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RiverLink Preliminary Concept Design

Technical Report GW/RiverLink-T-17/15 for RiverLink Pedestrian Bridge Design Statement

Prepared by Beca Limited

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Revision History

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on behalf of	Beca Limited		

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1 Introduction

1.1 Project Description

1.1.1 Project Partnership

RiverLink is a partnership project between the Greater Wellington Regional Council (GWRC), Hutt City Council (HCC), and the New Zealand Transport Agency (NZTA) with the aim to deliver better flood protection, better lifestyle and improved transport links for the people of central Lower Hutt. The RiverLink project area focuses on the three kilometre section of the Hutt River and its city interfaces between Kennedy-Good Bridge and the Ewen Bridge.

1.1.2 Governance and Decision Making

Governance for the project is joined through the Hutt Valley Flood Management Subcommittee (HVFMS), comprising of Councillors/Mayors from GWRC, HCC and UHCC and Iwi representatives. NZTA reports progress to the HVFMS, but its governance occurs independently. A Project Management Group, comprising of senior management from GWRC, HCC and NZTA manages the project. A Project Working Group comprising of officers from GWRC, HCC and NZTA, assisted by consultants (see below), carry out the RiverLink project work.

1.1.3 Integrated Design Approach

An integrated design approach has been followed since the partnership was established in 2014 with the advent of the Options Evaluation Phase (see below). RiverLink is now in the Preliminary Design Phase which is enabled by the three partners working together with an integrated design approach on what would otherwise be separate work programmes which comprise:

- Hutt River Floodplain Management Plan (2001) (HRFMP) work programme that aims to improve flood protection to a 440 year standard for Lower Hutt city centre and central residential areas. The HRFMP established in 2001 the need to undertake the protection work. Other flood protection actions in the HRFMP have already been undertaken that improve protection to areas upstream and downstream of the RiverLink section. With the HRFMP the Hutt River Environmental Strategy 2001 (HRES) sets the strategic direction for managing the Hutt River environment. This strategy is currently under review to update and provide more specific environmental outcomes for the Hutt River. The review reflects recreational and environmental challenges with growing and competing demands on the river. The strategy will reflect the design for RiverLink and set new objectives and directions for the whole river environment.
- Making Places City Centre Vision (2009) work programme that aims to make Lower Hutt city centre a more attractive place for people to live, work and play. Making Places is encouraging of new investment in development and the urban renewal of the city centre to the benefit of Hutt City and the region as a whole. A particular focus for Making Places as part of RiverLink is where the city centre interfaces with the river to take advantage of this natural asset in developing the amenity and attraction of the city as a destination and place to invest.
- State Highway 2 Melling Intersection Investigations (2016) work programme that is considering a range of options to improve the overall resilience, safety, reliability and efficiency of the highway at its intersection with Melling Bridge/Link and Block Roads. It is considering the accessibility of the city by a range of modes including public transport, walking and cycling.

1.1.4 Options Evaluation

The current Preliminary Design Phase was preceded by an Options Assessment Phase initiated in 2014 and completed in 2015. The Options Evaluation Phase of RiverLink considered a range of options in various combinations of the elements of flood protection, city centre development and transport connections. Completed in December 2015 the Options Evaluation process considered ten river corridor improvement options with each option designed to provide the recommended 440 year flood protection standard to Lower Hutt city centre and the central residential areas[1]. The ten options were evaluated using a multi-criteria analysis method (MCA) and the two best performing options relative to the criteria were selected for community consultation to seek feedback on preferences.

The community feedback strongly supported the longer-term protection performing option known as "Option A". Option A consisted of a 90 metre wide river channel with 25 metre berms on each bank to provide high levels of flood protection at design standard (2,800 cumecs) flood flows. The Melling Bridge also has to be replaced to provide the desired flood protection. The option makes provision to accommodate the Making Places elements of a promenade and new urban development at the stop bank interface. Option A requires 117 properties to be acquired to widen the river corridor. The Hutt Valley Flood Management Subcommittee and the Councils of Hutt City and Greater Wellington[2] adopted Option A as the basis for a preliminary design in December 2015. The purchase of any of the required 117 properties is proceeding on a voluntary basis – if an owner wishes to sell their property, GWRC is purchasing it. The Preliminary Design phase for RiverLink commenced in June 2016.

1.1.5 Preliminary Design

The Preliminary Design phase is intended to produce an integrated design incorporating the three partners' work programmes and optimising the benefits of the linkages between the programme elements.

The design is expected to enable an order of value from the project (costs and benefits) to be estimated, together with a strategy for consents and designations, as well as a preferred project delivery model. This package of design, consent strategy, value and delivery model will then be presented collectively as the Preliminary Design to enable decisions to be made as to how to proceed.

The aim is to have a project package that is fully supported by the partners and that can proceed to a consents and designations process, principally[3] under the Resource Management Act and Public Works Act. The decision to proceed to that next stage of the process (Consents Phase) will be made in the latter part of 2017 and would start in 2018 following the statutory procedures mandated by the relevant statutes.

There are multiple elements to consider in the preliminary design and there are multiple specialists undertaking the technical inputs as listed below. Given the integrated approach to the design of RiverLink, these Technical Reports may need to be read in conjunction to understand the interdependencies.

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[1] (Hutt River City Section Upgrade Project, Options Evaluation Report July 2015).
[2] GWRC order paper 9 December Meeting.
[3] Others statutes may apply

For a summary (without technical detail) and for easier reference, the composite Preliminary Design Report [4] provides an overall description of the project, its integrated elements, the design decisions made along with the parameters and assumptions within the design. The technical reports that are drawn on for the Preliminary Design Report are as follows:

- River Works undertaken by Damwatch, DHI and Waterscape (refer Technical Report T-17/9)
- Stop banks and relocation of services undertaken by Opus (refer Technical Report T-17/10)
- Stormwater upgrades undertaken by Wellington Water (refer Technical Report T-17/11)
- Transport and parking undertaken by GHD (refer Technical Report T-17/13)
- Structures undertaken by Beca (refer Technical Report T-17/14)
- Landscape, ecology and urban design (includes bridge architecture) undertaken by Boffa Miskell (refer Technical Report T-17/16)
- In addition to the technical design inputs there are specialist reports on the following:
- Project development cost estimates undertaken by BECA (refer Technical Report T-17/17)
- Operation and maintenance requirements and costs – commence April once the draft design reports are completed (refer Technical Report T-17/18)
- Community engagement/consultation undertaken by GW/HCC assisted by consultants (refer Technical Report T-17/19)
- Planning and consenting strategy undertaken by Boffa Miskell (refer Technical Report T-17/20)
- Property acquisition strategy undertaken by The Property Group (refer Technical Report T-17/21)
- Economic assessment undertaken by HCC (refer Technical Report T-17/22)
- Melling Intersection Indicative Business Case – MWH managed by NZTA. The outputs of this programme of work will issue separately.

1.2 Role and Background

The Pedestrian Bridge has been develop to preliminary concept design stage to inform the decision making process for the project, to allow cost estimates to be prepared and to form a basis for developing resource consent applications.

[4] RiverLink Preliminary Design Report T17/8)

2 Design Criteria

2.1 Introduction

The Pedestrian Bridge across the Hutt River is to be constructed to provide improved access between the Hutt City CBD and Melling railway station and car parking on the west side of the Hutt River. The 180m long bridge is located in line with Margaret Street. Refer to report reference T-17/16 for details.

The design and performance criteria adopted for the preliminary concept design of the Pedestrian Bridge are provided below.

2.2 Design Performance

It has been assumed that the Pedestrian Bridge will need to be designed to normal standards for civil engineering structures of this type. It is assumed that the pedestrian bridge will require building consent as it is used by people. Collapse could lead to loss of life.

The design philosophy adopted is to design this structure to meet both service and ultimate requirements. These will address loading due to static and seismic loads with the intention of designing the structure to meet normal levels of performance. Under the service limit state earthquake the structure should be undamaged and under the ultimate limit state earthquake it should be repairable. Under a maximum credible earthquake the structure should not collapse.

2.3 Design Standards

The works are designed in accordance with the requirements of the following documents:

- NZTA Bridge Manual 3rd Edition including Amendment 1
- AS/NZS 1170.0:2002 Structural Design Actions - General Principles
- NZS 1170.5:2004 Structural Design Actions - Earthquake Actions - New Zealand
- NZS 3101:2006 Concrete Structures Standard
- NZS 3404:1997 Steel Structures Standard.

2.4 Clearance Requirements

From discussions with Greater Wellington Regional Council and Hutt City Council it has been agreed that the clearances required for the pedestrian bridge are:

- Vertical clearance above waterway – the bridge soffit shall be at top of stop-bank crest level and rise up at 1/20 slope for 20m on each side of the river, with a smooth vertical curve provided through these points. This is required to provide 1m clearance to the river level to pass large debris carried during floods.
- Horizontal clearance at waterway – the bridge shall extend over the full river width between stop-banks, which is about 176m, although piers are permitted within the waterway to reduce structural span. Piers within the normal river channel are permissible but are not preferred.
- The horizontal width of the pedestrian bridge between handrails is assumed to be 4m which exceeds the minimum of 3m for shared pedestrian/cyclist use.

Refer to the Riverworks design report T-17/09.

2.5 Design Loads

The following sets out the design loads assumed.

2.5.1 Dead Loads

Dead loads are derived from unit material weights and structural component dimensions. Weights of materials have been allowed for as follows:

- Reinforced concrete - 25 kN/m^3
- Structural steel - 77 kN/m^3
- Unit weight of fill material - 18 kN/m^3

2.5.2 Superimposed Dead Loads

Dead loads are derived from unit material weights and structural component dimensions. Weights of materials have been allowed for as follows:

- Surfacing – 23 kN/m^3
- 1.4m high pedestrian/cyclist barriers - 1.0kN/m each side
- Services – no allowance

2.5.3 Live Loads

- Footpath load - 5kPa
- Light maintenance vehicles – assumed to be included in above

2.5.4 Seismic Loads

The seismic design parameters adopted for the design are shown in Table 1.

Table 1: Seismic Design Parameters

Parameter	Value	Comment
Importance level (IL)	IL 2	Normal bridges, not falling into other levels.
Design working life	100 years	From section 2.1.3 of the Bridge Manual
ULS return period	1000 years	From Table 2.2 of the Bridge Manual
SLS return period	25 years	From Table 2.2 of the Bridge Manual
Site subsoil class to NZS 1170.5	D	Refer geotechnical section
Hazard factor (Z)	Z = 0.42	From Table 3.3, NZS 1170.5

The structural ductility factors adopted in the seismic design of the structure are as shown in table 2 below.

Table 2: Structural Ductility Factors

Limit State and Earthquake Direction	Structural Ductility Factor Adopted (μ)
ULS Longitudinal and Transverse	μ = 3 for the design of the potential plastic hinge zones of the columns and piles, the design of all other elements was based on the resulting actions arising from the overstrength member capacities of the columns and piles.
SLS Longitudinal and Transverse	μ = 1, the structure was designed elastically

2.5.5 Wind Loads

Wind loading is not critical for a structure of this size/type and was not considered. Refer to the NZTA Bridge Manual for wind loading requirements.

2.5.6 Flood Loading and Scour

Hydraulic and debris loading on piers will be assumed as per the NZTA Bridge Manual.

2.6 Geotechnical Conditions

From previous geotechnical investigations (T&T 1991, Beca 1999), the ground profile can be summarised as comprising from the surface:

- Surface fills and silts deposits (including the stop-bank)
- Taita gravels (typically 7-10m thick) which form the bed and channel of the Hutt River and provide a high permeability layer extending from the river under the stop-banks
- Petone Marine Beds (typically 10m thick) of silty fine sands (with some beds of clean sandy fine gravel). These beds have low vertical permeability and are the confining aquiclude for the Waiwhetu Gravels
- Waiwhetu Gravels which extend from around RL -7.5m and are around 100m thick. The material is made up of permeable sandy gravels and has artesian pressures with a static head of around RL 3m.

From a geotechnical desktop study that has been undertaken for Daly Street wall, the design requires to address the geotechnical site hazards listed below:

- Weak fill and alluvial soils that are likely to liquefy during a large earthquake, resulting in large vertical and horizontal ground movement at the abutments
- Rupture of the nearby active Wellington Fault, resulting in abrupt vertical and horizontal movements near the ground surface
- Temporary elevated ground water profiles associated with flood of the Hutt River
- The Waiwhetu Aquifer, a local water source, protected by Greater Wellington Regional Council.

Refer to Appendix B for the assumed geological section at this location.

3 Design Options

3.1 Options Considered

Design concepts that have been considered for the pedestrian bridge include:

- Option 1 – A single span variable depth arch bridge across the full river channel between stop-banks
- Option 2 – A three span bridge of variable depth and two piers located outside the main river channel
- Option 3 – A four span bridge of variable or constant depth with two piers located outside the main river channel and one within it
- Option 4 – An asymmetric two span cable stay bridge with a single column located on the west side of the river channel with a 50m high back-leaning mast which supports the deck weight without back cables being required
- Option 5 – A three span suspension bridge with V-shaped piers located outside the main river channel
- Option 6 – A four span truss bridge with the trusses braced above the deck and fully enclosed
- Option 7 – A single span arch bridge with a single arch spanning between stop-banks and cables supporting the deck.

Refer to the Urban Design and Landscape Report for sketches of these options.

3.2 Interaction with Stop-banks

The interaction of the pedestrian bridge with the stop-banks relates primarily to the geotechnical interaction of the pedestrian bridge with the stop-bank fill materials, and in particular the movement of the stop-bank under seismic loads due to liquefaction. This will occur with all bridge options outlined above.

The pedestrian bridge will be founded on piled abutments which are located within the cross section of the stop-banks. Any lateral movement of the stop-bank due to liquefaction will cause very high loads onto the abutment and piles which will lead to either very large diameter piles being required or the abutment suffering damage. Any vertical settlement of the stop-bank will put additional load onto the piles which will cause settlement of the abutment. The stop-banks will start to move under a 1/200 level annual probability of exceedance (AEP) earthquake with movement expected towards the Hutt River.

The movement of the stop-bank due to liquefaction could also affect the bridge piers within the river channel due to the lateral spreading of the stop-bank towards the river channel. This could load at least the first pier on each side of the bridge and lead to damage to the pier and piles.

It is expected that ground improvement will be required below the abutments to mitigate this effect and to allow an economical design to be developed for the abutment and piers. A ground block which is 10m wide and 30m long with a depth of 10m below ground level is envisaged comprising of vibro-stone columns. This is assumed to be required for all bridge options and is included in the cost estimates.

3.3 Interaction with Pedestrian Footway System

The interaction of the pedestrian bridge with the pedestrian footway system which runs on top of the stop-banks and within the outer river flood channel as well as outside the stop-banks, relates primarily to the level of the bridge where it lands on the stop-bank at each abutment. All bridge options will require the soffit of the bridge to be level with the crest of the stop-bank to suit the hydraulic requirements of the river as stated in section 2.4.

Each structural options will have a different structural depth at the end of the bridge which relates to its ends spans which will dictate the level of the pedestrian footway at the bridge end. For options with the curved deck soffits, the level of the deck may also be determined by the structural depth at the first pier from the abutments where this could impinge on the profile for the water level described in section 2.4.

The level of the deck surface at each stop-bank and its height above the stop-bank will require approach ramps to be provided which will mean that the stop-bank has to increase in height above that required for flood control purposes. This increase in height will need to be graded on each side down to normal stop-bank level which will increase the visual impact of the stop-bank. Various abutment options will be investigated in the next phase.

The bridge options which are higher above the stop-bank level will therefore require a greater increase in the level of the stop-bank and will have a greater visual impact than lower options.

3.4 Interaction with Hutt River

The interaction of the pedestrian bridge with the Hutt River relates to its height above the river to provide the required vertical clearance to the flood level and the impact of the piers that are located with the river channel between stop-banks on the river hydraulics.

All the options considered are assumed to be constructed above the clearance profile stated in section 2.4 as being below this level would not be acceptable to GWRC as it would reduce the river flood capacity, which is against a core objective for this project.

From discussions with the hydraulics designers, all the options considered are deemed to be acceptable in relation to the number of piers provided with the river between stop-banks. Options that provided unacceptable levels of obstruction to the river channel were discounted at an earlier stage.

3.5 Option Selection

The design team selected a preferred option to take forward to concept design using a simple un-weighted multi-disciplinary assessment (MCA) process. The criteria adopted in the MCA were:

- Pedestrian bridge experience for users – views of the river and linear park
- Flood capacity – impact on the waterway capacity
- Accessibility/levels – at each of the bridge, height above stop-bank and ramps required
- Cost - based on relative order of cost for each option
- Formal appropriateness – suitability for the location.

The detailed assessment matrix and the reasons for the option selection is provided in the Urban Design and Landscape Report.

Option 3, a four span bridge, was selected as the preferred option due to its open experience for bridge users, its thin structural depth which reduces its impact on the flood levels, its relatively thin deck and the extend of ramps required, its low cost compared to other options and its appropriateness for its location and required function.

3.6 Description of Preferred Option

The structural layout and details of the proposed bridge is shown in Appendix A. The architectural aspects of this option are presented in the Landscape and Urban Design Report.

The bridge is assumed to be constructed of either concrete or steel for the superstructure with concrete piers and abutments.

The four span bridge is assumed to be a simple rectilinear beam of constant depth with straight vertical piers. The deck has a clear width between handrails of 4m and an overall width including handrails of 5m. An option to reduce the clear width from 4m to 3m was identified in the value engineering process and should be investigated in the next phase as this would reduce the bridge cost.

The spans are assumed to be 40+50+50+40m to give an overall length of 180m and the structural depth is assumed to be 1.75m. The bridge has a gentle vertically curved profile rising from each abutment to the centre of the river. The end spans are assumed to be shorter than the middle spans to give a structurally efficient design for a continuous structure, which is more efficient and shallower than a simple supported span structure.

The handrails are assumed to be simple metal railings to allow maximum visibility of the river and linear park, for bridge users.

The bridge piers are assumed to be supported on pile caps with four 900mm diameter bored concrete piles which are 20m long under each pier. The abutments have pile caps with two 900mm bored concrete piles, 20m long. Piles of this length will require special measures to allow their construction into the aquifer.

A ground improvement block is provided under each abutment which is 10m wide, 30m long and 10m deep from ground level. The ground improvement is envisaged to be vibro-stone columns which are 1m in diameter on a 3m triangular pattern.

4 Assumptions/Risks/Costs/Actions

4.1 Assumptions

The key design assumptions are:

- The pedestrian bridge is of importance level 2 with a design life of 100 years
- The preferred option is a four span bridge of constant structural depth
- The raising of the stop-banks at the pedestrian bridge to suit the level of the deck is acceptable visually and can be accommodated within the available corridor width
- No additional structure is required beyond the stop-banks to connect the pedestrian bridge to Margaret Street or Melling Station and that these connections are at-grade or provided for separately
- The piles for the stop-bank can be installed into the aquifer and resource consents obtained
- The ground improvement at each abutment can be constructed whilst protecting the river from flooding. The sequence of constructing the stop-banks and the ground improvement will need to be considered in detail.
- Lighting on the pedestrian bridge will be provided separately
- It is not practical to design the bridge to cater for fault movement where this occurs below the bridge and so it is excluded from the design criteria
- Light maintenance vehicles that may need to use the bridge can be accommodated within the assumed pedestrian loading and no special edge barriers are required for vehicle impact.

4.2 Risks and Opportunities

The key risks are:

- It is not feasible to construct the piles into the aquifer, requiring more shorter piles to be provided
- The ground improvement cannot be constructed within the stop-bank without excessive temporary works
- A more complex and expensive bridge option is selected at the next phase of the project leading to increase in project cost
- Approach structures are required to connect the pedestrian bridge to the footway network on each end
- Additional loading is required for the maintenance vehicle leading to additional cost
- Pile sizes and depths increase based on detailed geotechnical investigations and analysis
- Ground improvement dimensions increase based on detailed geotechnical investigations and analysis
- A more expensive form of ground improvement is required based on detailed geotechnical investigations and analysis.

The key opportunities are:

- Refine the structural depth and foundations required based on more detailed analysis
- Reduce the width of the pedestrian bridge to 3m between handrails
- Consider a bridge with more but shorter spans to reduce the structural depth, foundations and costs
- Reduce or eliminate ground improvement at abutments based on detailed geotechnical investigations and analysis
- Reduce pile sizes and depths based on detailed geotechnical investigations and analysis.

4.3 Cost Estimate

The preliminary cost estimate for Option 3 taken from the Preliminary Cost Estimate Report dated 8 June 2017 is $9.36M. This excludes Main Contractor's P&G, overhead and profit and estimating contingency. It is based on a rate per square m of $13,000. Refer to report reference T-17/17 for a breakdown of the cost.

4.4 Actions

Key actions identified are:

- Carry out geotechnical investigations to confirm the assumed ground conditions and improve the certainty levels for the cost estimate
- Confirm that the above assumptions are valid
- Undertake further work to confirm that the form and layout for the pedestrian bridge meets the requirements of the stakeholders for the various elements of the project
- Investigate the key opportunities identified above.

Appendix A

Pedestrian Bridge Sketches

Appendix B

Assumed Geological Section