA system
URBAN DESIGN	▪ No food kiosk / toilet / cafe ▪ Mana Whenua Artwork and interpretation signage ▪ Simple layout - entry access orientated away from the residential properties ▪ Dedicated gathering area



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NORTH

LEGEND:

SURFACES:

P1	CONCRETE - TYP1
P2	CONCRETE - TYP2
P3	PLAZA PAVING
S1	GRASS
S2	FEATURE ROCKS
S3	'SEFAR' FABRIC ENCLOSED CANOPY
S4	MESH ENCASING
S5	GLASS SCREEN

TREES:

- EXISTING TREE RETAINED
- PROPOSED TREE PEDESTRIAN

FURNITURE:

L1	LIGHT POLE
LB	LITTER BIN
IS	INTERPRETIVE SIGNAGE
BR	BIKE RACKS
TS	TURNSTILES
TB	TIMBER BENCH
DF	DRINKING FOUNTAIN
PS	BIKE PUMP STATION
	PROPOSED SECURITY FENCE
	RELOCATED SERVICES

CLIENT: SKYPATH — AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT: SKYPATH NORTHERN LANDING

RESET URBAN DESIGN

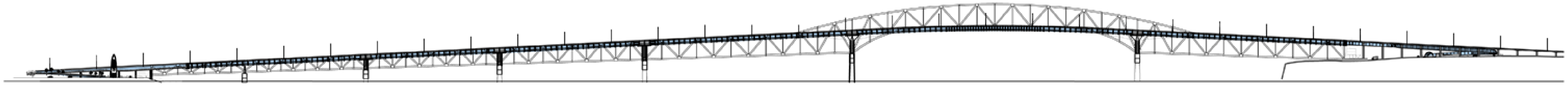
TITLE: MITIGATION PLAN 02 Northern Landing

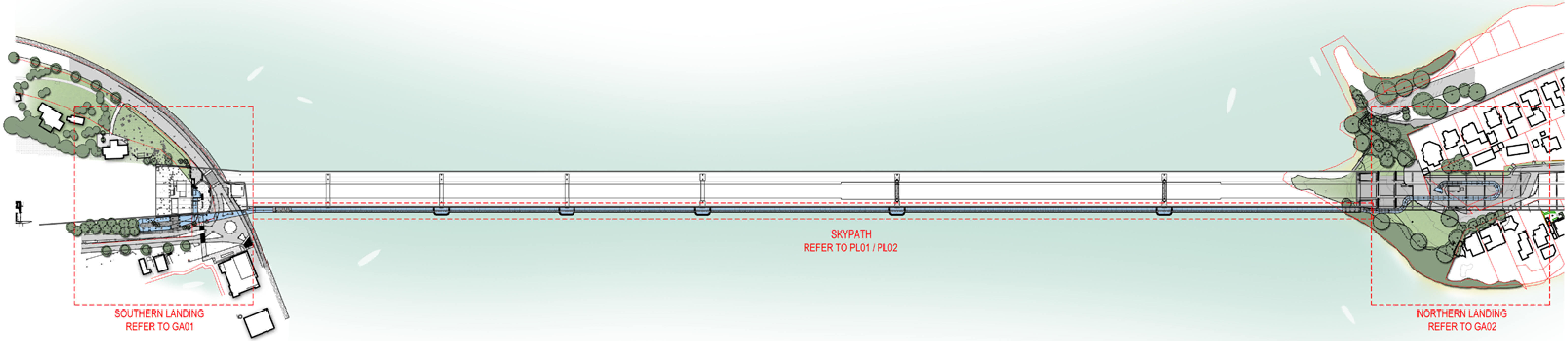
DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	AB		
APPROVED BY	GF	DATE	01.07.14

JOB NUMBER	DRAWING NUMBER	REVISION
2719	MP02	A

ISSUED FOR: RESOURCE CONSENT

AREA PLANS 02





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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	10.06.14

KEY

CLIENT

SKYPATH
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AUCKLAND HARBOUR PATHWAY TRUST

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DESIGNED BY	TEAM	SCALE	1:3500 @ A3
DRAWN BY	AB/AN		
APPROVED BY	GF	DATE	14.05.14
JOB NUMBER	2719	DRAWING NUMBER	DD KP01

PROJECT
SKYPATH

TITLE
SKYPATH
Key Plan

ISSUED FOR
RESOURCE CONSENT

REVISION
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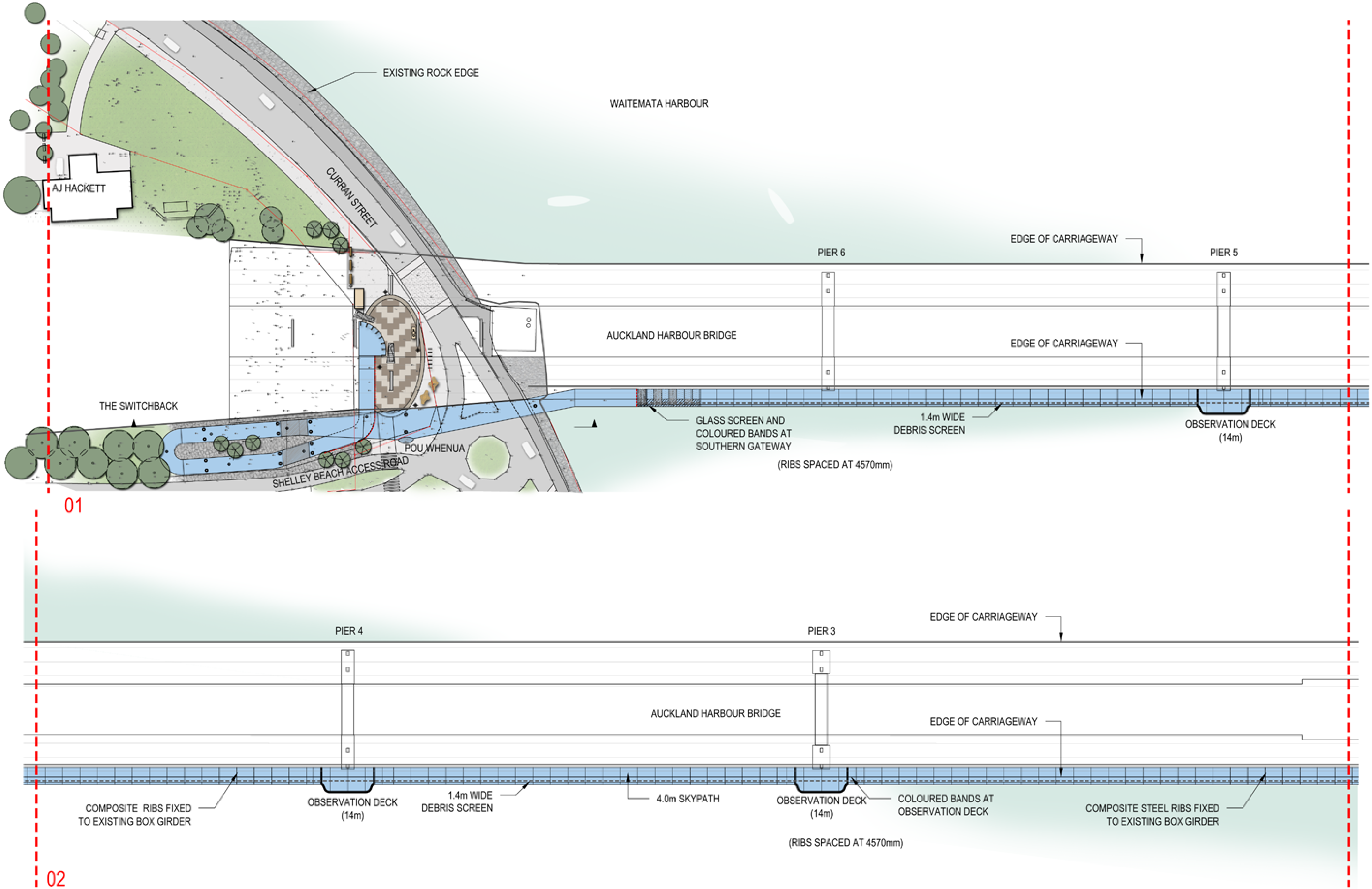

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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

CLIENT
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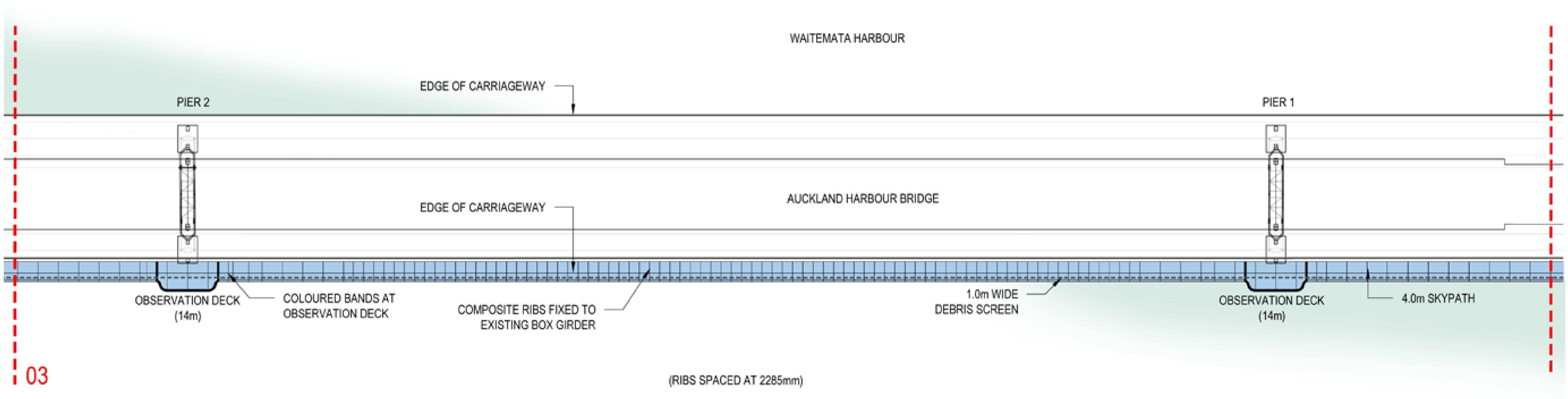
DESIGNED BY	TEAM	SCALE	1:1000 @ A3
DRAWN BY	AB		
APPROVED BY	GF	DATE	30.06.14

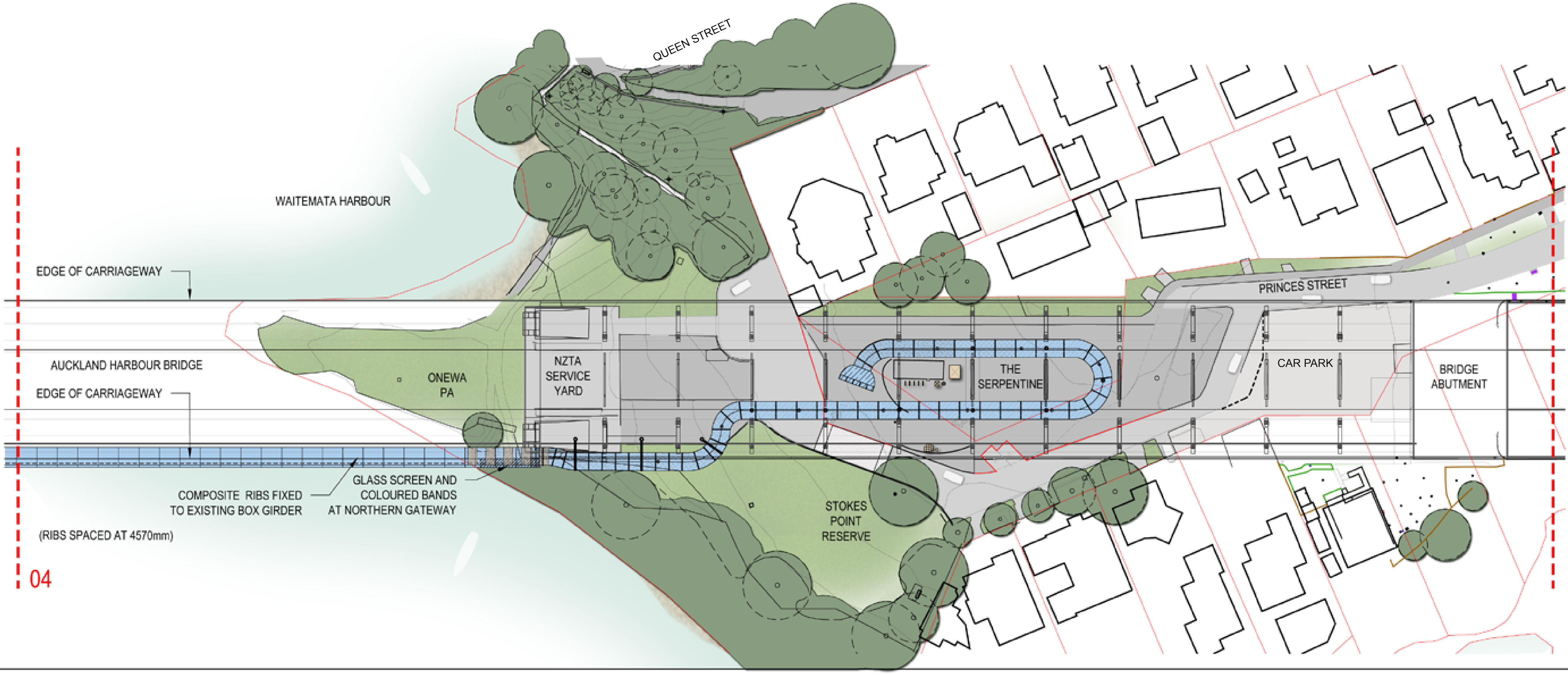
JOB NUMBER 2719
DRAWING NUMBER DD PL01

PROJECT
SKYPATH

TITLE
SOUTHERN LANDING & SKYPATH
Plan

ISSUED FOR RESOURCE CONSENT
REVISION A





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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

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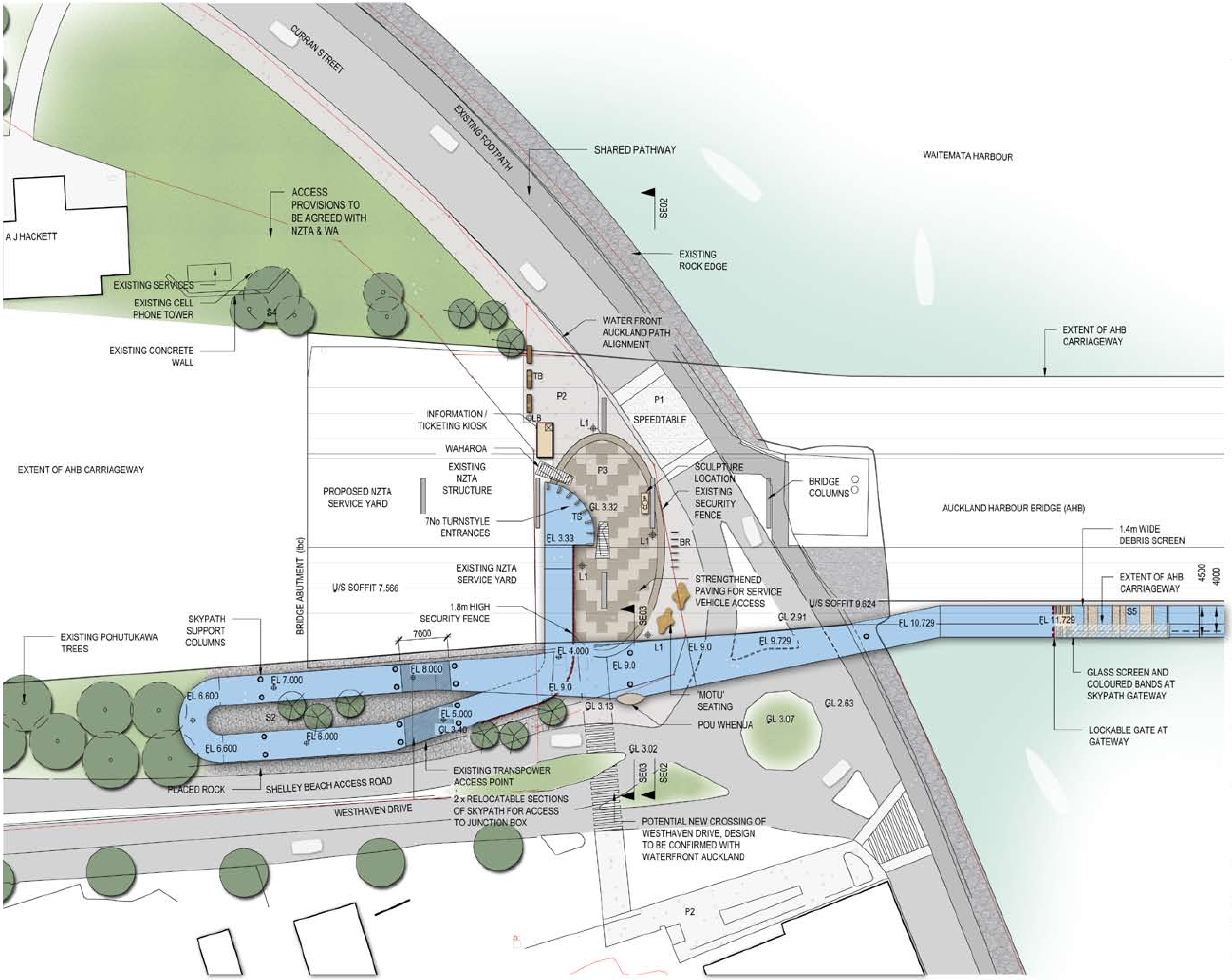
DESIGNED BY	TEAM	SCALE	1:1000 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD PL02

PROJECT
SKYPATH

TITLE
NORTHERN LANDING AND SKYPATH
Plan

ISSUED FOR RESOURCE CONSENT
REVISION A

GENERAL ARRANGEMENT PLANS 03



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NORTH

LEGEND:

SURFACES:

P1	CONCRETE - TYP1
P2	CONCRETE - TYP2
P3	PLAZA PAVING
S1	GRASS
S2	FEATURE ROCKS
S3	'SEFAR' FABRIC ENCLOSED CANOPY
S4	MESH ENCASING
S5	GLASS SCREEN

TREES:

	EXISTING TREE RETAINED
	PROPOSED TREE

FURNITURE:

L1	PEDESTRIAN LIGHT POLE
LB	LITTER BIN
IS	INTERPRETIVE SIGNAGE
BR	BIKE RACKS
TS	TURNSTILES
TB	TIMBER BENCH
DF	DRINKING FOUNTAIN
PS	BIKE PUMP STATION
	PROPOSED SECURITY FENCE
	RELOCATED SERVICES

No	Revision	By	Chk	Appd	Date
D	RESOURCE CONSENT	AN	GF	GF	30.06.14
C	UPDATED TO TCG COMMENTS	AN	GF	GF	03.06.14
B	UPDATED TO NEW BDY	AN	GF	GF	23.05.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

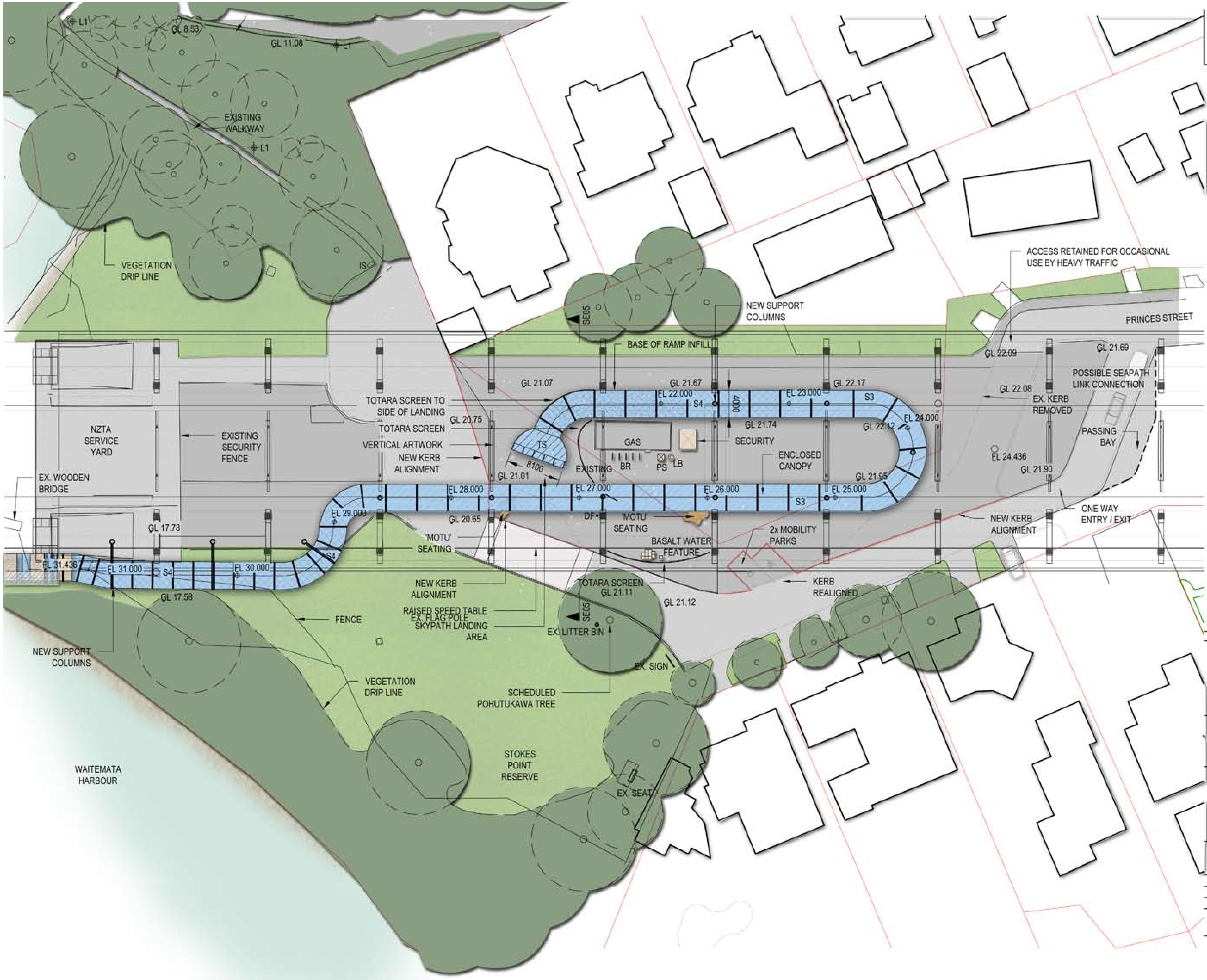
SKYPATH
SOUTHERN LANDING

RESET URBAN DESIGN

TITLE
GENERAL ARRANGEMENT 01
Southern Landing Plan

DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	AB		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER 2719	DRAWING NUMBER GA01		REVISION D

FOR RESOURCE CONSENT



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NORTH

SURFACES:

- P1 CONCRETE - TYP1
- P2 CONCRETE - TYP2
- P3 PLAZA PAVING
- S1 GRASS
- S2 FEATURE ROCKS
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- S4 MESH ENCASING
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TREES:

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- PROPOSED TREE PEDESTRIAN

FURNITURE:

- L1 LIGHT POLE
- LB LITTER BIN
- IS INTERPRETIVE SIGNAGE
- BR BIKE RACKS
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- PS BIKE PUMP STATION
- PROPOSED SECURITY FENCE
- RELOCATED SERVICES

No	Revision	By	Chk	Appd	Date
C	RESOURCE CONSENT	AN	GF	GF	30.06.14
B	UPDATED RAMP LAYOUT	AN	GF	GF	30.05.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
NORTHERN LANDING

RESET URBAN DESIGN

TITLE

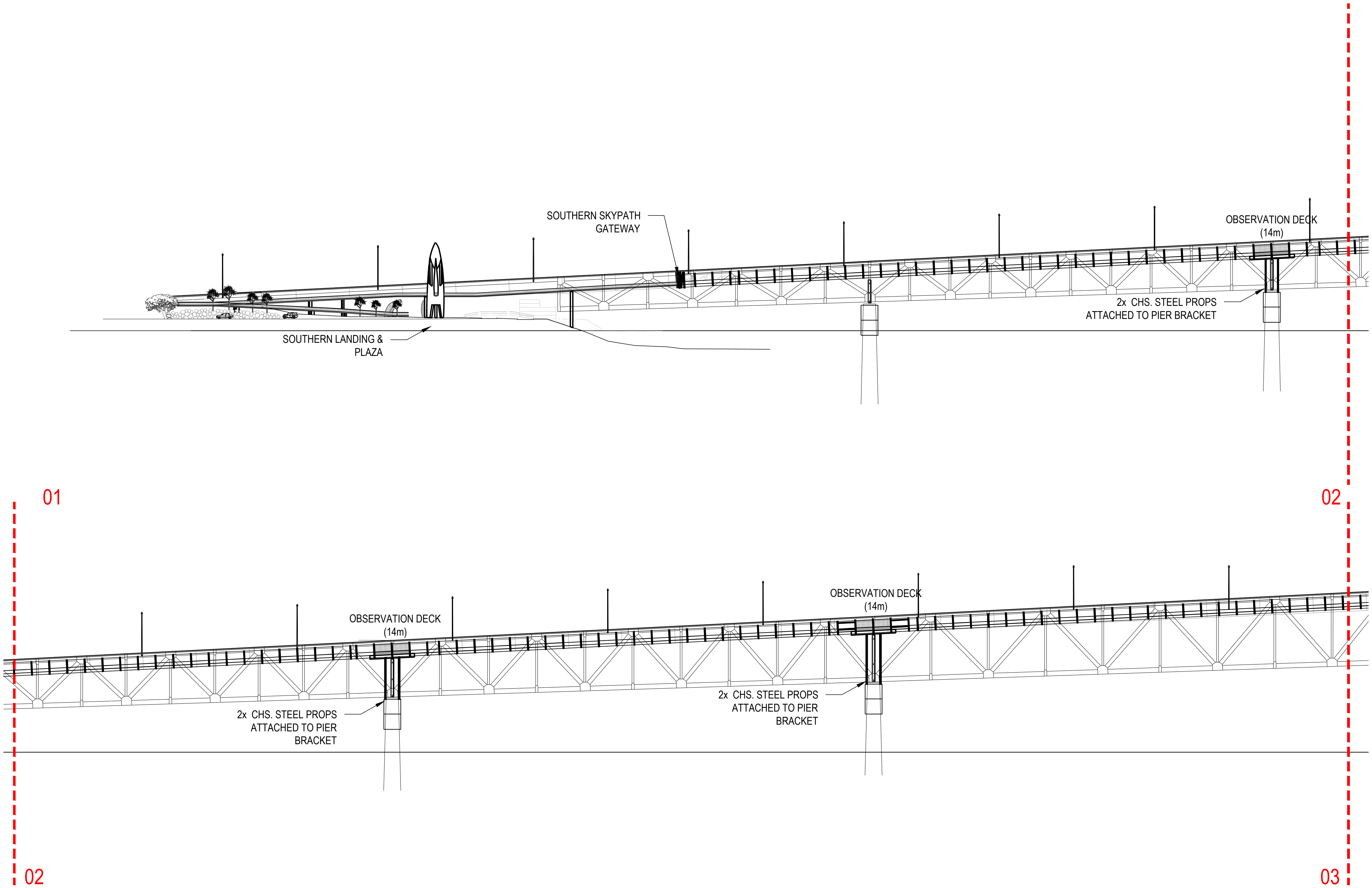
GENERAL ARRANGMENT 02
Northing Landing Plan

DESIGNED BY	TEAM	SCALE	1:500 @ A3
DRAWN BY	AB		
APPROVED BY	GF	DATE	30.06.14

JOB NUMBER	DRAWING NUMBER	REVISION
2719	GA02	C

ISSUED FOR RESOURCE CONSENT

SECTIONS AND ELEVATIONS 04



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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

CLIENT
SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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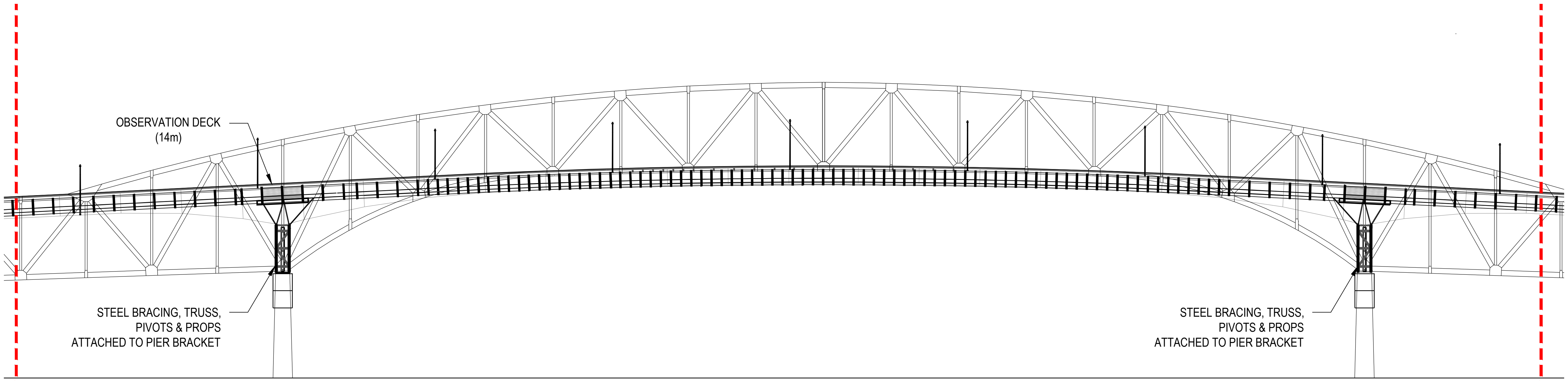
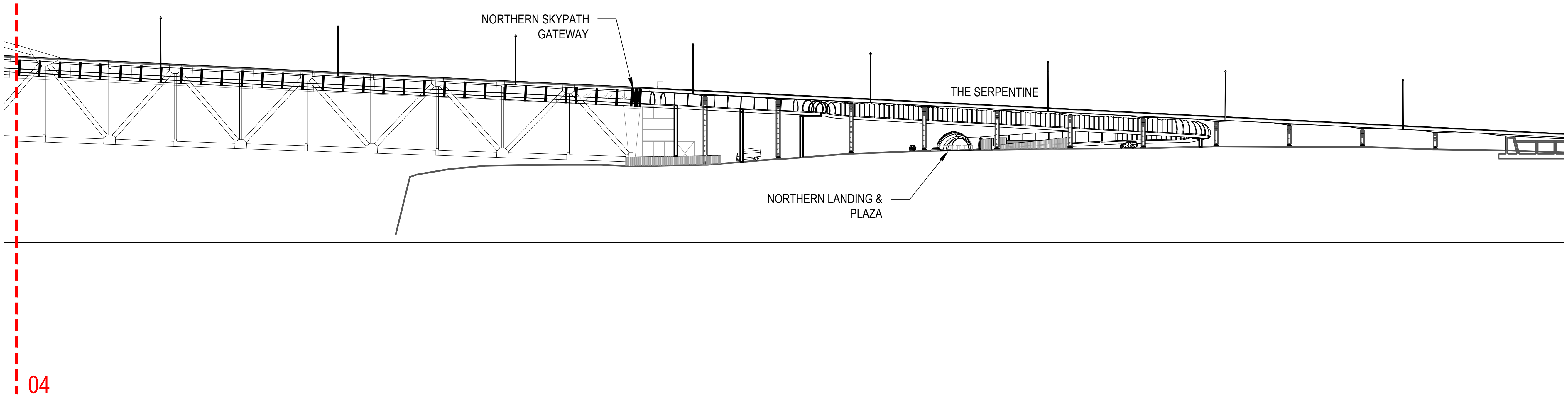
DESIGNED BY	TEAM	SCALE	1:1000 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD EL01

PROJECT
SKYPATH

TITLE
OVERALL BRIDGE
Elevation 1 of 2

ISSUED FOR RESOURCE CONSENT
REVISION A





NORTH

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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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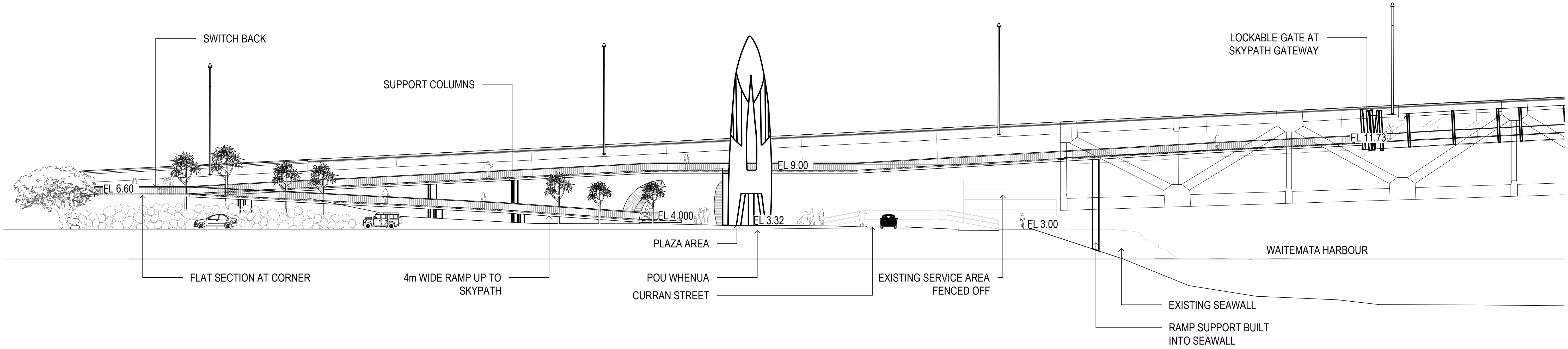
DESIGNED BY	TEAM	SCALE	1:1000 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD EL02

PROJECT
SKYPATH

TITLE
OVERALL BRIDGE
Elevation 2 of 2

ISSUED FOR RESOURCE CONSENT

REVISION A



NORTH

DO NOT SCALE.
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BEFORE COMMENCING ANY WORK

No.	Revision	By	Chk	Appd	Date
B	RESOURCE CONSENT	AN	GF	GF	30.06.14
A	FOR INFORMATION	AN	GF	GF	09.06.14

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

RESET URBAN DESIGN

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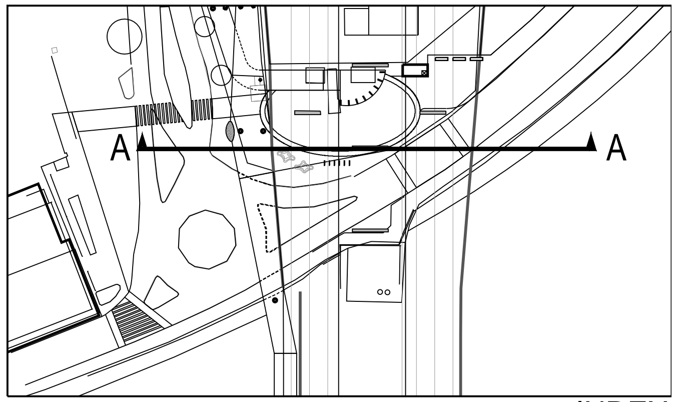
DESIGNED BY	TEAM	SCALE	1:400 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD SE01

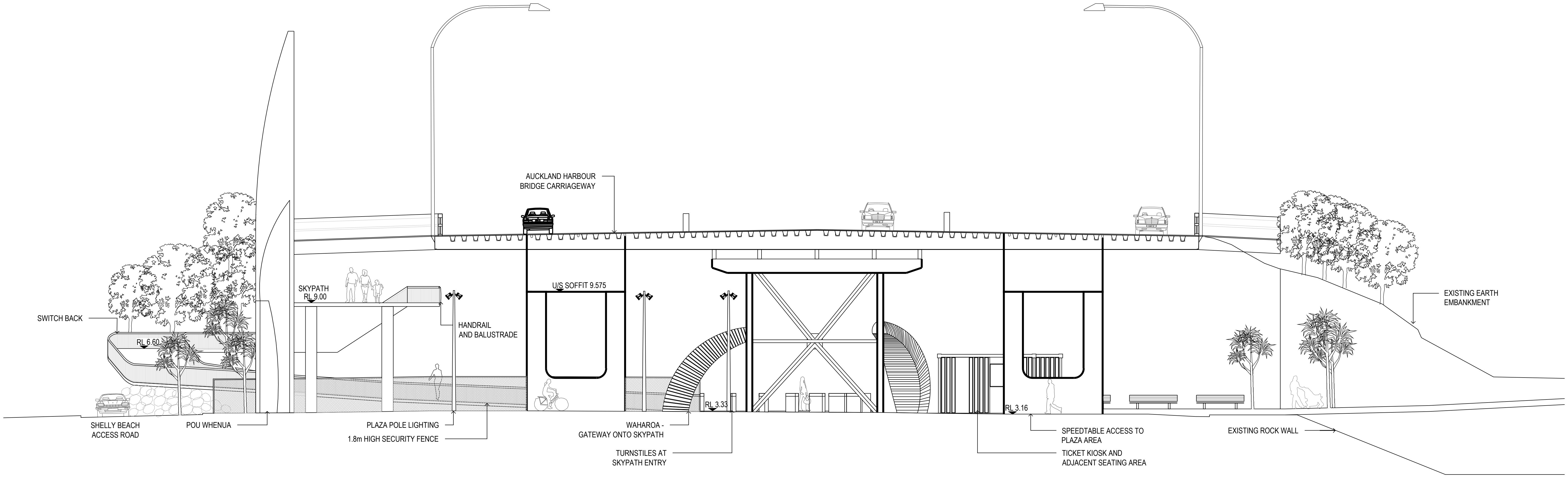
PROJECT
SKYPATH

TITLE
SOUTHERN LANDING
LONG SECTION

ISSUED FOR: RESOURCE CONSENT

REVISION: B





NORTH

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BEFORE COMMENCING ANY WORK

No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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LEVEL 1 SHED 20 PRINCE'S WHARF
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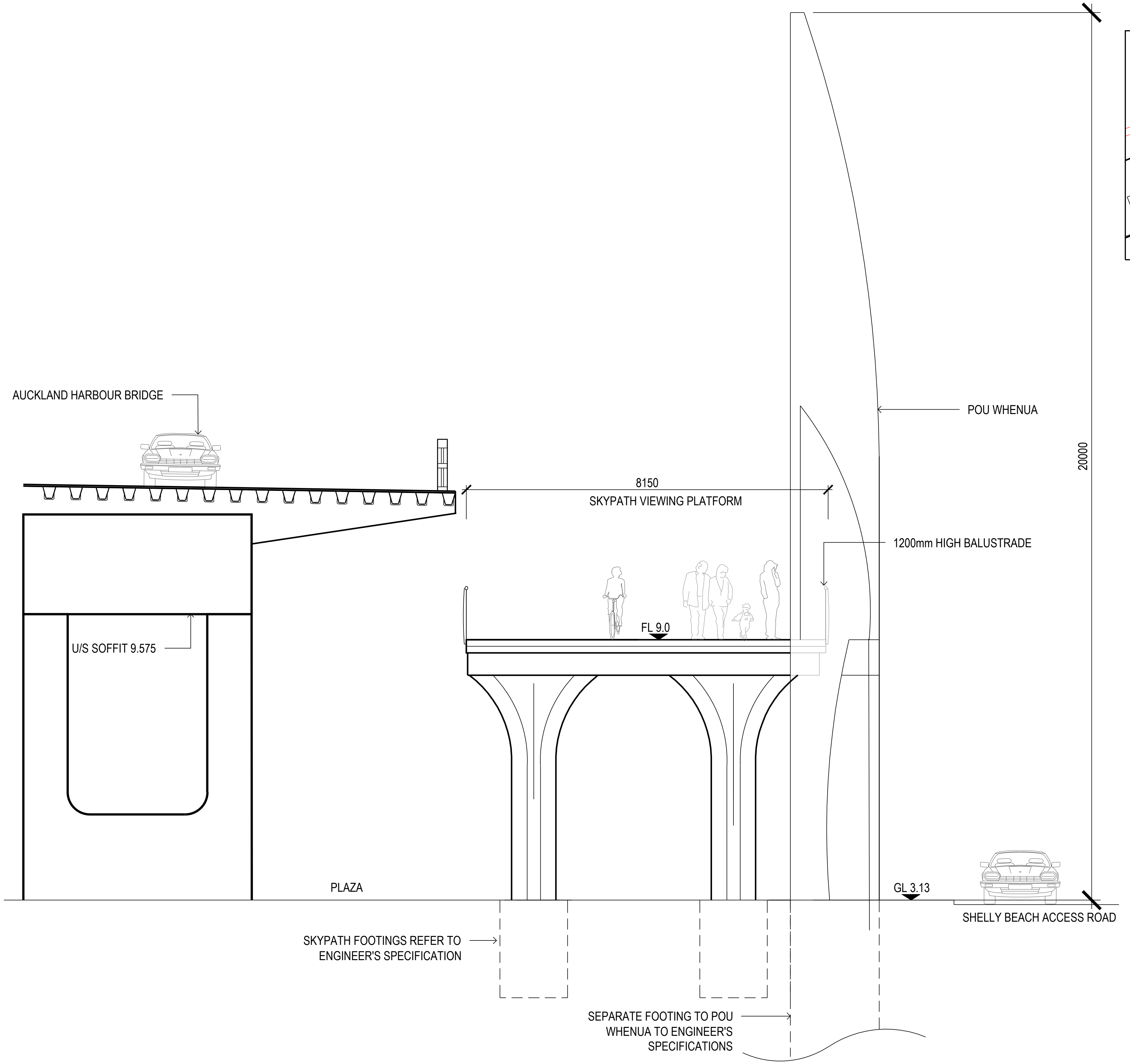
DESIGNED BY	TEAM	SCALE	1:200 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14

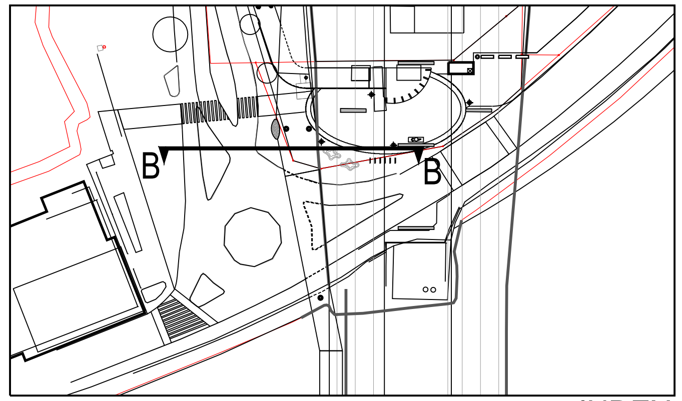
JOB NUMBER 2719
DRAWING NUMBER DD SE02

PROJECT
SKYPATH

TITLE
SOUTHERN LANDING
Cross Section A-A

ISSUED FOR RESOURCE CONSENT
REVISION A





INDEX

NORTH

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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

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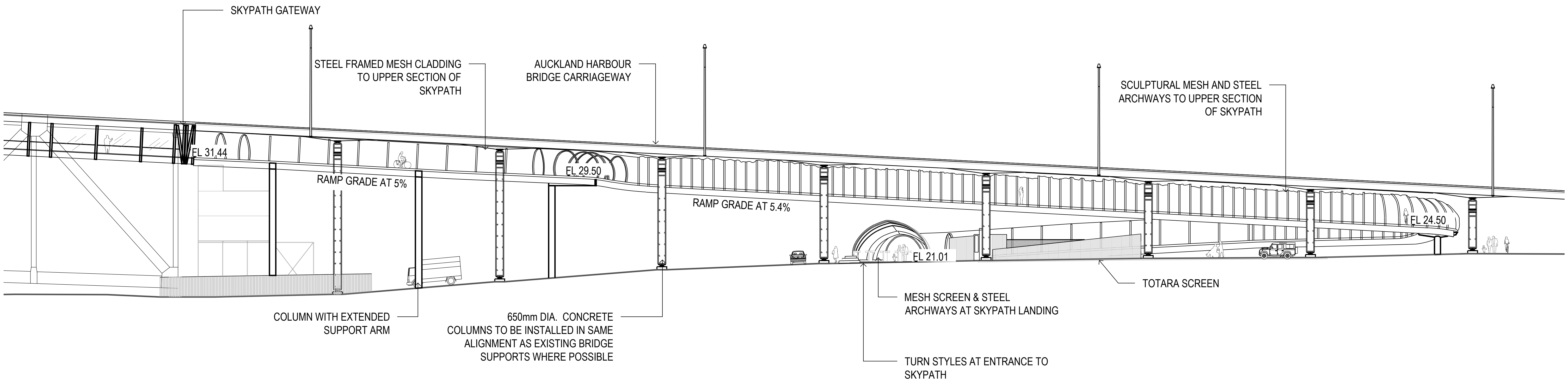
DESIGNED BY	TEAM	SCALE	1:100 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14

JOB NUMBER 2719
DRAWING NUMBER DD SE03

PROJECT
SKYPATH

TITLE
SOUTHERN LANDING VIEWING PLATFORM
Cross Section B-B

ISSUED FOR RESOURCE CONSENT
REVISION A



NORTH

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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No.	Revision	By	Chk	Appd	Date
B	RESOURCE CONSENT	AN	GF	GF	30.06.14
A	FOR INFORMATION	AN	GF	GF	09.06.14

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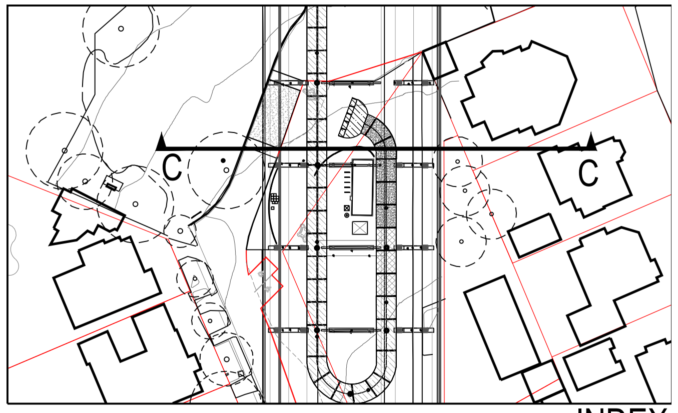
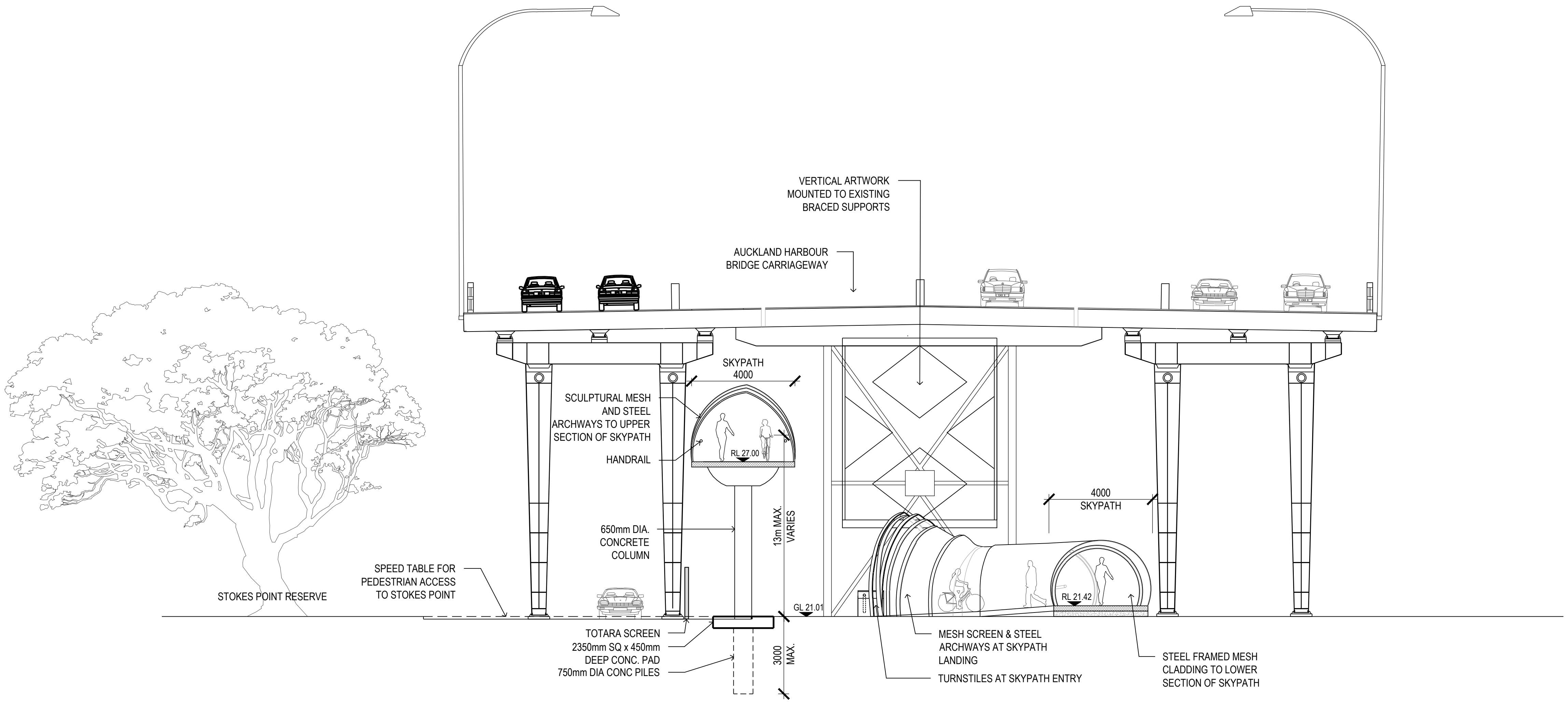
DESIGNED BY	TEAM	SCALE	1:400 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD SE04

PROJECT
SKYPATH

TITLE
NORTHERN LANDING
LONG SECTION

ISSUED FOR RESOURCE CONSENT
REVISION B





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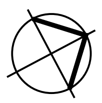

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No.	Revision	By	Chk	Appd	Date
B	RESOURCE CONSENT	AN	GF	GF	30.06.14
A	FOR IFORMATION	AN	GF	GF	03.06.14

KEY

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SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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DESIGNED BY	TEAM	SCALE	1:200 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD SE05

PROJECT

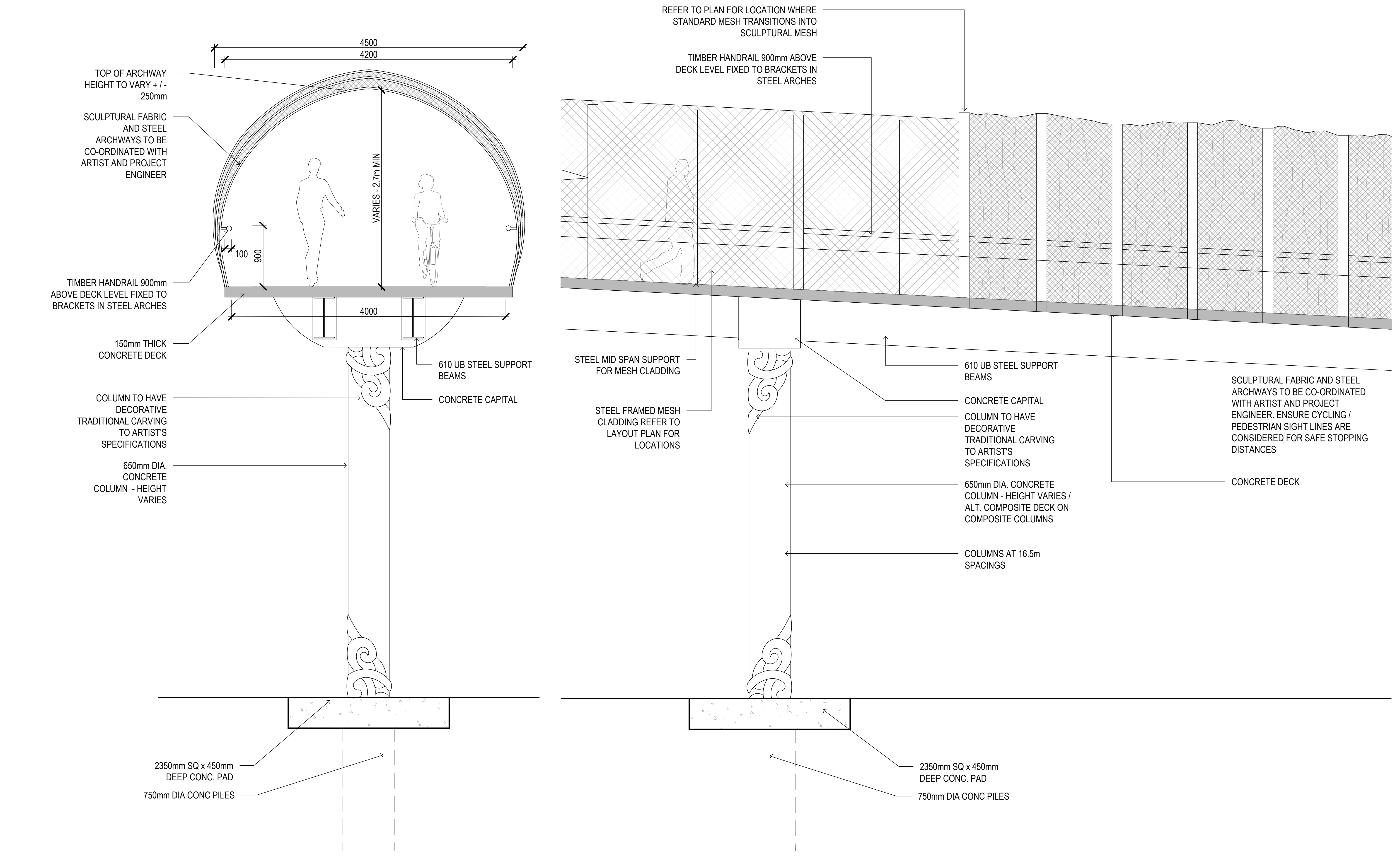
SKYPATH

TITLE

NORTHERN LANDING
Cross Section C-C

ISSUED FOR: RESOURCE CONSENT

REVISION: B



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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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DESIGNED BY	TEAM	SCALE	1:50@ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER	DD SE06

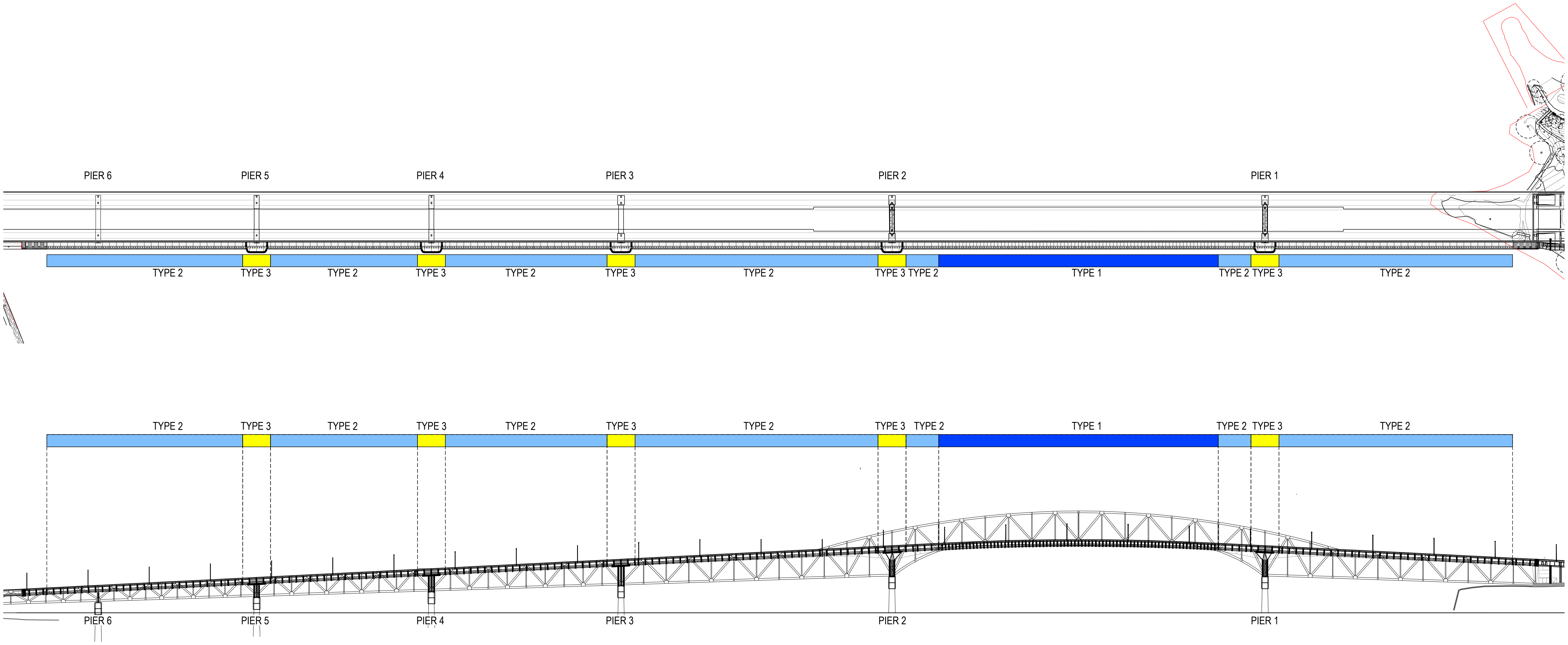
PROJECT
SKYPATH

TITLE
NORTHERN LANDING
Skypath Landing Detail Section

ISSUED FOR RESOURCE CONSENT

REVISION A

DESIGN ELEMENTS 05



NORTH

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BEFORE COMMENCING ANY WORK

No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

KEY

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST
AUCKLAND HARBOUR PATHWAY TRUST

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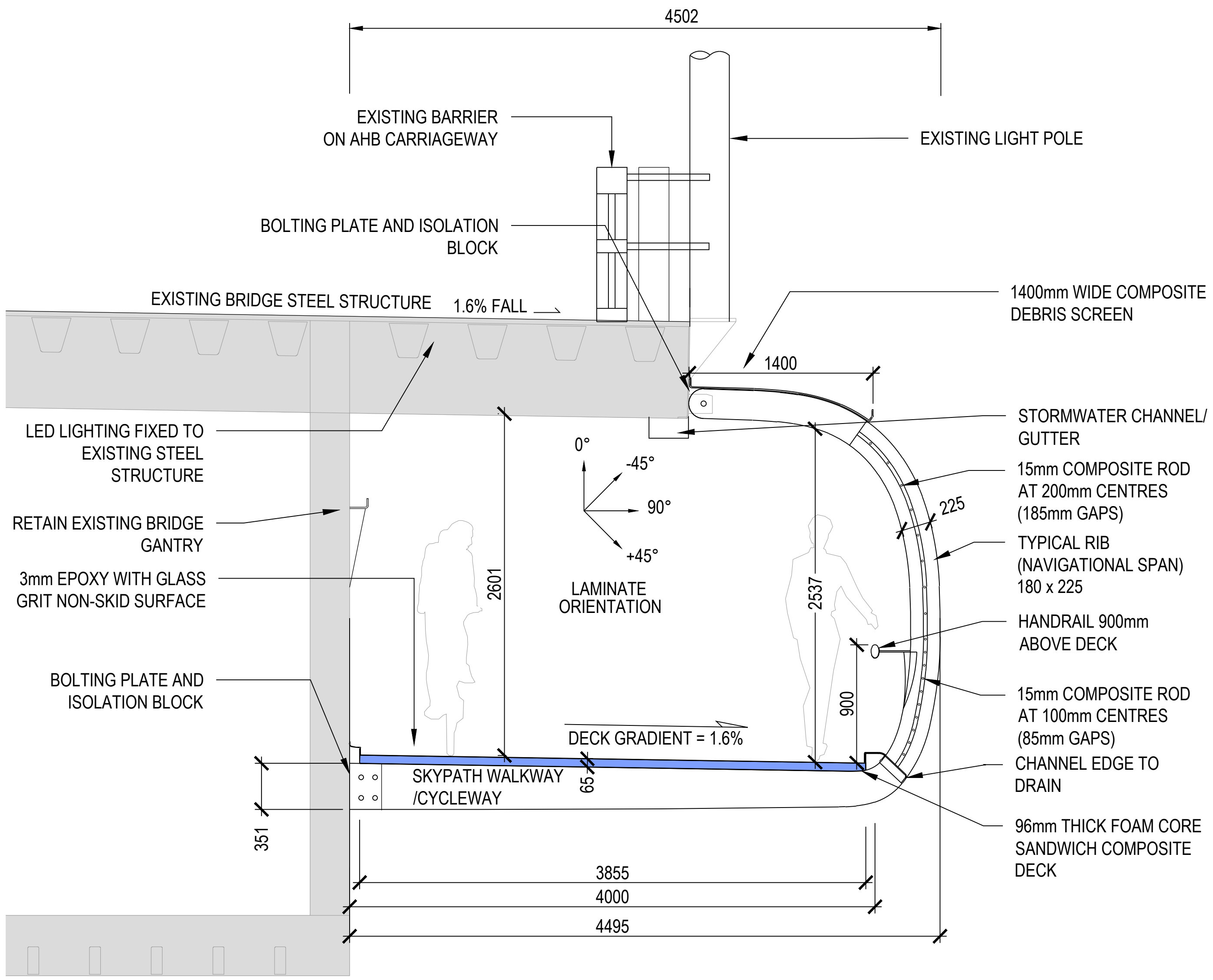
DESIGNED BY	TEAM	SCALE	1:2500 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	16.07.14

JOB NUMBER 2719
DRAWING NUMBER DD KP02

PROJECT
SKYPATH

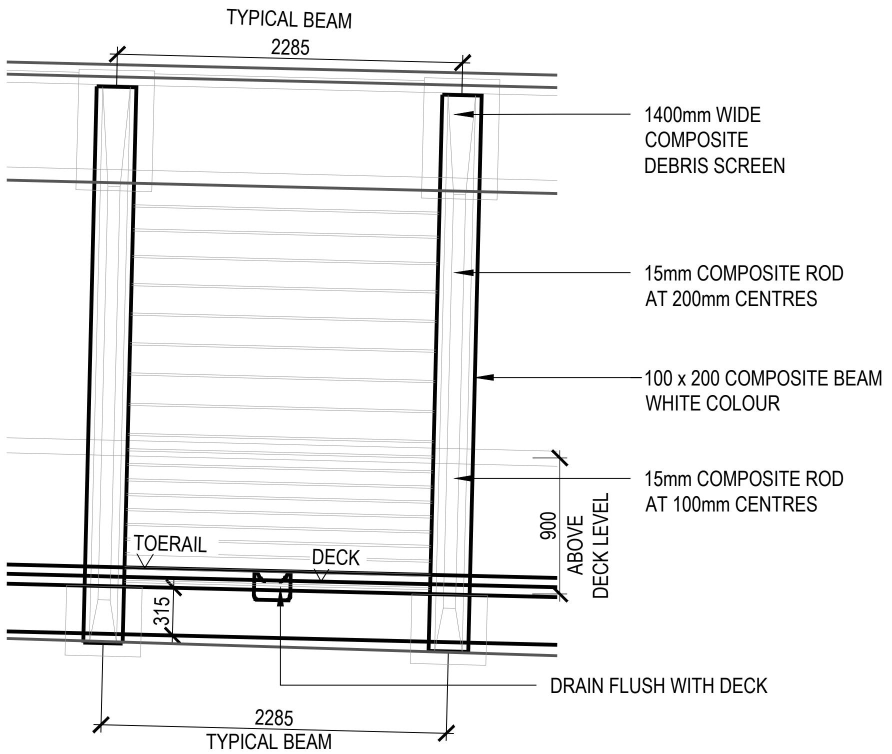
TITLE
MODULE TYPE
Key Plan

ISSUED FOR RESOURCE CONSENT
REVISION A



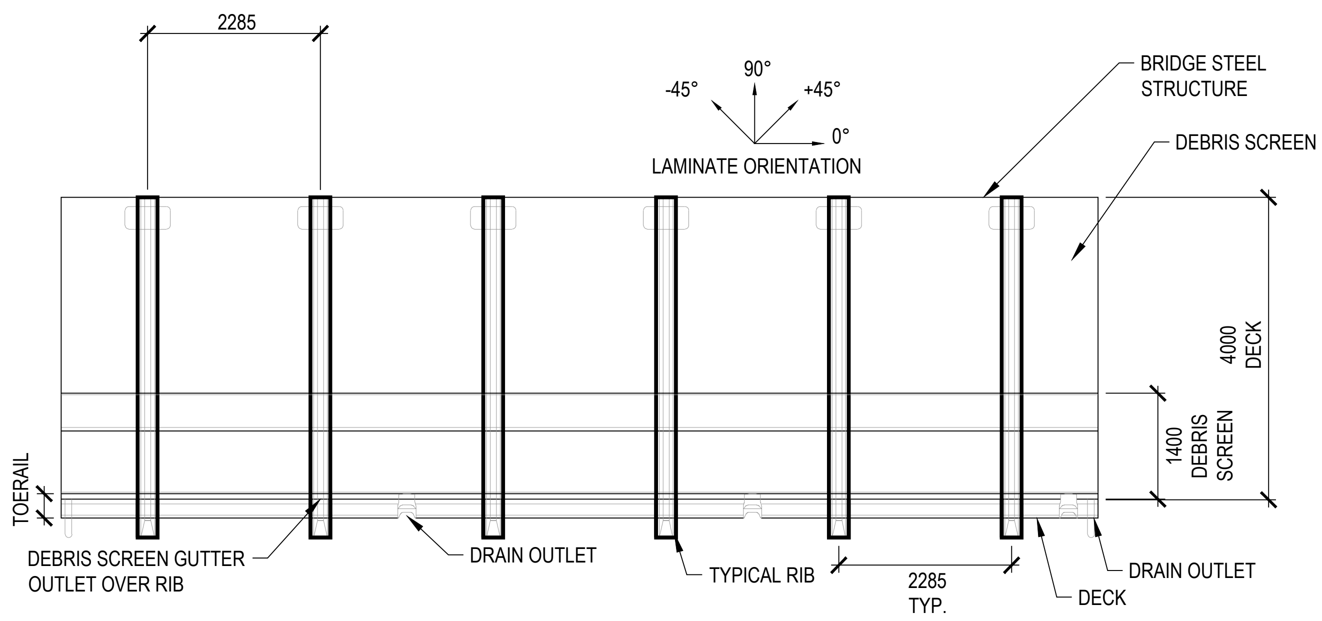
TYPE 1 - SKYPATH

SECTION 1:50



TYPE 1 - SKYPATH

ELEVATION 1:50



TYPE 1 - SKYPATH

PLAN 1:100

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NORTH

No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

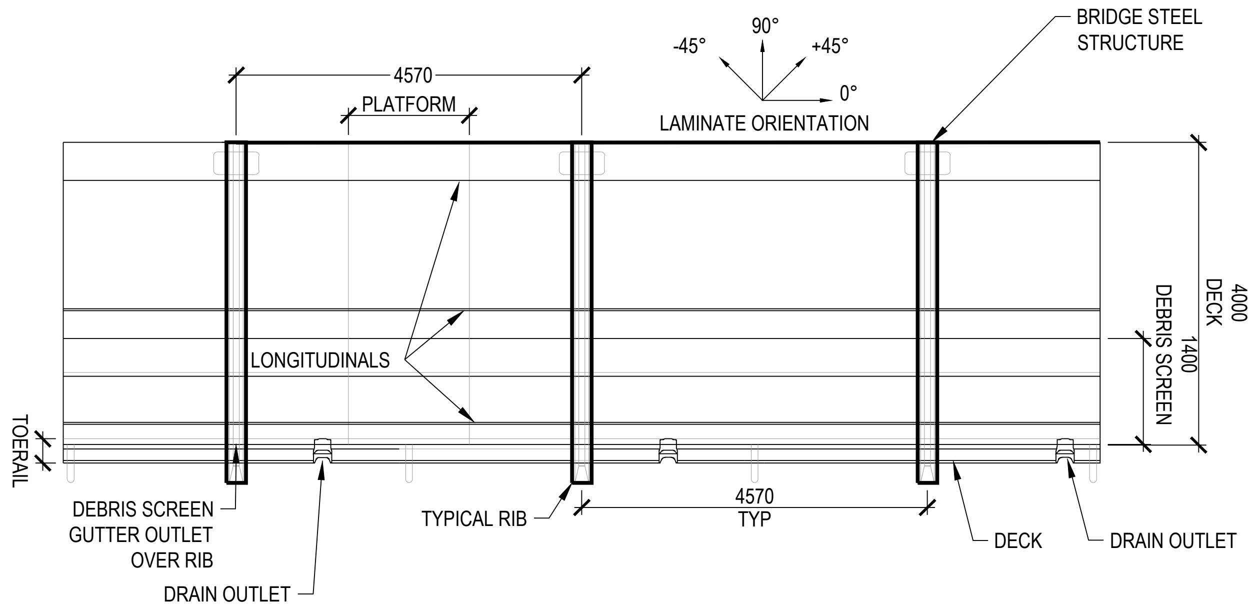
RESET URBAN DESIGN

TITLE
TYPE 1 MODULE
Plan, Elevation & Section

DESIGNED BY	TEAM	SCALE	Scale as Shown
DRAWN BY	AN		
APPROVED BY	GF	DATE	16.07.14

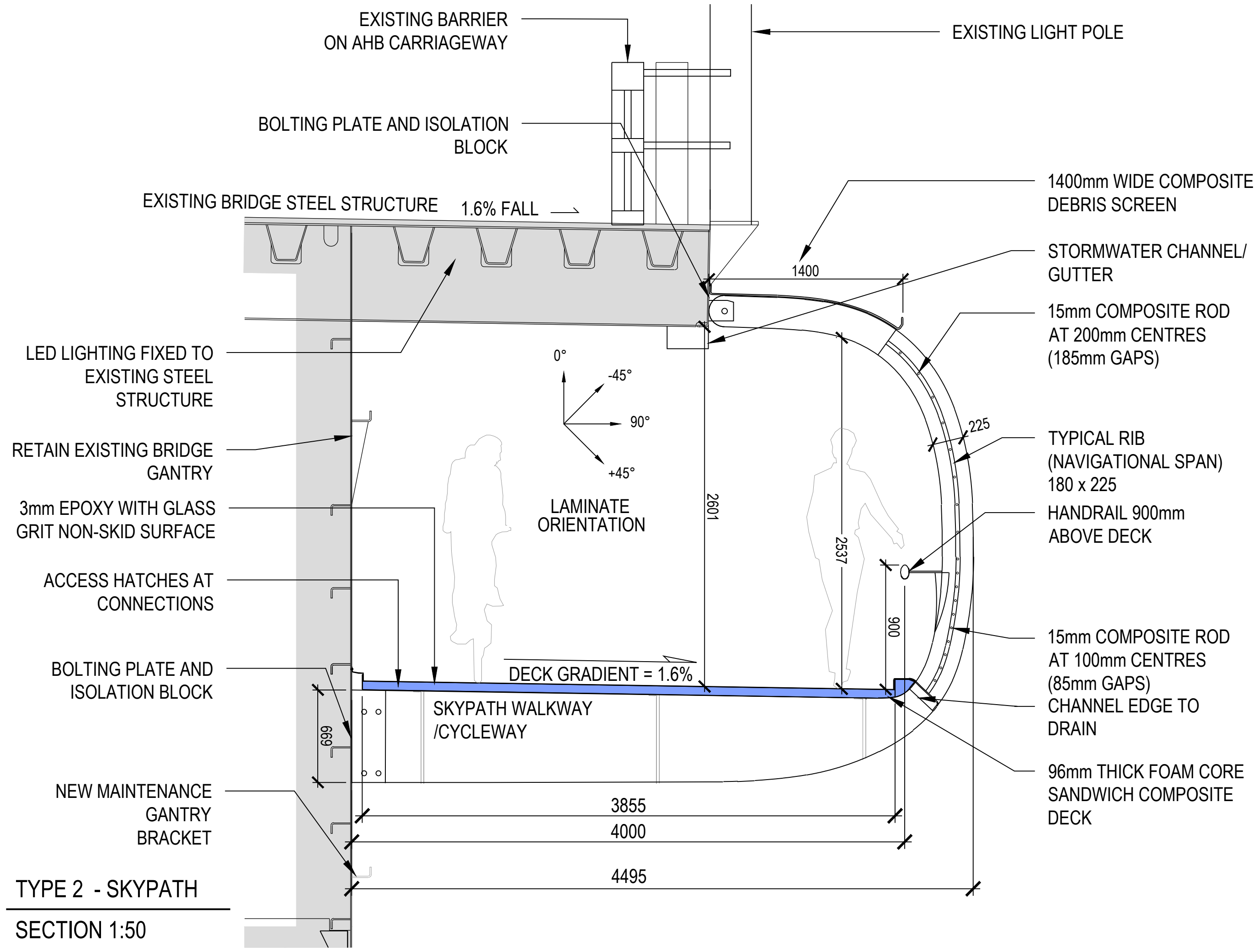
JOB NUMBER	DRAWING NUMBER	REVISION
2719	T1-01	A

ISSUED FOR RESOURCE CONSENT



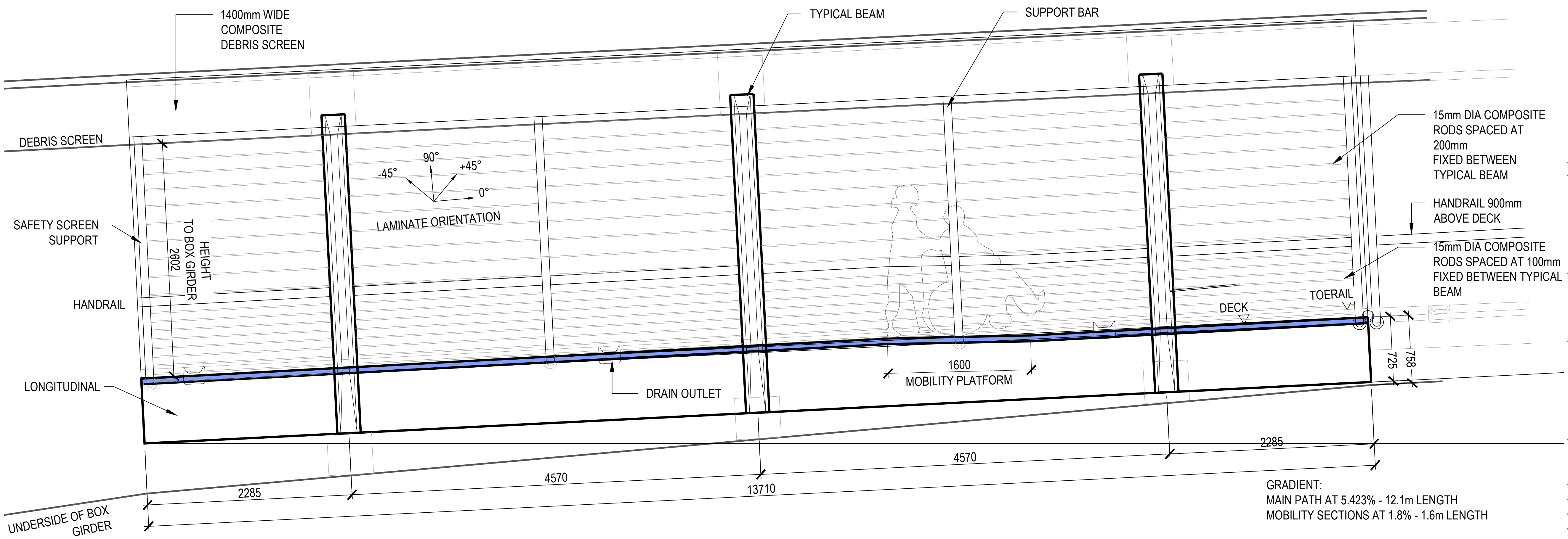
TYPE 2 - SKYPATH

PLAN 1:100



TYPE 2 - SKYPATH

SECTION 1:50



GRADIENT:
MAIN PATH AT 5.423% - 12.1m LENGTH
MOBILITY SECTIONS AT 1.8% - 1.6m LENGTH

TYPE 2 - SKYPATH

ELEVATION 1:50

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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

RESET URBAN DESIGN

TITLE
TYPE 2 MODULE
Plan, Elevation & Section

DESIGNED BY	TEAM	SCALE	Scale as Shown
DRAWN BY	AN		
APPROVED BY	GF	DATE	16.07.14
JOB NUMBER	DRAWING NUMBER	REVISION	
2719	T2-01	A	

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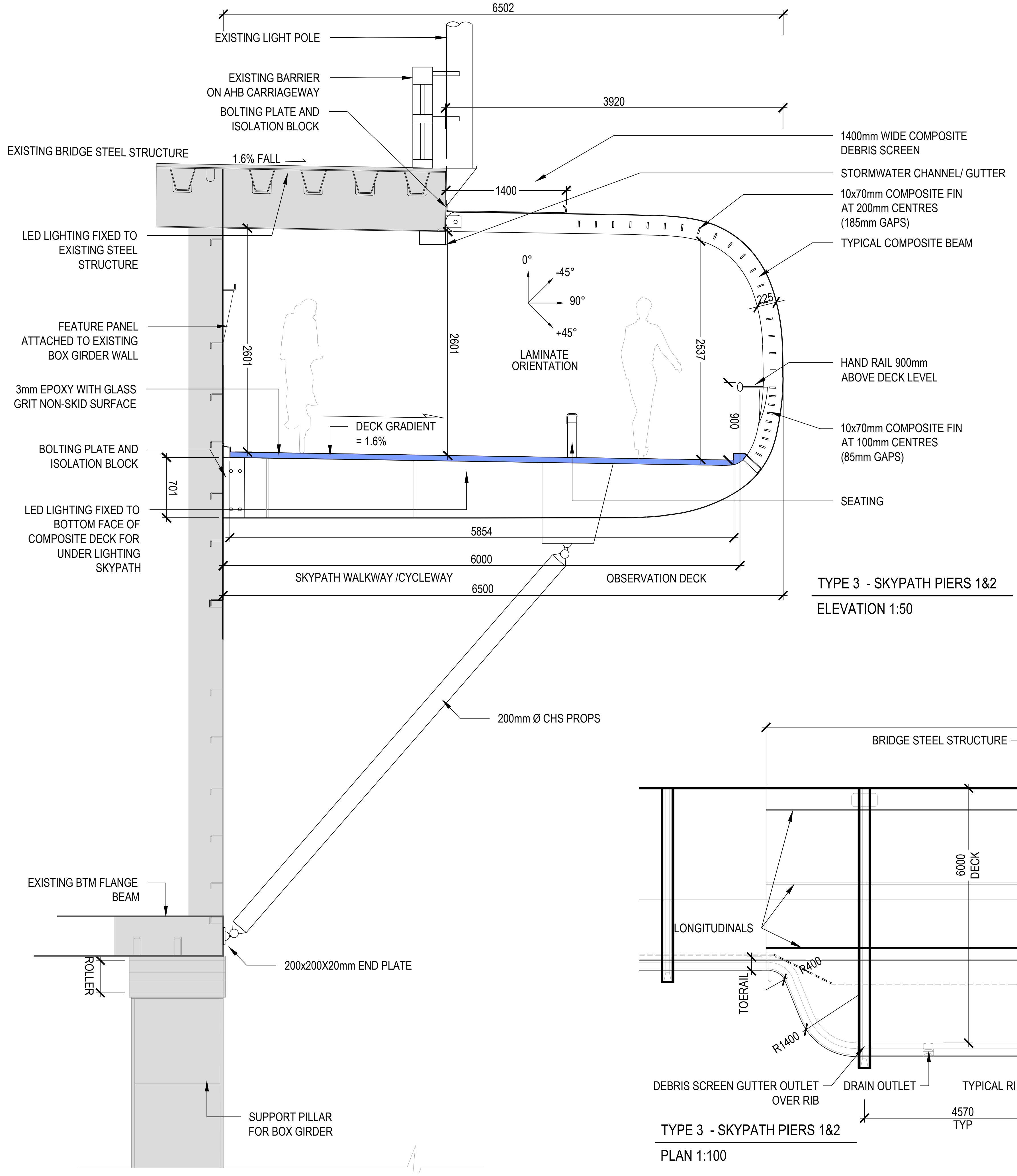
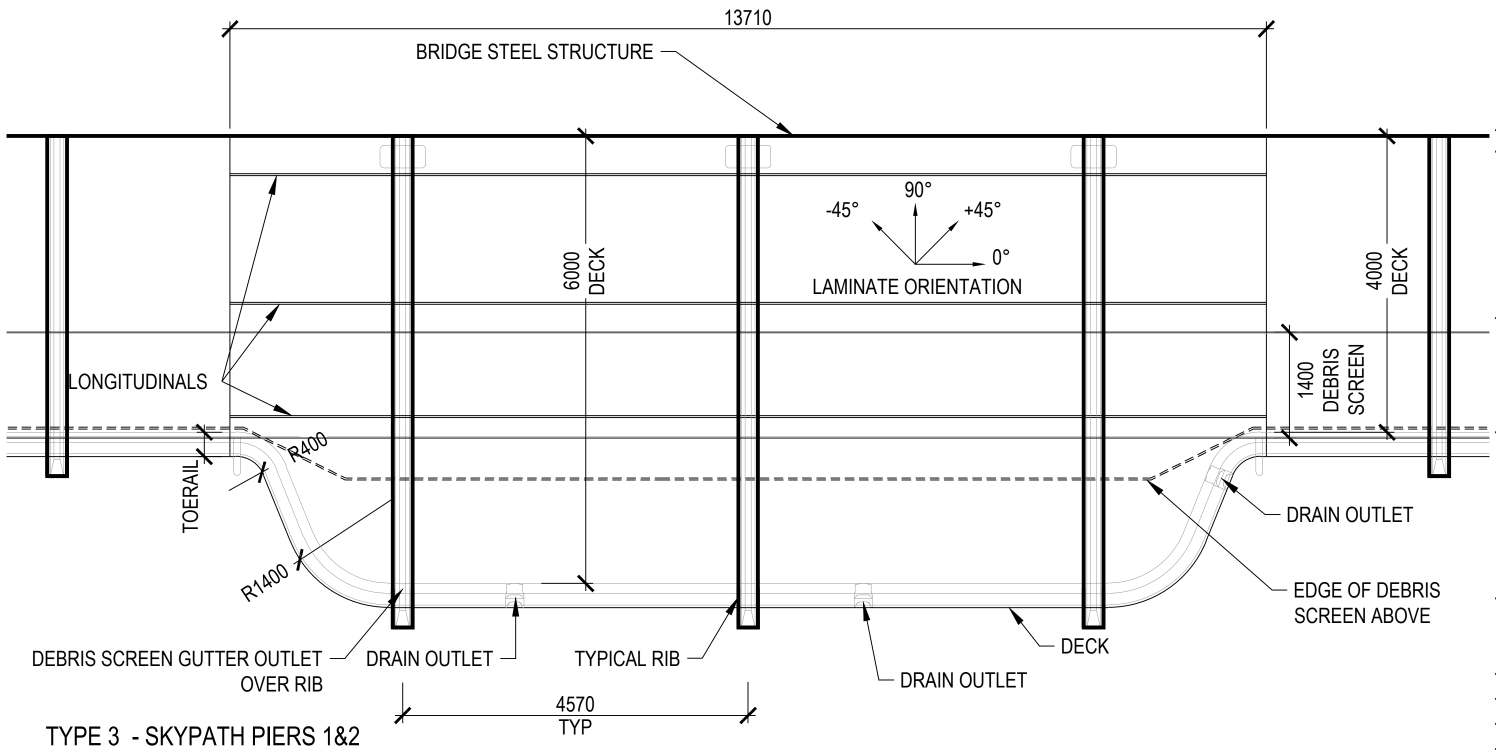
NORTH



TYPE 3 - SKYPATH PIERS 1&2

ELEVATION 1:50



TYPE 3 - SKYPATH PIERS 1&2

PLAN 1:100

No.	Revision	By	Chk	Appd	Date
B	UPDATED TO ENGINEER'S DETAILS	AN	GF	GF	12.08.14
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

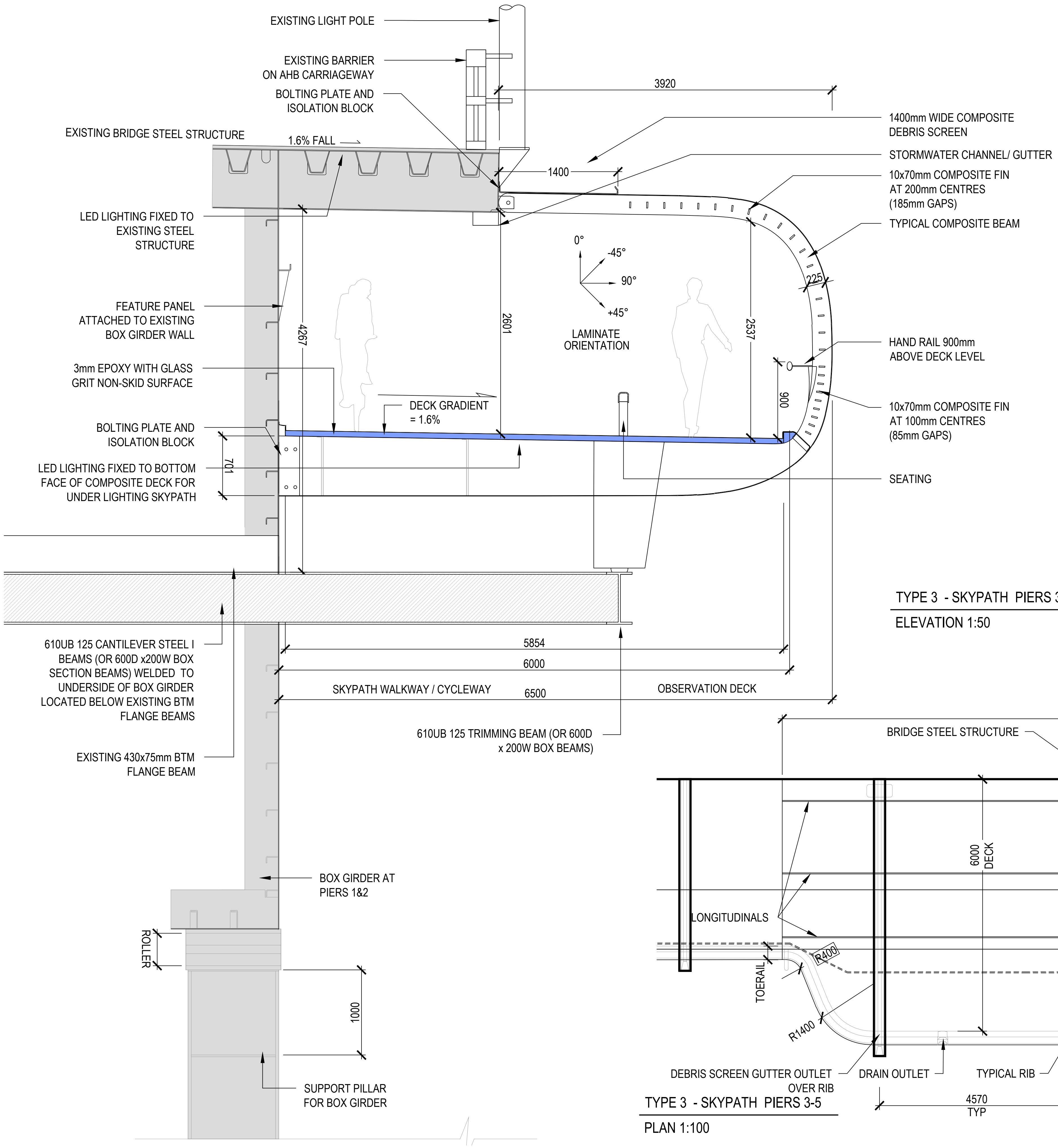
SKYPATH
MODULE DETAILS

RESET URBAN DESIGN

TITLE
TYPE 3 MODULE - PIERS 1&2
Plan & Section

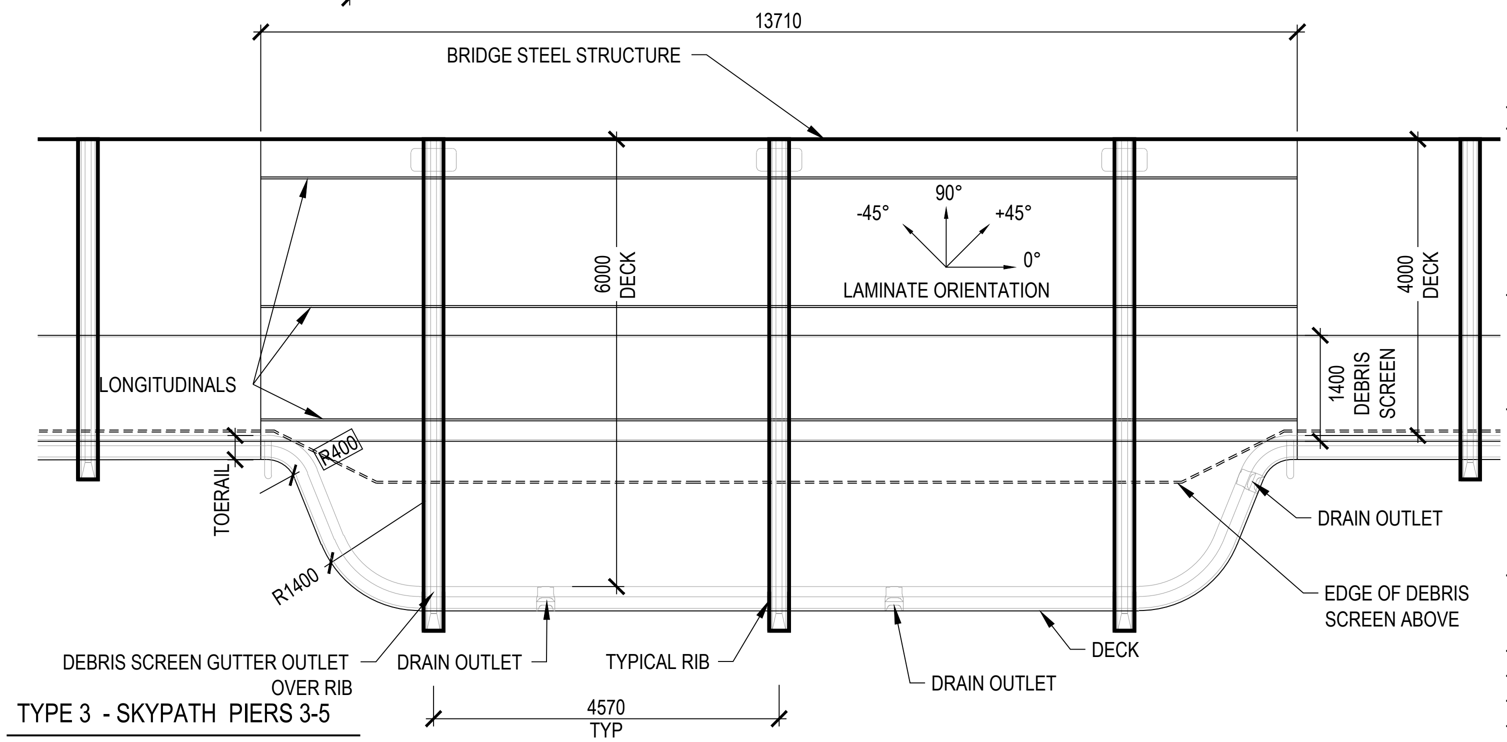
DESIGNED BY	TEAM	SCALE	Scale as Shown
DRAWN BY	AN		
APPROVED BY	GF	DATE	12.0.14
JOB NUMBER	DRAWING NUMBER		REVISION
2719	T3-01 A		B

ISSUED FOR RESOURCE CONSENT



TYPE 3 - SKYPATH PIERS 3-5

ELEVATION 1:50



TYPE 3 - SKYPATH PIERS 3-5

PLAN 1:100

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NORTH

No.	Revision	By	Chk	Appd	Date
B	UPDATED TO ENGINEER'S DETAILS	AN	GF	GF	12.08.14
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

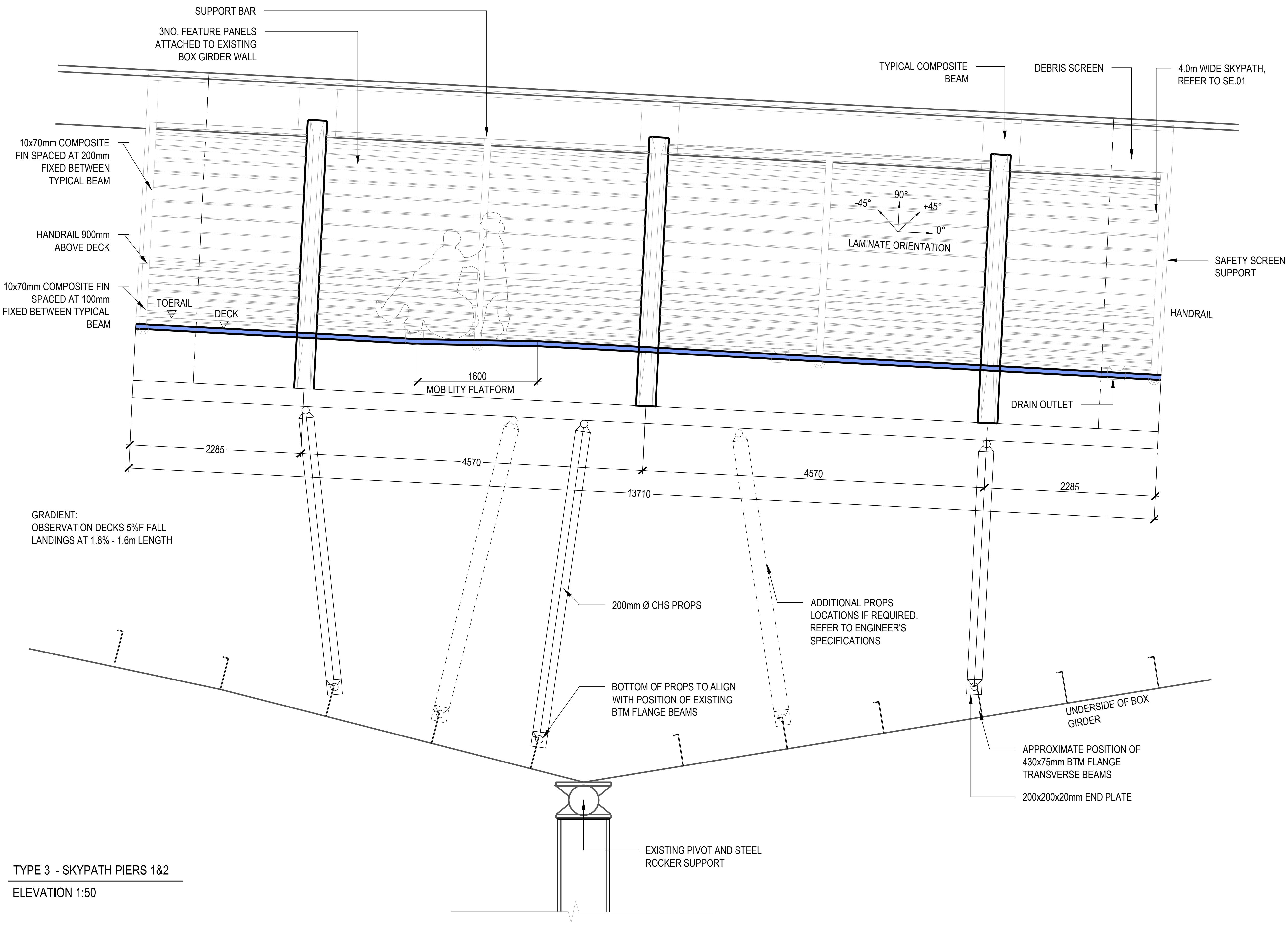
RESET URBAN DESIGN

TITLE
TYPE 3 MODULE - PIERS 3-5
Plan & Section

DESIGNED BY	TEAM	SCALE	Scale as Shown
DRAWN BY	AN		
APPROVED BY	GF	DATE	12.08.14
JOB NUMBER	DRAWING NUMBER	REVISION	
2719	T3-01 B	B	

ISSUED FOR RESOURCE CONSENT

NORTH



TYPE 3 - SKYPATH PIERS 1&2

ELEVATION 1:50

No.	Revision	By	Chk	Appd	Date
B	UPDATED TO ENGINEER'S DETAILS	AN	GF	GF	12.08.14
A	RESOURCE CONSENT	AN	GF	GF	16.07.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

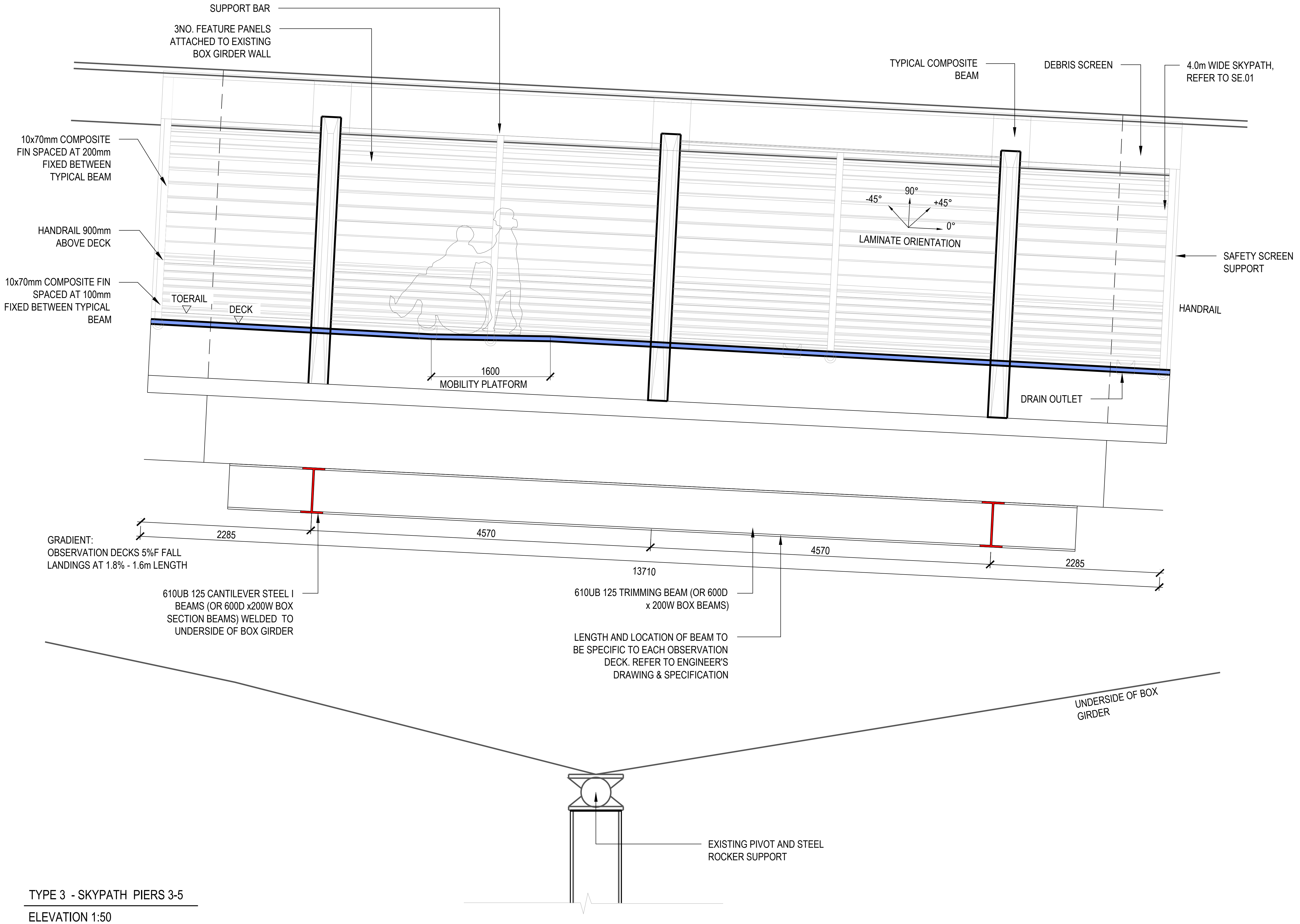
RESET URBAN DESIGN

TITLE
TYPE 3 MODULE - PIERS 1&2
Elevation

DESIGNED BY	TEAM	SCALE	1:50 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	12.08.14

JOB NUMBER	DRAWING NUMBER	REVISION
2719	T3-02 A	B

ISSUED FOR RESOURCE CONSENT



TYPE 3 - SKYPATH PIERS 3-5

ELEVATION 1:50

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NORTH

No.	Revision	By	Chk	Appd	Date
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CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

RESET URBAN DESIGN

TITLE
TYPE 3 MODULE - PIERS 3-5
Elevation

DESIGNED BY	TEAM	SCALE	1:50 @ A3
DRAWN BY	AN		
APPROVED BY	GF	DATE	12.08.14

JOB NUMBER	DRAWING NUMBER	REVISION
2719	T3-02 B	B

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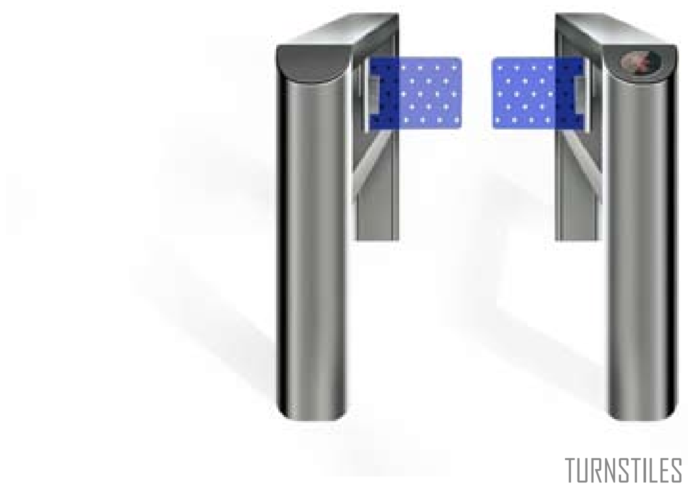
BIKE RACKS

INTERPRETIVE SIGNAGE

TICKETING



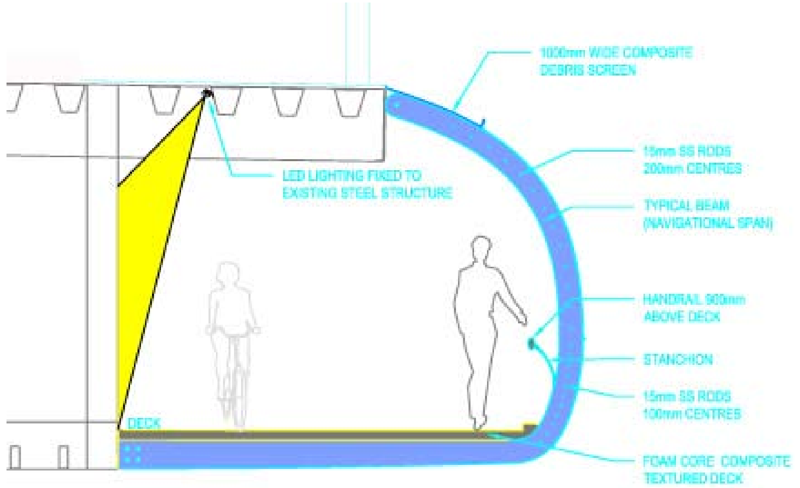
TURNSTILES (INDICATIVE)

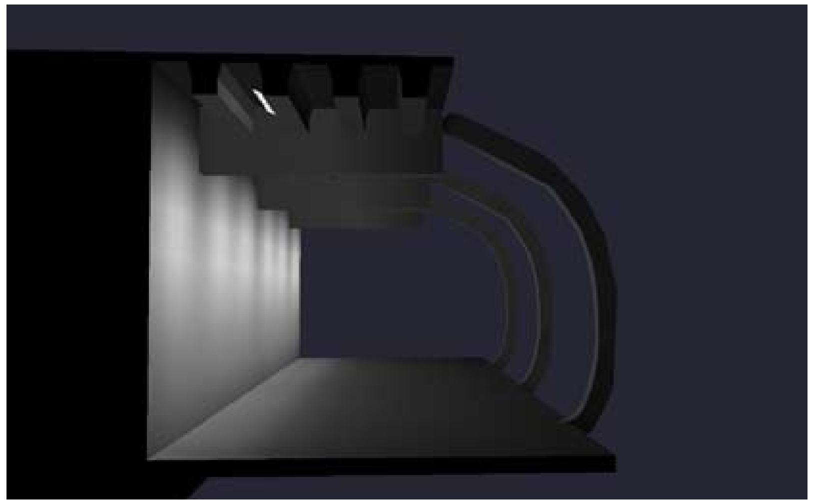
PLAZA SEATING

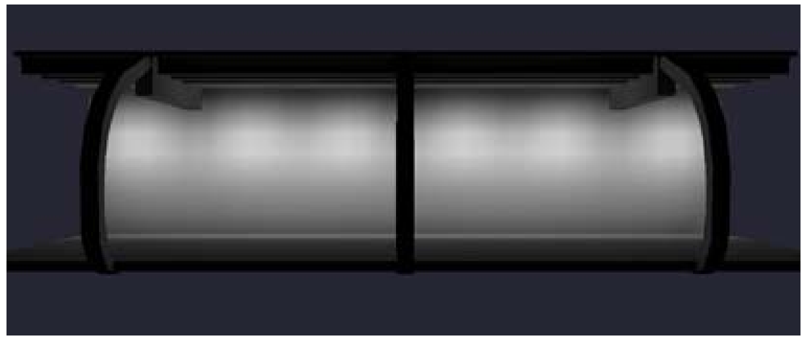
INFORMATION

LIGHTING

*NB - scales vary - for visual purposes only







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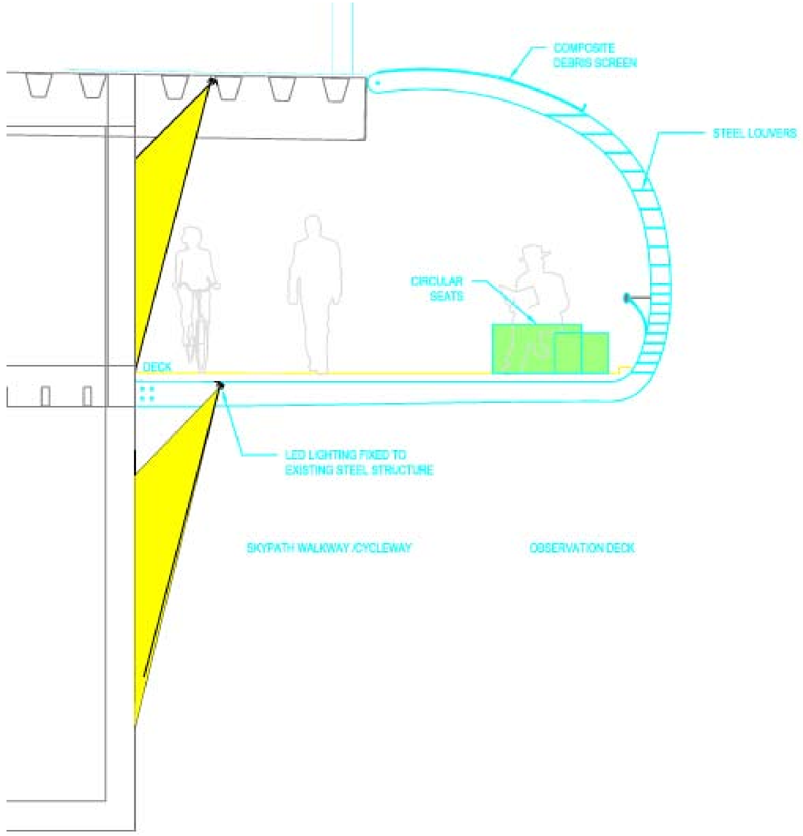
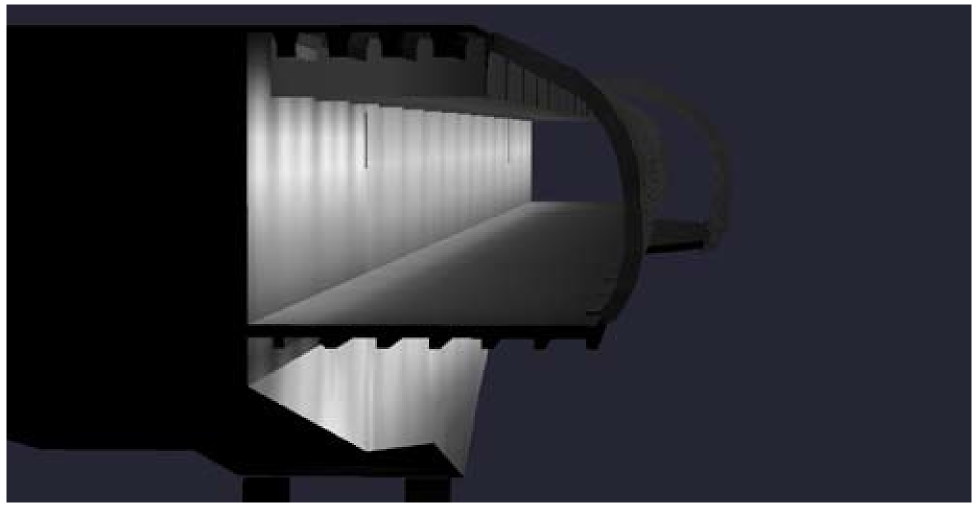
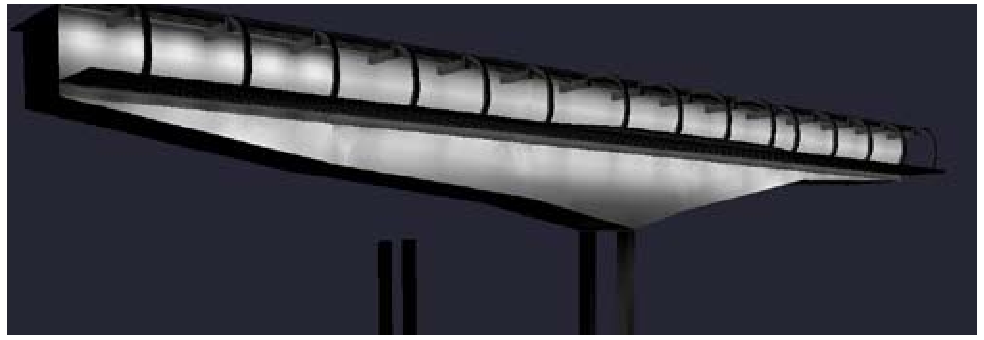


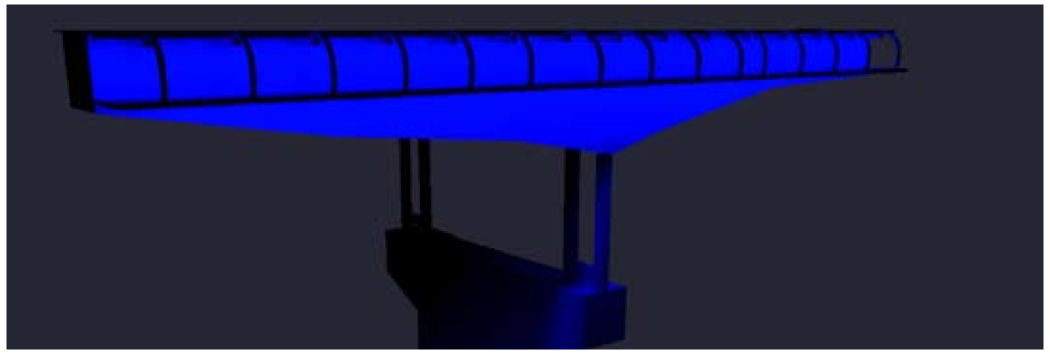


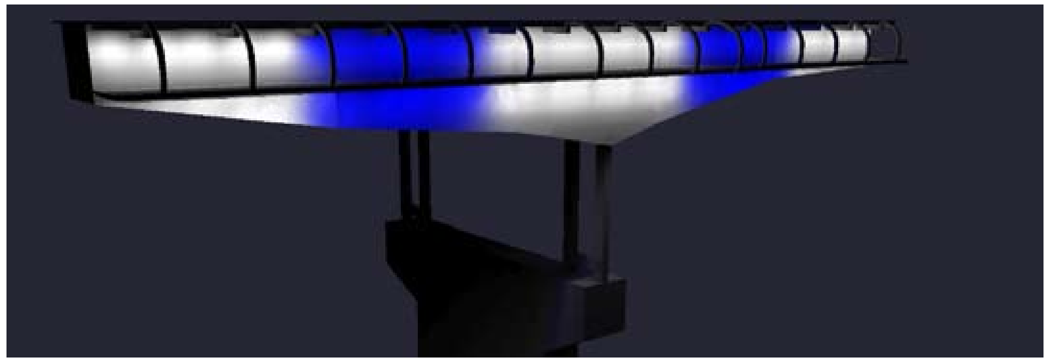


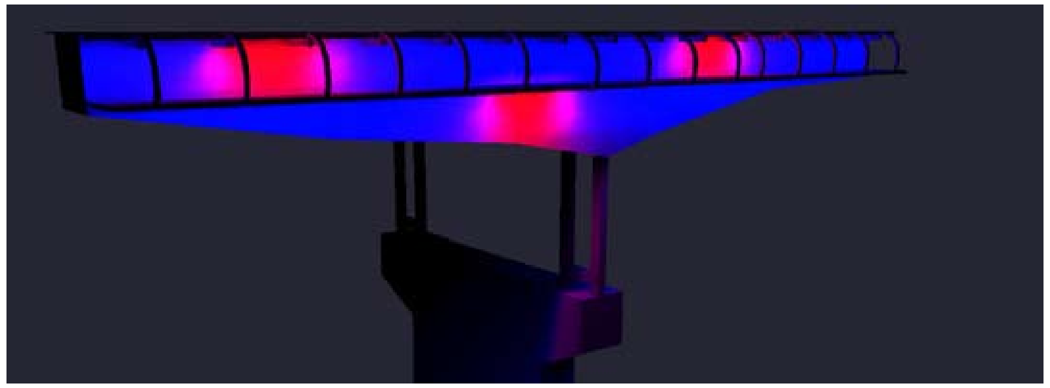
OBSERVATION DECK

LED FEATURE LIGHTING UNIT

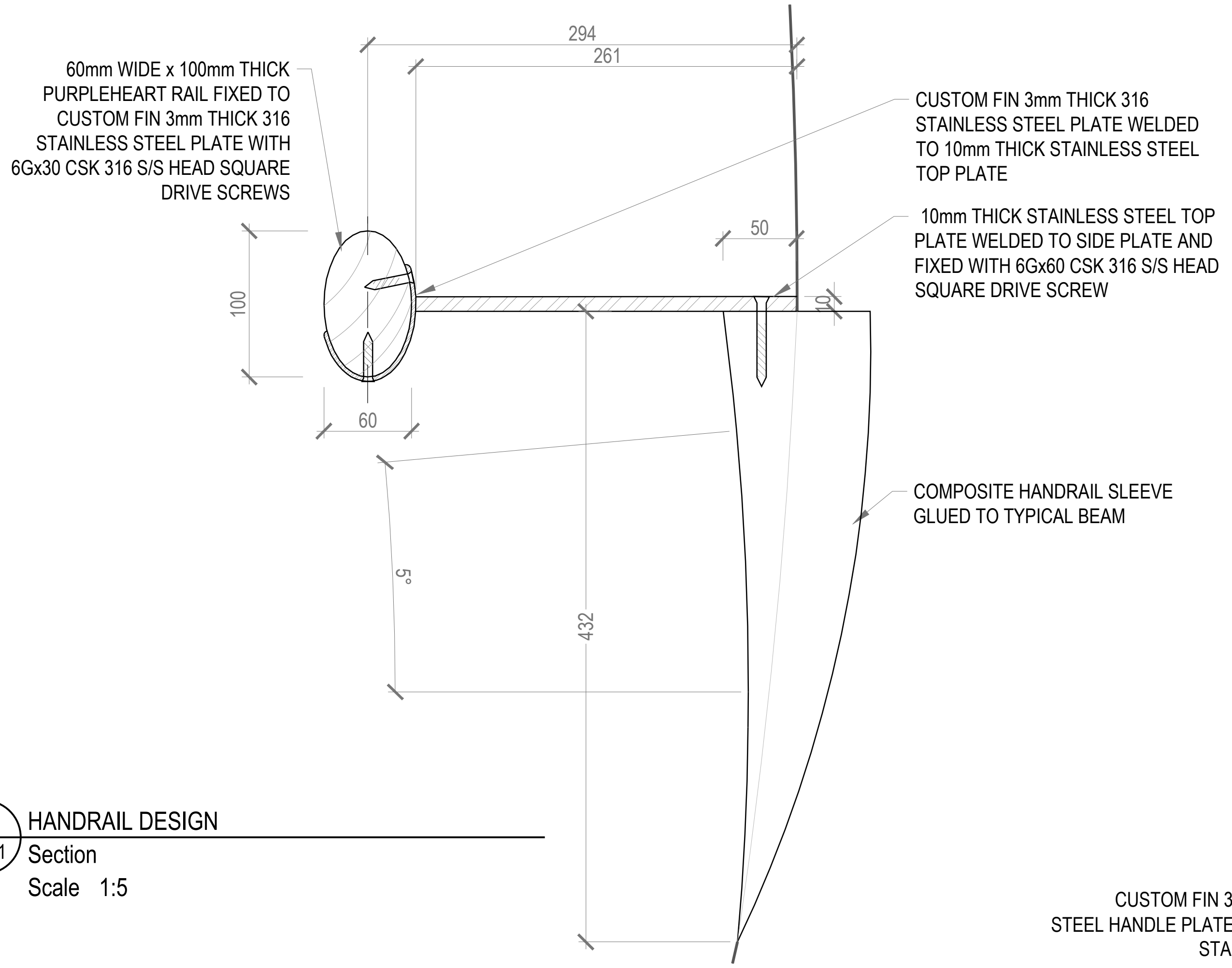
BROAD COLOUR SPECTRUM



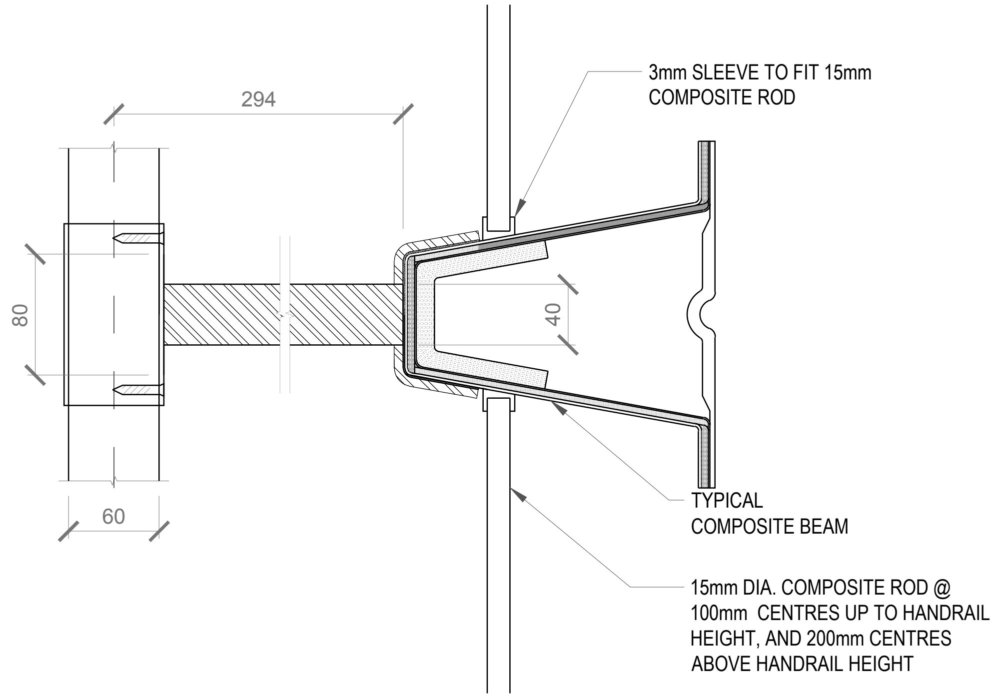




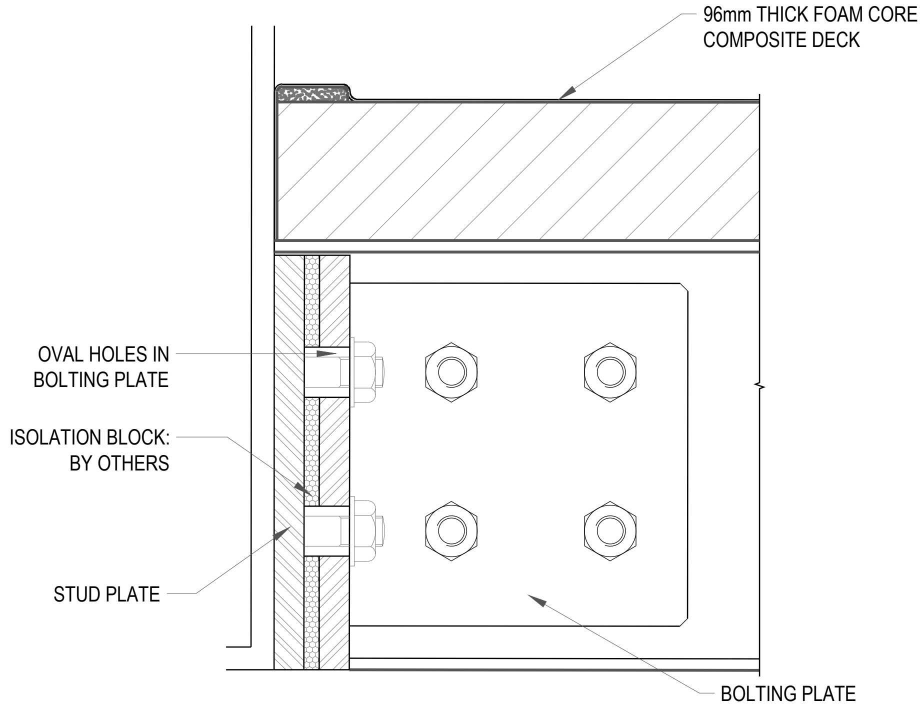
SPECIAL EFFECTS



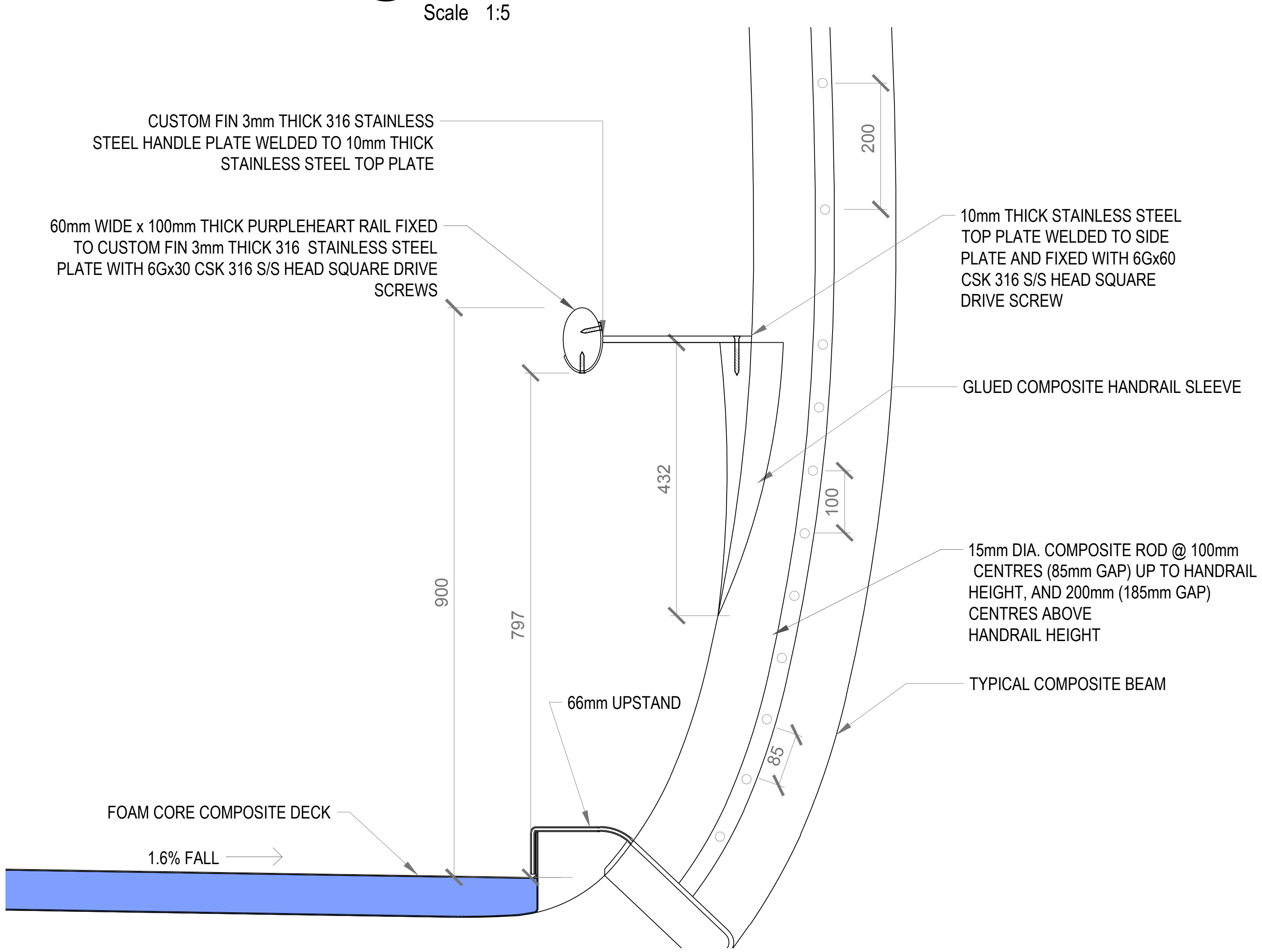
A DE.01 HANDRAIL DESIGN
Section
Scale 1:5



B DE.01 HANDRAIL SUPPORT BRACKET
Plan
Scale 1:5



C DE.01 LOWER BEAM CONNECTION
Vertical Section
Scale 1:5



D DE.01 HANDRAIL DESIGN
Section
Scale 1:10

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No.	Revision	By	Chk	Appd	Date
A	RESOURCE CONSENT	AN	GF	GF	30.06.14

CLIENT

SKYPATH
AUCKLAND HARBOUR BRIDGE PATHWAY TRUST

PROJECT

SKYPATH
MODULE DETAILS

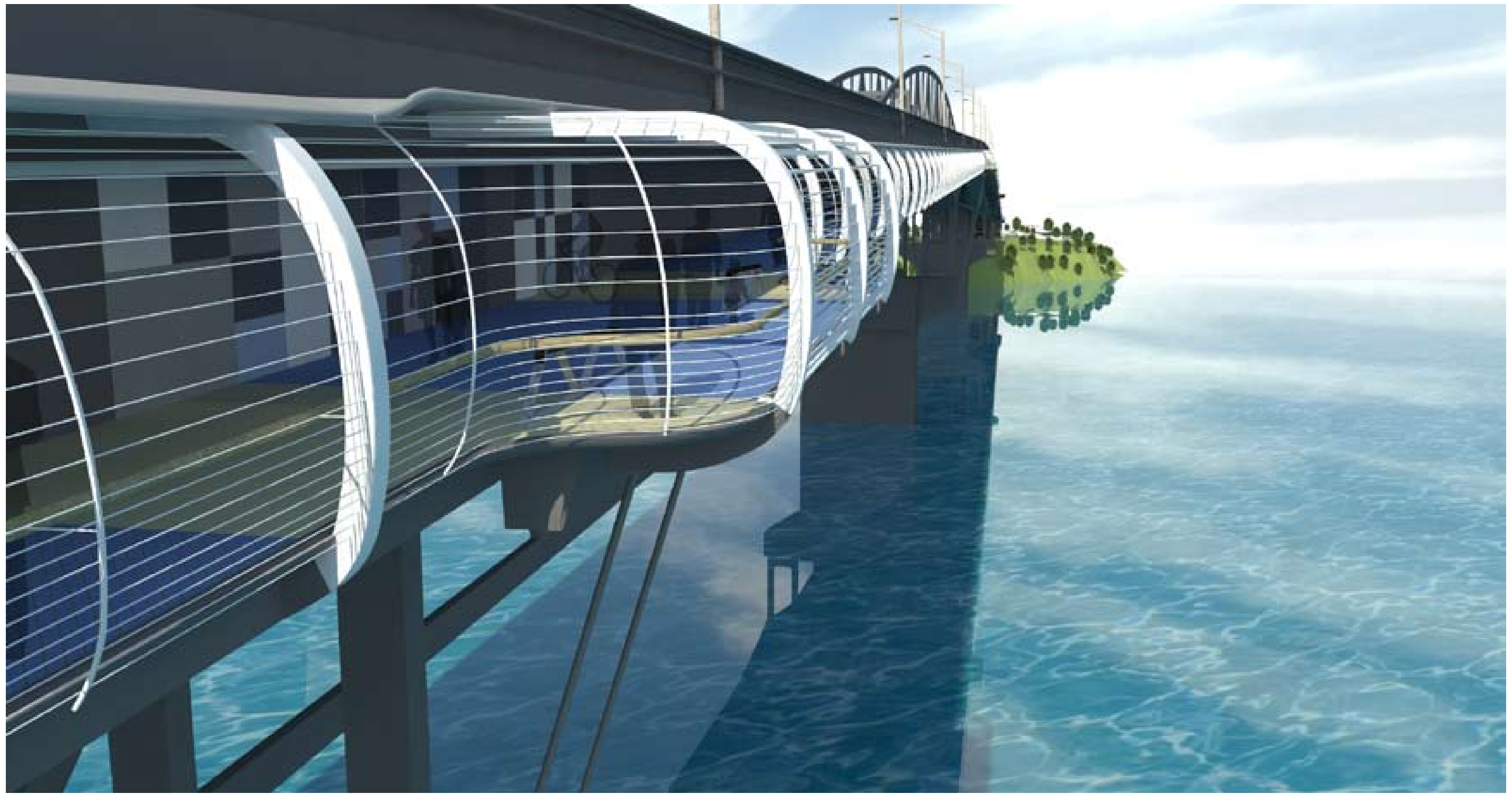
RESET URBAN DESIGN

TITLE
TYPICAL HANDRAIL
Sections & Details

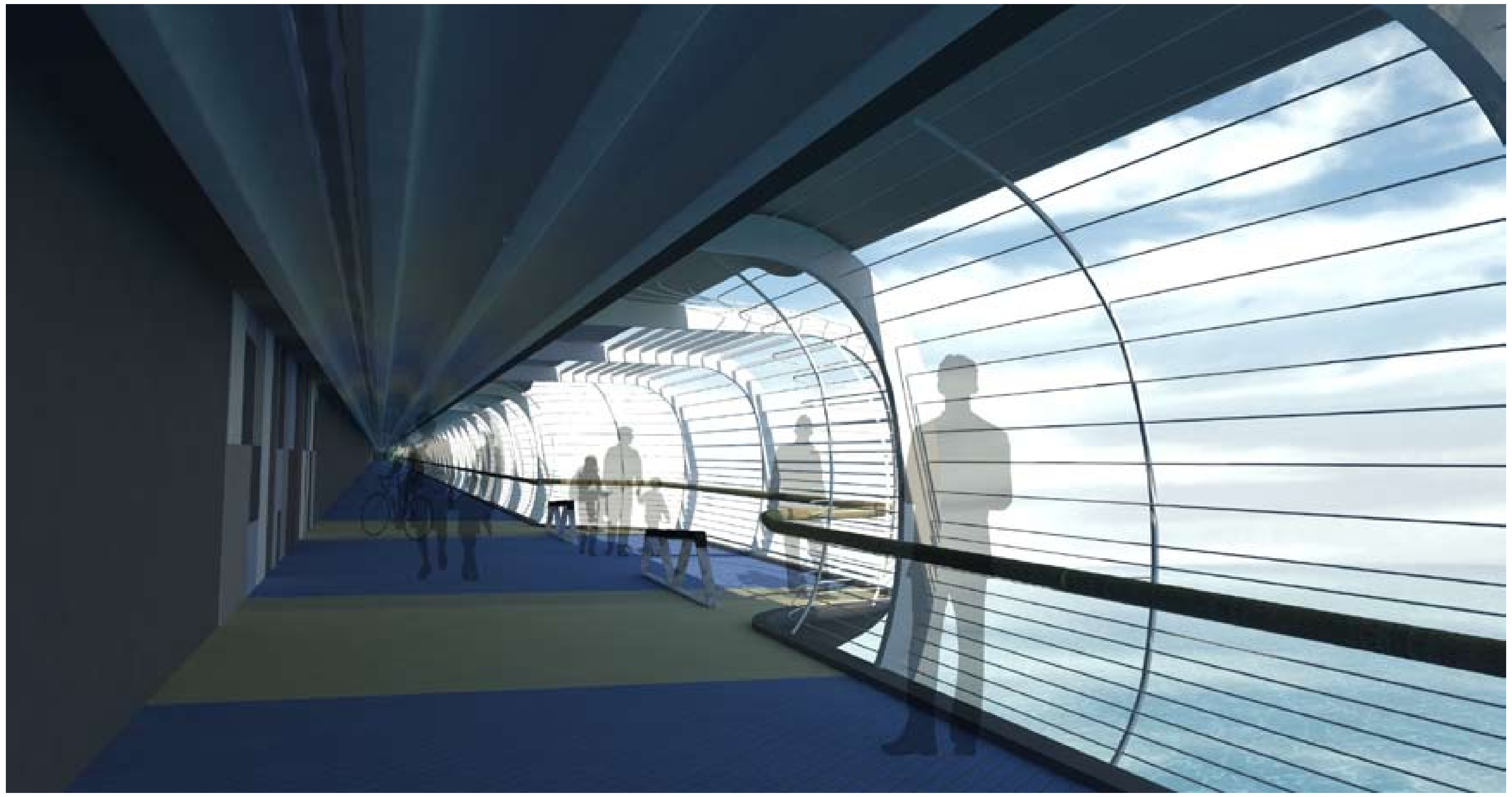
DESIGNED BY	TEAM	SCALE	Scale as Shown
DRAWN BY	AB		
APPROVED BY	GF	DATE	30.06.14
JOB NUMBER	2719	DRAWING NUMBER DE01	REVISION A

ISSUED FOR RESOURCE CONSENT

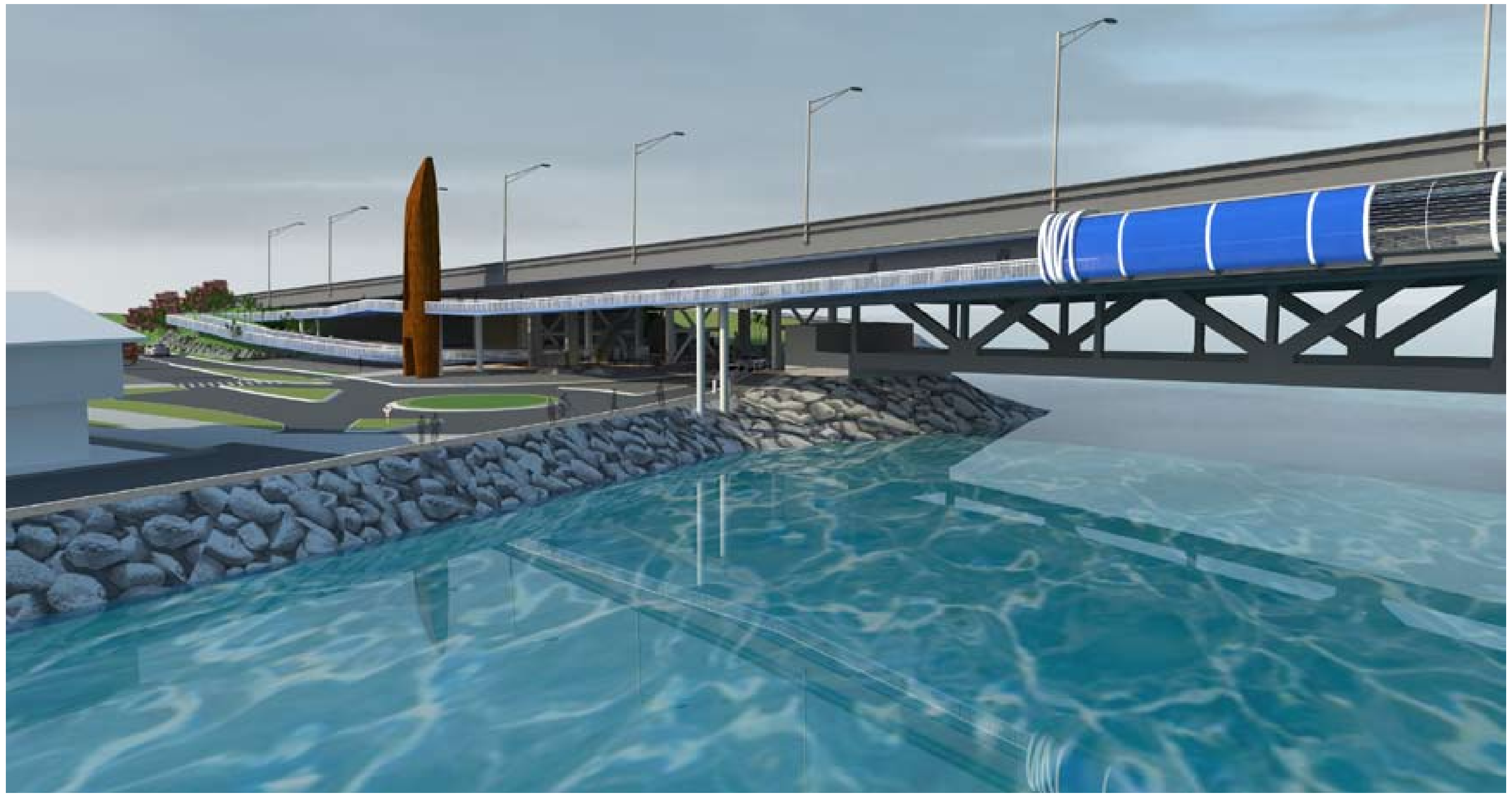
PHOTOMONTAGES 06


01 Bridge Span - Facing Northcote Point


02 Bridge Span - Facing Northcote Point



03 View on Path within Standard Span



04 View of Southern Landing

Existing View

05 View of Southern Landing from Westhaven Drive

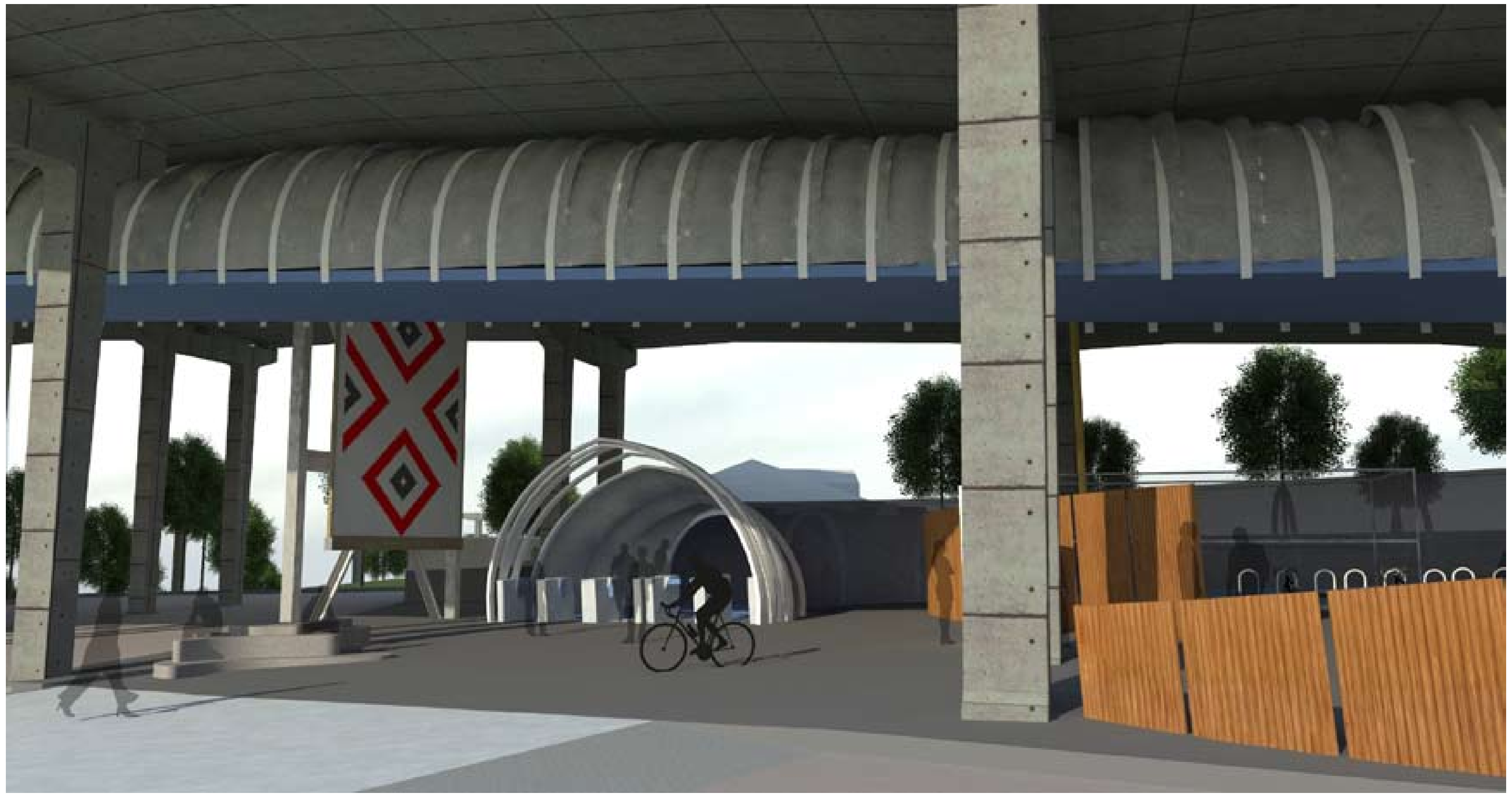
Existing View

06 View of Southern Landing

Existing View

07 View of Southern Landing


Existing View


08 View of Northern Landing

Existing View

09 View of Northern Landing

Existing View

10 View of Northern Landing

Appendix B

AHB SkyPath – Weight & Reaction Load Summary, Rev. D (GU5135.6004)

Engineered Structures

Technical Report

AHB Skypath – Weight & Reaction Load Summary

GU5135.6004

Circulation: AHB Skypath
Author: RG, TS

Business Unit:	Engineered Structures	**Department:**	Asia Pacific
Classification:	Commercial in Confidence	**Approved by:**	Tony Stanton

16th July 2014

Issue and Amendments

ISSUE	AMENDMENTS	DATE	APPROVED	INITIAL
A	First Issue	20/06/14	s 9(2)(a) [redacted]	T.S.
B	Symmetrical Observation Platforms	9/07/14	[redacted]	T.S.
C	Pin attachment to all observation decks	11/07/14	[redacted]	T.S.
D	Run Type 1 units full width of nav span	16/07/14	[redacted]	T.S.

This Report has been prepared For

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TABLE OF CONTENTS

1 Overview and Introduction

The aim of this report is to summarise the dead load of the SkyPath assembly as relevant to where it attaches to the AHB primary structure. A preliminary analysis of all of the composite unit types has been completed in Altair Hyperworks in order to develop the design in sufficient detail to better estimate the weight of the composite structure. An estimate has also been made for the fitout of the each type of module to cover non-structural weights.

A summary of the basis of this weight study is given below including the margins added to each component, and a break down for each type of unit.

At the end of this document, we have provided a full table of reaction loads for the estimated dead loads summarised below.

We have also provided factored reaction loads including live load, to show the distribution between attachment points of each rib.

2 Dead Weight Summary

Below is the summary of the dead weights used in this preliminary analysis. The deadweight is made up of the composite structure and some attached metal support structure at the piers, as well as the non-structural fitout items.

A margin over the calculated weights is included for both the composite structure and fitout to account of uncertainty in final specification, build, design and specification variance. These margins are shown below for each of the items.

The structural analysis was run concurrent with the weight estimate which was updated throughout this preliminary phase as laminate or structure was added. This running total was compared with the assumed dead weight of the structure used in the structural analysis to ensure we remained within our design target.

This can be seen in table 1 below with the difference between the FEA dead weight, and the estimated dead weight of the preliminary design. As a result we are carrying an additional margin in this analysis of approximately 13,000kg (or approximately 5%) spread across all the units. The observation decks in particular carry a larger margin due to the size of these units and therefore potential usage and therefore potential for variability.

The steel work supporting the observation decks also appears in the reactions provided at the end of this document. The weights for these units were extracted from the FEA model and are summarised below at the end of table 1. These members were made stiff in the FEA so as to provide support to the observation deck for analysis of the composite structure, final specifications and weights of these units to be confirmed by Aireys.

In the table below Type 1 refers to the units over the navigation span, Module 22 is an over length version of the Type 1 module attached to Box 22 of the box girder. Type 2 modules are the standard units either side of the navigation span. Type 3 refers to the observation decks located at Piers 1 through 5. Please refer to the layout drawing on page 15 and also the Reset drawings for the geometry of each module type.

Table 1: Dead weight summary

Type	Type composite Weight kg	Type composite Weight plus 20% kg	Type hardware kg	Type hardware wt plus 15% kg	Single module composite & hardware total wt with % factors kg	Self-Weight Applied in FEA kg	Total Number
1	1933	2320	396	455	2775	2900	10
BOX 22	2146	2575	450	517	3092	3190	1
2	2219	2663	374	430	3093	3200	58
Margins Applied to Type 3		30%		40%			
3	3372	4384	525	735	5119	6200	5

Dead weights of observation deck support structures included in model. Support pillars were modelled as stiff steel sections, and given sufficient stiffness to support the observation deck in order to obtain accurate reactions at the box girder. The values below are what is included in the FEA model on this basis, final specification of steel work to be confirmed during detail design by Airey Consultants

Type		Self-Weight Applied in FEA kg	
Type 3 Posts		6387	5

Total Dead Weight Included in FEA kg	277443
Total Estimated Dead Weight kg	264438

3 Approximate Material Quantity

The following section includes a summary of the approximate materials quantities and fitout items used for calculation the dead load of each of the unit types.

The materials lists have been based on the preliminary FEA of each of the units but have been completed in generic material weights and thickness, rather than a detailed construction specification. The materials quantities presented below are formed from the weight estimate including the factor shown in table 1 which is applied to all items in the estimate. As such the materials quantities presented correspond to the margined weight for the composites. These quantities do not however include any wastage and represent only the material quantities in the finished part, at this factored weight.

Weight estimates were completed with the basic assumption the mobility platforms being built into the units through locally increasing the core thickness as this was the heaviest option under consideration. A fibre weight fraction that corresponds to a filled fire retardant epoxy resin was also used in this estimate.

These quantities are based on preliminary design only and are to be confirmed during detailed design. Resin consumption for fibre wet out, core uptake and surface priming, coves and adhesives are included in the weight estimate, although they do not appear in the materials list below which covers reinforcements and core materials.

The composite structure includes

- Deck
- Ribs and patching at pins
- Solid Debris Screen
- Longitudinal deck webs and shear ties
- Expansion join cover plates
- Toerail moulding
- Miscellaneous flashing panels

A breakdown of the non-structural items included with each unit is also provided in the following section.
The fitout weight excludes the brackets and pins attached to the box girder at the rib mounting points.

3.1 Type 1 Materials Weight Estimate

Table 2: Type 1 Materials Quantities

Fabric List	Fibre Weight Fraction	Material Thickness [mm]	Total m²
EQ1000	0.61	0.93	294
EQ1200	0.61	1.12	159
EQ2000	0.61	1.86	235

Tape List	Fibre Weight Fraction	Material Thickness [mm]	Total m²	Total Length m
EDB600-100mm	0.65	0.51	5.2	52
EDB600-150mm	0.65	0.51	3.6	24
EQ1200-150mm	0.61	1.12	7.4	49
EQ1200-200mm	0.61	1.12	9.9	49
CU450-40mm	0.65	0.46	49.0	1224
CU450-50mm	0.65	0.46	3.6	72
CU450-80mm	0.65	0.46	55.6	696

Core List	Total m²
XF4-3.6mm-4mm	9
GPETFR-100-5mm	30
GPETFR-100-10mm	34
GPETFR-100-25mm	1
GPETFR-100-65mm	62
GPETFR-200-10mm	6

3.2 Type 1 Fitout weight

Table 3: Type 1 – Fitout items

TYPE 1 COMPONENT	DESCRIPTION	Weight per item (kg)	Number of items	Total length of box (m)	Area (m^2)	Totals (kg)
Non-skid pavement	3mm thick Epoxy and Stone Aggregate 2.35kg/m2				55.0	129.3
primer paint	Primer High Build solids=43%, sg=1.2kg/l				138.8	17.9
gloss paint	Topcoat solids=72%, sg=1.4kg/l				83.8	21.1
tinned cu lighting wire	35kg/km, 35gm/m	0.48		13.7		6.6
PVC lighting conduit	.5kg/m for 25mm dia	0.50		13.7		6.9
LED lighting strip	2 strips full length (.14kg/m)	0.28		13.7		3.8
barrier tube bolting top	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	4.0			0.3
barrier tube bolting bottom	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	4.0			0.3
handrail support hardware	6 plates at 1.64kg each	1.64	6.0			9.8
handrail bolting plates	encapsulated 10mm bolting plate in top of composite sleeve	0.23	6.0			1.4
handrail support bolting	2xM10 bolts-28gm + 4x6g30mm screws at 5gm ea	0.08	6.0			0.5
handrail	purpleheart hardwood at 4.7kg/m	4.70	13.7			64.4
expansion plate bolts at deck	M12 x 100mm at 300crs	0.11	14.0			1.6
expansion plate bolts at debris screen	M8 x 25mm at 300mm crs	0.02	5.0			0.1
hatch plate fasteners	4 x hatch locking fasteners fastener = 360gms each per hatch	0.36	24.0			8.6
flashing fasteners	M6x20mm bolts washers at 400crs, wt/fastener=7.4gms	0.01	3.4			0.0
top rib fasteners	barrel pins at 1kg/ea for type 1 boxes	1.00	6.0			6.0
bottom rib fasteners	Bolts M20x200 .55kg/ea, 4 per rib, type 1 = 6x4	0.55	24.0			13.2
barrier rods	15mm composite rods at .4kg/m, 19 rods	7.60		13.7		104.2
	TOTAL					396

3.3 Box 22 Materials Weight Estimate

Table 4: Box 22 – Materials Quantities

Fabric List	Fibre Weight Fraction	Material Thickness [mm]	Total m²
EQ1000	0.61	0.93	336
EQ1200	0.61	1.12	168
EQ2000	0.61	1.86	258

Tape List	Fibre Weight Fraction	Material Thickness [mm]	Total m²	Total Length m
EDB600-100mm	0.65	0.51	5.2	52
EDB600-150mm	0.65	0.51	3.6	24
EQ1200-150mm	0.61	1.12	8.4	56
EQ1200-200mm	0.61	1.12	11.2	56
CU450-40mm	0.65	0.46	57.1	1428
CU450-50mm	0.65	0.46	3.6	72
CU450-80mm	0.65	0.46	64.9	811

Core List	Total m²
XF4-3.6mm-4mm	10
GPETFR-100-5mm	34
GPETFR-100-10mm	38
GPETFR-100-25mm	1
GPETFR-100-65mm	69
GPETFR-200-10mm	6

3.4 Box 22 Fitout weight

Table 5: Box 22 – Fitout item

BOX 22 COMPONENT	DESCRIPTION	Weight per item (kg)	Number of items	Total length of box (m)	Area (m^2)	Totals (kg)
Non-skid pavement	3mm thick Epoxy and Stone Aggregate 2.35kg/m2				60.5	142.2
primer paint	Primer High Build solids=43%, sg=1.2kg/l				173.4	21.9
gloss paint	Topcoat solids=72%, sg=1.4kg/l				98.5	24.8
tinned cu lighting wire	35kg/km, 35gm/m	0.48		15.7		7.5
PVC lighting conduit	.5kg/m for 25mm dia	0.50		15.7		7.8
LED lighting strip	2 strips full length (.14kg/m)	0.28		15.7		4.4
barrier tube bolting top	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	4.0			0.3
barrier tube bolting bottom	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	4.0			0.3
handrail support hardware	7 plates at 1.64kg each	1.64	7.0			11.5
handrail bolting plates	encapsulated 10mm bolting plate in top of composite sleeve	0.23	7.0			1.6
handrail support bolting	2xM10 bolts-28gm + 4x6g30mm screws at 5gm ea	0.08	7.0			0.5
handrail	purpleheart hardwood at 4.7kg/m	4.70	15.7			73.6
expansion plate bolts at deck	M12 x 100mm at 300crs	0.11	14.0			1.6
expansion plate bolts at debris screen	M8 x 25mm at 300mm crs	0.02	5.0			0.1
hatch plate fasteners	4 x hatch locking fasteners fastener = 360gms each per hatch	0.36	28.0			10.1
flashing fasteners	M6x20mm bolts washers at 400crs, wt/fastener=7.4gms	0.01	3.4			0.0
top rib fasteners	barrel pins at 1kg/ea for type 1 boxes	1.00	7.0			7.0
bottom rib fasteners	Bolts M20x200 .55kg/ea, 4 per rib, type 1 = 6x4	0.55	28.0			15.4
barrier rods	15mm composite rods at .4kg/m, 19 rods	7.60		15.7		118.9
	TOTAL					449.5

3.5 Type 2 Materials Weight Estimate

Table 6: Type 2 – Materials Quantities

Fabric List	Fibre Weight Fraction	Material Thickness [mm]	Total m²
EQ1000	0.61	0.93	346
EQ1200	0.61	1.12	154
EQ2000	0.61	1.86	230

Tape List	Fibre Weight Fraction	Material Thickness [mm]	Total m²	Total Length m
EDB600-100mm	0.65	0.51	5.8	58
EDB600-150mm	0.65	0.51	7.4	49
EQ1200-150mm	0.61	1.12	7.4	49
EQ1200-200mm	0.61	1.12	9.9	49
CU450-40mm	0.65	0.46	24.8	619
CU450-50mm	0.65	0.46	7.4	148
CU450-80mm	0.65	0.46	27.8	348

Core List	Total m²
XF4-3.6mm-4mm	9
GPETFR-100-5mm	26
GPETFR-100-10mm	53
GPETFR-100-25mm	1
GPETFR-100-65mm	105
GPETFR-200-10mm	1

3.6 Type 2 Fitout Weight

Table 7: Type 2 – Fitout Items

TYPE 2 COMPONENT	DESCRIPTION	Weight per item (kg)	Number of items	Total length of box (m)	Area (m^2)	Totals (kg)
Non-skid pavement	3mm thick Epoxy and Stone Aggregate 2.35kg/m2				55.0	129.3
primer paint	Primer High Build solids=43%, sg=1.2kg/l				121.7	15.3
gloss paint	Topcoat solids=72%, sg=1.4kg/l				66.7	16.8
tinned cu lighting wire	35kg/km, 35gm/m	0.48		13.7		6.6
PVC lighting conduit	.5kg/m for 25mm dia	0.50		13.7		6.9
LED lighting strip	2 strips full length (.14kg/m)	0.28		13.7		3.8
barrier tube bolting top	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	8.0			0.6
barrier tube bolting bottom	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	8.0			0.6
handrail support hardware	3 plates at 1.64kg each	1.64	3.0			4.9
handrail bolting plates	encapsulated 10mm bolting plate in top of composite sleeve	0.23	3.0			0.7
handrail support bolting	2xM10 bolts-28gm + 4x6g30mm screws at 5gm ea	0.08	3.0			0.2
handrail	purpleheart hardwood at 4.7kg/m	4.70	13.7			64.4
expansion plate bolts at deck	M12 x 100mm at 300crs	0.11	14.0			1.6
expansion plate bolts at debris screen	M8 x 25mm at 300mm crs	0.02	45.0			0.8
hatch plate fasteners	4 x hatch locking fasteners fastener = 360gms each per hatch	0.36	12.0			4.3
flashing fasteners	M6x20mm bolts washers at 400crs, wt/fastener=7.4gms	0.01	3.4			0.0
top rib fasteners	barrel pins at 1kg/ea	1.00	4.0			4.0
bottom rib fasteners	Bolts M20x200 .55kg/ea, 4 per rib,	0.55	16.0			8.8
barrier rods	15mm composite rods at .4kg/m, 19 rods	7.60		13.7		104.2
	TOTAL					373.8

3.7 Type 3 Materials Weight Estimate

Table 8: Type 3 Materials Quantities

Fabric List	Fibre Weight Fraction	Material Thickness [mm]	Total m²
EQ1000	0.61	0.93	616
EQ1200	0.61	1.12	229
EQ2000	0.61	1.86	316

Tape List	Fibre Weight Fraction	Material Thickness [mm]	Total 0 m²	Total Length m
EDB600-100mm	0.65	0.51	26.2	262
EDB600-150mm	0.65	0.51	4.2	28
EDB600-200mm	0.65	0.51	7.5	37
EQ1200-150mm	0.61	1.12	8.0	53
EQ1200-200mm	0.61	1.12	10.7	53
CU450-40mm	0.65	0.46	39.3	983
CU450-80mm	0.65	0.46	36.8	460
CU450-300mm	0.65	0.46	187	623

Core List	Total m²
XF4-3.6mm-4mm	11
GPETFR-100-5mm	32
GPETFR-100-10mm	42
GPETFR-100-25mm	1
GPETFR-100-65mm	169
GPETFR-100-20mm	80

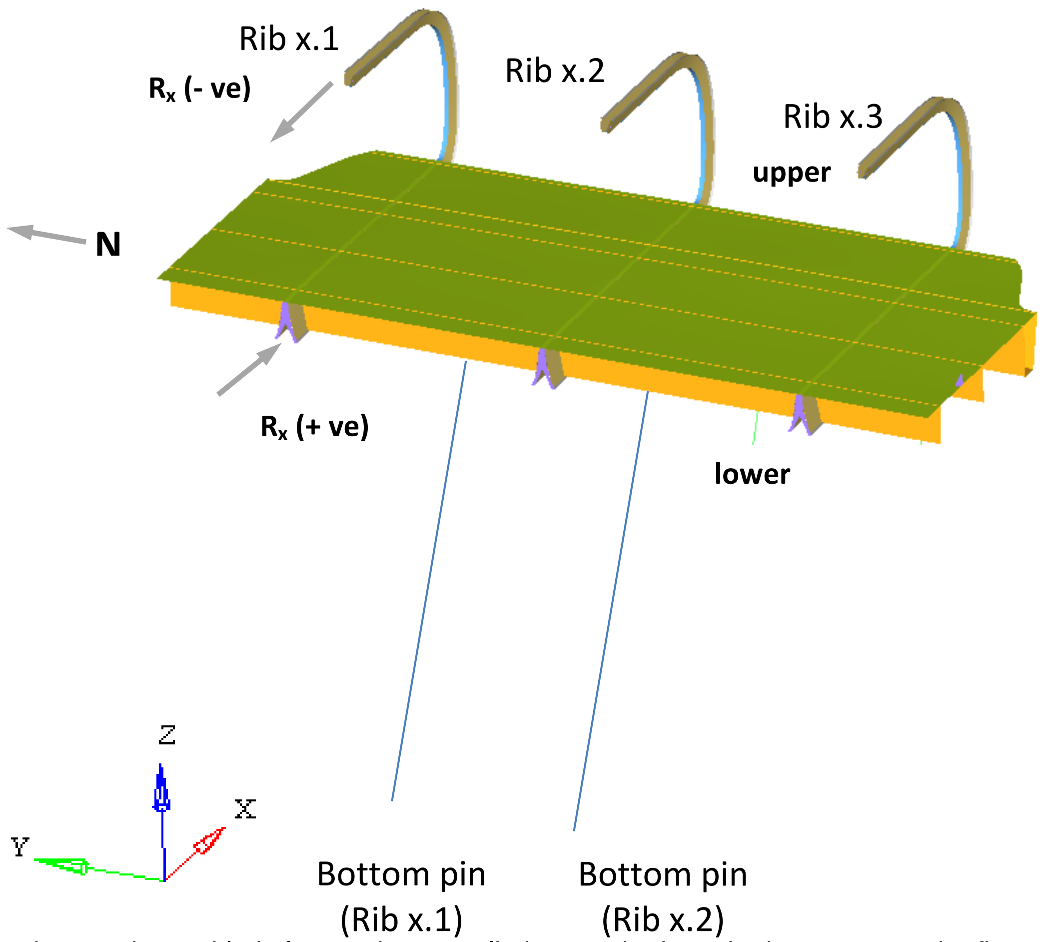
3.8 Type 3 Fitout Weight

Table 9: Type 3– Fitout Items

TYPE 3 – COMPONENT	DESCRIPTION	Weight per item (kg)	Number of items	Total length of box (m)	Area (m^2)	Totals (kg)
Non-skid pavement	3mm thick Epoxy and Stone Aggregate 2.35kg/m2				77.2	181.4
primer paint	Primer High Build solids=43%, sg=1.2kg/l				144.8	18.2
gloss paint	Topcoat solids=72%, sg=1.4kg/l				67.6	17.0
tinned cu lighting wire	35kg/km, 35gm/m	0.48		13.7		6.6
PVC lighting conduit	.5kg/m for 25mm dia	0.50		13.7		6.9
LED lighting strip	2 strips full length (.14kg/m)	0.28		13.7		3.8
barrier tube bolting top	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	8.0			0.6
barrier tube bolting bottom	30mm bolt 28g, nut 19g, washer 4g total = 81gm	0.08	8.0			0.6
handrail support hardware	3 plates at 1.64kg each	1.64	3.0			4.9
handrail bolting plates	encapsulated 10mm bolting plate in top of composite sleeve	0.23	3.0			0.7
handrail support bolting	2xM10 bolts-28gm + 4x6g30mm screws at 5gm ea	0.08	3.0			0.2
handrail	purpleheart hardwood at 4.7kg/m	4.70	15.8			74.4
expansion plate bolts at deck	M12 x 100mm at 300crs	0.11	14.0			1.6
expansion plate bolts at debris screen	M8 x 25mm at 300mm crs	0.02	45.0			0.8
hatch plate fasteners	4 x hatch locking fasteners fastener = 360gms each per hatch	0.36	12.0			4.3
flashing fasteners	M6x20mm bolts washers at 400crs, wt/fastener=7.4gms	0.01	3.4			0.0
top rib fasteners	barrel pins at 1kg/ea	1.00	4.0			4.0
bottom rib fasteners	Bolts M20x200 .55kg/ea, 4 per rib,	0.55	16.0			8.8
barrier rods	15mm composite rods at .4kg/m, 19 rods	12.00		15.8		190.0
	TOTAL					524.9

4 Reaction Loads and Moments

4.1 General Labelling (Type 3 Pier 4 Shown)



In the reactions table below we have applied a standard numbering system. The first numeral corresponds to the box number, and the second the the cross girder number (box and cross girder are both refering to the main bridge box girder). Both the boxes and cross girders are numbered from North to South. For the majority of boxes the ribs of the SkyPath modules are attached to the box girder at the cross girders.

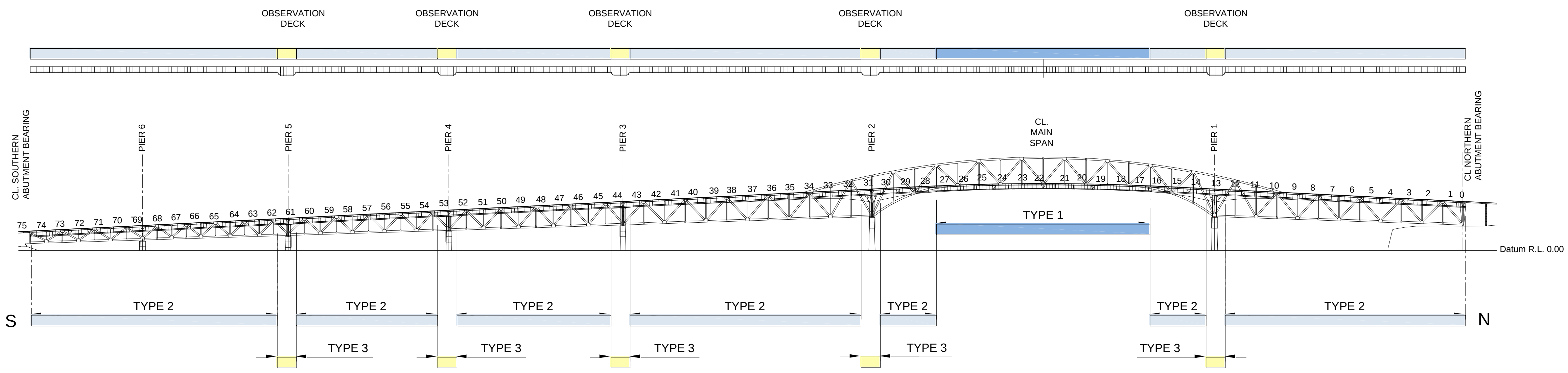
For boxes 17-19, and 25-27 in addition to the ribs attached to the cross girders there are intermediate ribs that are attached to the fascia beam along the edge of the box girder deck. These attachments are mid way between cross girders.

Reactions for these ribs attached to the fascia are denoted with an f and numbered to the previous cross girder of the box the module is attached to. Please refer to the attached layout drawing on page 15 for further information.

The module type has been indicated in the table, along with the uniformly distributed load applied to each rib as relevant to the rib spacing. This UDL is based on the 5kPA live load used in the design of the composite structure.

For type 3 units which are fitted with supports from the bridge pier brackets, reactions have been provided at the bottom of the post component attached to the composite structure. For Pier 1 and 2 units this corresponds to the bottom of the support truss. For Piers 3,4 & 5 this corresponds to the bottom of the support posts. As such these reactions include the self weight of the steel work to that point as sumamarised in table 1. The reaction loads of these pins are labelled with the previous rib's number. These support posts have been modelled with a joint that is pinned to allow rotation around x and y axis.

The reactions are provided for the upper and lower mounting points of each rib as shown above.



STANDARD MODULE TYPES			
MODULE TYPE	NOMINAL RIB SPACING	MAX DEPTH (RIB+DECK)	MOBILITY PLATFORMS
TYPE 1	2287mm	420mm	NONE
TYPE 3	4750mm	740mm	YES
TYPE 4	4750mm	770mm	YES

NOTE:
NUMBERING INCREMENTS FROM NORTH TO SOUTH

P1	FEASIBILITY DESIGN FOR COMMENT ONLY	J.P.	T.S.		24-06-14
ISSUE	MODIFICATIONS	Drawn:	Checked:	Approved:	Issued:

Client: AHB PATHWAY TRUST
Project: AUCKLAND HARBOUR BRIDGE SKYPATH
Drawing Title: GENERAL ARRANGEMENT
Sheet Title: MODULE LAYOUT
Primary Scale at A1: 1:1500
Drawing Number: GU5135 - 106
Sheet: 1 OF 1

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CHECK THIS DISTANCE = 100mm

Table 10: Un-factored Dead Load Reactions – Full Summary

The UDL specified below relates to a 5kPA live load applied to the deck.

Reaction Loads & Moments

BOX n°	Frame Type	Rib n°	UDL kN/m	Location	Dead Load Reactions Fx (kN)	Fz (kN)	My (kN.m)
1	Type 2	1.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		1.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		1.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
2	Type 2	2.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		2.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		2.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
3	Type 2	3.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		3.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		3.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
4	Type 2	4.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		4.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		4.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
5	Type 2	5.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		5.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		5.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

6	Type 2	6.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		6.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		6.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
7	Type 2	7.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		7.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		7.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
8	Type 2	8.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		8.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		8.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
9	Type 2	9.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		9.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		9.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
10	Type 2	10.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		10.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		10.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
11	Type 2	11.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		11.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		11.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

12	Type 2	12.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		12.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		12.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
13	Type 3 - Pier 1	13.1	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
				Bottom pin	10.3	52.6	-
		13.2	22.9	Upper Pin	-0.2	0.8	-
				Lower Pin	-18.4	4.2	-
				Bottom pin	10.3	52.6	-
		13.3	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
14	Type 2	14.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		14.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		14.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
15	Type 2	15.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		15.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		15.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
16	Type 2	16.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		16.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		16.3	17.2	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

17	Type 1	17.0f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		17.1	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		17.1f	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		17.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		17.2f	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		17.3	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
18	Type 1	18.0f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		18.1	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		18.1f	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		18.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		18.2f	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		18.3	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
19	Type 1	19.0f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		19.1	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		19.1f	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		19.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		19.2f	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		19.3	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0

20	Type 1	20.0f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		20.1	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		20.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		20.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		20.4	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		20.5	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
21	Type 1	21.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		21.2	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		21.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		21.4	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		21.5	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		21.6	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
22	Type 1	22.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		22.2	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		22.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		22.4	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		22.5	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		22.6	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		22.7	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0

23	Type 1	23.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		23.2	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		23.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		23.4	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		23.5	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		23.6	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
24	Type 1	24.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		24.2	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		24.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		24.4	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		24.5	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		24.6	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
25	Type 1	25.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		25.2	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		25.3	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		25.4	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		25.5	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		25.5f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0

26	Type 1	26.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		26.1f	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		26.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		26.2f	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		26.3	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		26.3f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
27	Type 1	27.1	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
		27.1f	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		27.2	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		27.2f	11.5	Upper	-0.8	1.4	-
				Lower	0.8	3.4	-4.8
		27.3	11.5	Upper	-0.8	1.4	-
				Lower	0.5	3.2	-4.7
		27.3f	11.5	Upper	-0.9	1.4	-
				Lower	1.1	3.6	-5.0
28	Type 2	28.1	17.2	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		28.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		28.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
29	Type 2	29.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		29.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		29.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
30	Type 2	30.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		30.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		30.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

31	Type 3 - Pier 2	31.1	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
				Bottom pin	10.3	52.6	-
		31.2	22.9	Upper Pin	-0.2	0.8	-
				Lower Pin	-18.4	4.2	-
				Bottom pin	10.3	52.6	-
		31.3	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
32	Type 2	32.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		32.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		32.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
33	Type 2	33.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		33.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		33.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
34	Type 2	34.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		34.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		34.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
35	Type 2	35.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		35.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		35.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
36	Type 2	36.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		36.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		36.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

37	Type 2	37.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		37.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		37.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
38	Type 2	38.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		38.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		38.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
39	Type 2	39.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		39.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		39.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
40	Type 2	40.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		40.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		40.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
41	Type 2	41.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		41.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		41.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
42	Type 2	42.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		42.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		42.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

43	Type 2	43.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		43.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		43.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
44	Type 3 - Pier 3	44.1	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
				Bottom pin	10.2	52.6	-
		44.2	22.9	Upper Pin	-0.2	0.8	-
				Lower Pin	-18.4	4.2	-
				Bottom pin	10.3	52.6	-
		44.3	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
45	Type 2	45.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		45.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		45.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
46	Type 2	46.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		46.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		46.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
47	Type 2	47.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		47.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		47.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
48	Type 2	48.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		48.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		48.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

49	Type 2	49.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		49.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		49.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
50	Type 2	50.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		50.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		50.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
51	Type 2	51.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		51.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		51.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
52	Type 2	52.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		52.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		52.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
53	Type 3 - Pier 4	53.1	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
				Bottom pin	10.2	52.6	-
		53.2	22.9	Upper Pin	-0.2	0.8	-
				Lower Pin	-18.4	4.2	-
				Bottom pin	10.3	52.6	-
		53.3	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
54	Type 2	54.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		54.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		54.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

55	Type 2	55.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		55.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		55.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
56	Type 2	56.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		56.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		56.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
57	Type 2	57.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		57.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		57.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
58	Type 2	58.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		58.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		58.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
59	Type 2	59.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		59.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		59.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
60	Type 2	60.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		60.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		60.3	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1

61	Type 2	61.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
	Type 3 - Pier 5	61.2	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
				Bottom pin	10.2	52.6	-
		61.3	22.9	Upper Pin	-0.2	0.8	-
				Lower Pin	-18.4	4.2	-
				Bottom pin	10.3	52.6	-
62	Type 3 - Pier 5	62.1	21.2	Upper Pin	-0.6	1.0	-
				Lower Pin	-0.5	5.2	-
	Type 2	62.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		62.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
63	Type 2	63.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		63.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		63.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
64	Type 2	64.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		64.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		64.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
65	Type 2	65.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		65.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		65.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
66	Type 2	66.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		66.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		66.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

67	Type 2	67.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		67.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		67.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
68	Type 2	68.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		68.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		68.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
69	Type 2	69.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		69.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		69.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
70	Type 2	70.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		70.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		70.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
71	Type 2	71.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		71.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		71.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
72	Type 2	72.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		72.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		72.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

73	Type 2	73.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		73.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		73.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
74	Type 2	74.1	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7
		74.2	22.9	Upper	-1.3	1.9	-
				Lower	0.5	8.1	-13.1
		74.3	22.9	Upper	-1.4	2.0	-
				Lower	1.7	8.8	-13.7

4.2 Reactions loads with factored load case (1.2 x Dead load + 1.5 x Live load)

The following reaction loads have been extracted from the preliminary FEA model for the above load combination. The live load is 5.0kPa in all cases.

The Type 3 units are supported by only a pair of posts, with the modules centred on the piers.

In our preliminary analysis the design live load was applied to the deck plate as a uniform pressure. The deck has a small outboard fall on it which has resulted in a small inwards action from this live load which can be seen in the factored live load reactions below. This does not affect the dead loads.

Table 11: Reaction loads - Type 1

BOX n°	Frame Type	Rib n°		Fx (kN)	Fz (kN)	My (kN.m)
20	Type 1	20.1	Upper	-9.6	15.1	-
			Lower	16.0	59.7	-74.2
		20.2	Upper	-8.5	13.8	-
			Lower	2.6	52.2	-67.9
		20.3	Upper	-9.0	15.0	-
			Lower	11.7	58.3	-74.3
		20.4	Upper	-9.0	15.0	-
			Lower	11.7	58.3	-74.3
		20.5	Upper	-8.5	13.8	-
			Lower	2.6	52.2	-67.9
		20.6	Upper	-9.6	15.1	-
			Lower	16.0	59.7	-74.2

Table 12: Reaction loads - Type 2

BOX n°	Frame Type	Rib n°		Fx (kN)	Fz (kN)	My (kN.m)
15	Type 2	16.1	Upper	-16.3	21.8	-
			Lower	25.0	131.0	-188.0
		16.2	Upper	-14.5	19.2	-
			Lower	3.1	114.0	-171.0
		16.3	Upper	-16.3	21.8	-
			Lower	25.0	131.0	-188.0

Table 13: Reaction loads - Type 3

BOX n°	Frame Type	Rib n°		Fx (kN)	Fz (kN)	My (kN.m)
31	Type 3	31.1	Upper Pin	-5.1	3.2	-
			Lower Pin	14.3	72.4	-
			Bottom pin	68.9	266	-
		31.2	Upper Pin	-1.9	1.7	-
			Lower Pin	-145.7	51.4	-
			Bottom pin	68.9	266	-
		31.3	Upper Pin	-5.1	3.2	-
			Lower Pin	14.3	72.4	-

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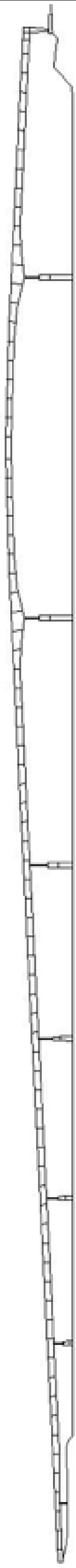
Appendix C
Overview of Pedestrian/Cyclist Load Cases

Table C-1: Pedestrian / cyclist Load Cases

Span No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**		
Length (m)	173.4	243.8	177.2	124.0	114.3	103.6	79.1		
Load Combination	**Span loaded? [1-Yes]**							**Loaded Length (m)**	**Loading (kN/m2)**
LC0	1	1	1	1	1	1	1	1015.4	0.74
LC1	1							173.4	1.21
LC2		1						243.8	1.01
LC3			1					177.2	1.20
LC4				1				124.0	1.41
LC5					1			114.3	1.46
LC6						1		103.6	1.51
LC7							1	79.1	1.67
LC8			1	1				301.2	0.89
LC9				1	1			238.3	1.02
LC10					1	1		217.9	1.08
LC11						1	1	182.7	1.18
LC12			1		1			291.5	0.91
LC13	1			1				297.4	0.90
LC14		1			1			358.1	0.80
LC15			1			1		280.8	0.93
LC16				1			1	203.1	1.12
LC17				1		1	1	306.7	0.88
LC18			1		1	1		395.1	0.74
LC19	1		1					350.6	0.81
LC20		1		1				367.8	0.78
LC21				1		1		227.6	1.05
LC22					1		1	193.4	1.15
LC23	1		1		1		1	544.0	0.74
LC24		1		1		1		471.4	0.74
LC25	1	1		1		1		644.8	0.74
LC26		1	1		1		1	614.4	0.74
LC27	1		1	1		1		578.2	0.74
LC28		1		1	1		1	561.2	0.74
LC29	1		1		1	1		568.5	0.74
LC30		1		1		1	1	550.5	0.74
LC31			1		1		1	370.6	0.78
LC32	1			1		1		401.0	0.74
LC33		1			1		1	437.2	0.74
LC34	1		1			1		454.2	0.74
LC35		1		1			1	446.9	0.74
LC36	1		1		1			464.9	0.74

Appendix D
Moment Comparison of SkyPath Assessment Load Combination with North-bound Strengthening Load

Table D-1: Critical Assessment Moment Ratios under assessment South-bound Traffic (100 %) and Full Pedestrian / cyclist Loading (BD 37/01)

Elevation	Location	Moment Ratio
	Abutment North	N/A
	Span 1	95 % (sagging)
	Pier 1	80 % (hogging)
	Span 2	109 % (sagging)
	Pier 2	80 % (hogging)
	Span 3	108 % (sagging)
	Pier 3	84 % (hogging)
	Span 4	105 % (sagging)
	Pier 4	87 % (hogging)
	Span 5	109 % (sagging)
	Pier 5	89 % (hogging)
	Span 6	108 % (sagging)
	Pier 6	87 % (hogging)
	Span 7	110 % (sagging)
	Pier 7	89 % (hogging)
	Span 8	99 % (sagging)
	Abutment South	N/A

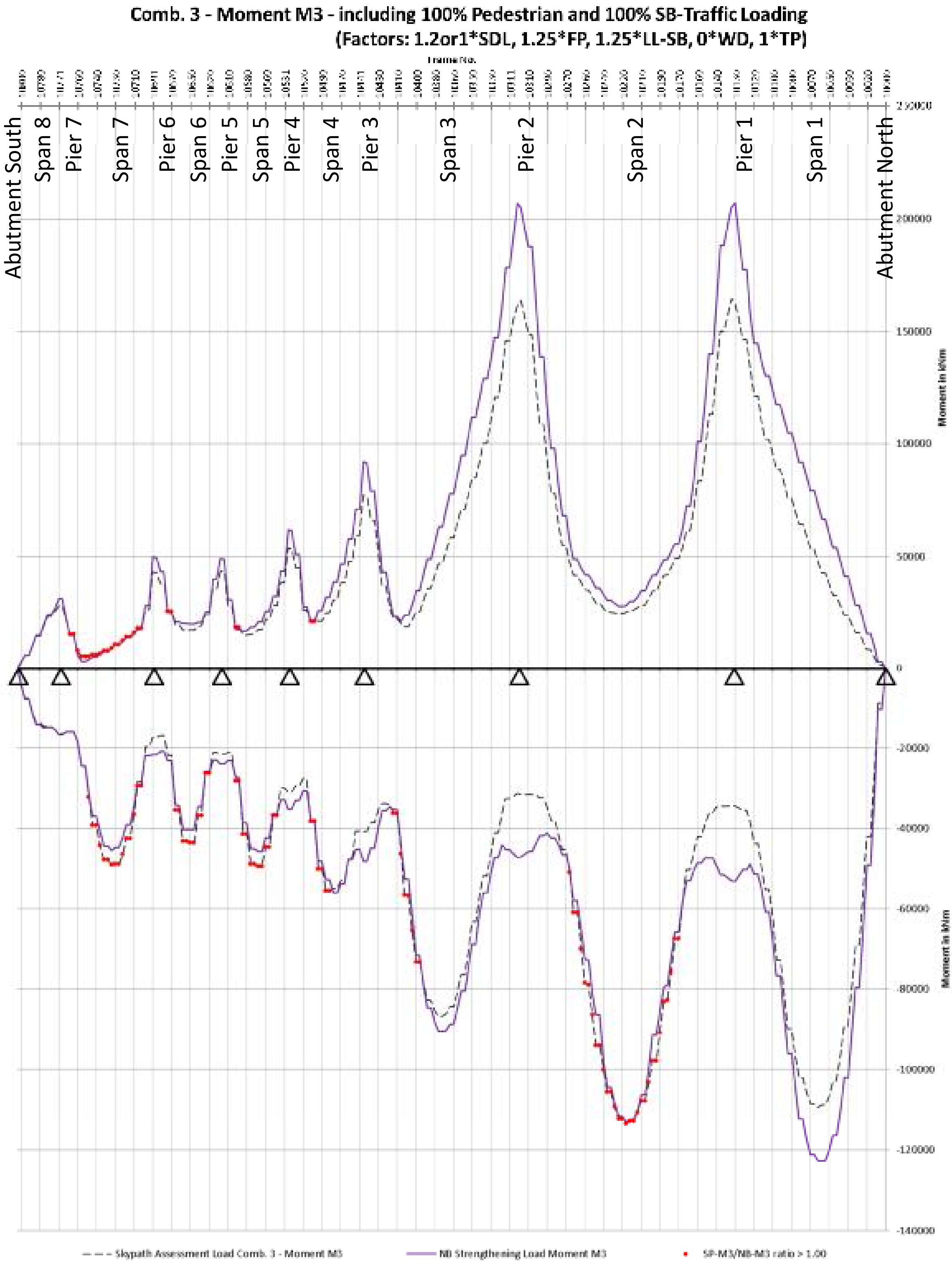


Figure D.1: Moment Comparison per Frame of SkyPath Assessment Load Combination (South-bound Traffic and Full Pedestrian / Cyclist Loading) with North-bound Strengthening Load

Appendix E

Assessment of D/C Ratios for Cross Girder Cantilevers with SkyPath Loads

Table E-1: Assessment of D/C Ratios for Cross Girder Cantilevers (Based on SkyPath Loads from Airey / Gurit)

Span	Load Case		
	Truck (Extreme LL)[1]	Truck (Single Trucks)[2]	Accidental Truck[3]
Span 1 cross girders	0.71	0.75	0.70
Span 2 cross girders	[illegible]	0.83	0.79
Span 3 cross girders	0.64	0.69	0.64
Span 4 cross girders	0.62	0.69	0.65
Span 5 cross girders	0.60	0.68	0.64
Span 6 cross girders	0.58	0.67	0.63
Span 7 cross girders	0.55	0.65	0.61

Table E-2: Assessment of D/C Ratios for Cross-Girder Cantilevers (Based on SkyPath Loads from Airey / Gurit with Additional 50 % Load to Represent Loss of Rib Attachment-to-Cross Girder Case)

Span	Load Case		
	Truck (Extreme LL)[1]	Truck (Single Trucks)[2]	Accidental Truck[3]
Span 1 cross girders	0.75	0.79	0.74
Span 2 cross girders	0.83	0.88	0.83
Span 3 cross girders	0.68	0.73	0.68
Span 4 cross girders	0.66	0.73	0.69
Span 5 cross girders	0.63	0.72	0.68
Span 6 cross girders	0.62	0.71	0.67
Span 7 cross girders	0.59	0.68	0.65

Notes (Table E-1 and E-2):

[1]) Single 39 tonne prototype truck (no impact) for local wheel load effects on the cross-girder combined with AHB live load used for extension bridge strengthening design (i.e. 110 % of 2007 TLS live load) for global effects; applied in both lanes with applicable multiple lane factors to produce most onerous effect on cross girders.

[2]) Single 39 tonne truck with full impact (I = 1.3) for both local and global effects, applied in both lanes with applicable 100 % - 70 % multiple lane factors to produce most onerous effect on cross girders.

[3]) 320 kN tandem axle accidental vehicle for both global and local effects (allowance for impact already included in axle loads); one set is applied at a time at any position across the deck to produce the most onerous effect on the cross girder.