Chapter 3
Alternatives Considered

ROUGHAN & O'DONOVAN

Comhairle Cathrach
& Contae Phort Láirge
Waterford City
& County Council

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3.1 Introduction

Directive 2011/92/EU (as amended by Directive 2014/52/EU), Article 5(d) provides that the information to be provided by the developer shall include "*a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment*".

This chapter outlines the alternative options considered for crossing the River Suir. Roughan & O'Donovan carried out a multi-criteria analysis (MCA) for 5 no. bridge options, taking into consideration many aspects including environmental impact. The bridge options were also assessed for their durability and future maintenance needs, buildability, construction and whole life costs and disruption/impact during construction as outlined in this chapter. Alternative bridge locations have not been assessed in this EIAR as this proposed bridge location is identified in the Waterford County Development Plan 2013-2019, the Planning Scheme for the North Quays Strategic Development Zone (SDZ) and the Waterford Planning, Landuse and Transport Strategy (PLUTS) 2004.

3.2 Project Brief Requirements

The proposed sustainable transport bridge is required to stimulate the coherent development of the city's various quarters, in particular integrating the substantial housing areas in Ferrybank and the proposed North Quays redevelopment with the city centre on the South Quays. The bridge is to be located in line with Barronstrand Street/ the Clock Tower to provide a continuous link connecting the city centre retail spine to the North Quay and beyond.

Five bridge options were developed in accordance with the following requirements:

- The bridge shall act as a public amenity affording greater appreciation and enjoyment of the river;
- The bridge elevation is to have a modest profile;
- The bridge solution shall be simple, elegant and sympathetic to its historic location and topographical setting as well as enhancing the long views from the length of both quays;
- High quality detailing;
- Safety – both real and perceived;
- Pedestrian and cycling use, access for all;
- A span of approximately 215m and a width of 3.5m to 4m;
- A design that reduces the perceived length of the bridge;
- Predicted flood levels and its effects on the bridge landing areas on the North and South Quays;
- Fully integrated design with the existing parking at the South Quays plaza and 19th century Clock Tower which is an important civic structure;
- Fully integrated design with the future North Quay development plaza at the bridge north side landing area;

- The relocated railway station entrance being in close proximity to the bridge landing area on the North Quays;
- Fully integrated design for disabled access;
- Integrated public lighting;
- The provision of a 25m clear span bridge opening section to permit river traffic with appropriate control location and structure for its operation;
- Public lighting providing safety and security in combination with sensitive architectural lighting which works with the sensitive marine landscape in which the bridge is sited;
- Appropriate pedestrian wind protection that provides a sense of safety and ensures the usability of the bridge in typical weather conditions; and
- Traffic access protection bollards at both bridge ends.

3.3 Design Parameters and Constraints

The Environmental Constraints Report for the Waterford North Quays Redevelopment project comprised a data collection exercise which focussed on determining the physical, environmental and engineering constraints which exist and which could affect the design and progress of the proposed development within the proposed study area

The Constraints Study was carried out at an early stage of the project with the objective of gathering as much background information relating to the study area as possible. The main design parameters and constraints arising from the constraints study in 2016 are listed below:

(i) Planning and Landuse

Policies were reviewed and objectives that support the development of a pedestrian bridge over the River Suir, green routes and cycling infrastructure were identified within the study area. These transport objectives were considered as part of design options for this project.

(ii) Biodiversity

The principal ecological constraint identified was the requirement to protect and enhance the conservation objectives of the Lower River Suir Special Area of Conservation (SAC) (site code 002137). The Lower River Suir SAC supports a range of Annex II species and Annex I habitats. Habitat and species surveys were required to confirm the presence of habitats and species on site. Hydrodynamic modelling was required, and a Natura Impact Statement was determined necessary for the proposed development. Consultations with NPWS and IFI were required as part of this process.

(iii) Hydrology

The protection of river water quality of the Lower River Suir SAC was an important consideration of the project design. Compliance with the requirements of the Water Framework Directive and the protection of fish populations were key considerations of the design process. Flood risks due to the construction and operation of the proposed development were important considerations. Hydrodynamic modelling was carried out for the project. A Flood Risk Assessment was carried out for the North Quays SDZ and incorporated the proposed sustainable transport bridge.

(iv) Soils and Geology

Geotechnical investigations have been carried out to inform potential contaminated land issues and ground conditions / depth to rock. The Port of

Waterford was consulted during the options assessment to establish if any maintenance/ dredging requirements should be considered which may impact on design options or construction operations.

(v) Archaeological and Architectural Heritage

The free standing crane on the South Quay is identified as a building/structure of Architectural Heritage and is included as part of the NIAH. The free standing crane is a protected structure.

The South Quays contain numerous protected structures and is designated as an Architectural Conservation Area (ACA). The study area is included as part of a Zone of Archaeological Potential which extends into parts of the Lower River Suir SAC. Consultation with the National Monuments Service (NMS) and an underwater archaeology assessment are necessary.

(vi) Landscape and Visual

There are a number of protected views to and from the study area included in the Waterford City Development Plan 2013-2019 and Ferrybank- Bellview Local Area Plan 2009.

The choice of the bridge width for pedestrians, cyclists and the electric vehicle is a key consideration in the design, both in terms of mobility and economics. While a bridge functional deck width of 3.5m to 4m was a requirement of the Project Brief as detailed in Section 3.2, this functional width was increased to 6.0m in order to meet relevant cross-section dimensional standards and accordingly meet the strategic objectives of the project. For the proposed bridge, taking into account the strategic location of the bridge in the city centre, it is recommended that a proposed functional width of the footpath shall be a minimum of 3m. This requirement was derived from the Transport Infrastructure Ireland (TII) Publication DN-STR-03005 Design Criteria for Footbridges. In addition, the proposed width of the cycleway has been based on the document, Provision of Cycle Facilities – National Cycling Manual published by the National Transport Authority (NTA) in 2011. Cycle lane widths shall be a minimum of 1.25m according to this design manual. Therefore, adopting a minimum two-lane cycleway with each lane of width 1.25m results in a proposed cycleway cross-section of 2.5m. The total functional width of the bridge is therefore proposed to be 6.0m comprising a footway with a width of 3.0m, a cycleway width of 2.5m, and a buffer zone of 0.5m.

3.4 Bridge Options Considered

The following five options have been assessed for the proposed bridge:

- Bridge Option 1 – Functional Opening Bridge
- Bridge Option 2 – Aesthetic Opening Bridge
- Bridge Option 3 – Functional Fixed Bridge
- Bridge Option 4 – Aesthetic Fixed Bridge
- Bridge Option 5 – Alternative Aesthetic Fixed Bridge

Bridge Option 1 – Functional Opening Bridge

The proposed bridge is 217m in length with a constant deck footway/cycleway width of 6m over its length. The deck alignment is straight on plan and follows a constant gradient of 1.2% (1 in 83 slope) rising from the South Quay landing area (+3.5m above Ordnance Datum Malin Head (mOD)) to the proposed North Quay plaza (+6.05mOD). 1.4m high metal parapets are provided along both edges to suit cycle requirements and will be fitted with wind shielding where required.

The bridge deck layout consists of 7 spans; a 38m long central span (opening) and four interior and two end fixed spans of 33m and 26m length respectively. The opening span is a single leaf bascule (fixed trunnion type) with approximately 30m of its length lifted about the pivot and the remaining length accommodating the lifting device/ machinery and counterweight. This arrangement provides the required 25m wide navigation clearance.

The visible depth and profile of the bridge deck parapet support and beams in elevation has been kept constant across all spans (approximately 1.7m) in order to provide uniform structural appearance of modest profile. The fixed spans are of standard beam and slab construction comprising 3 no. precast prestressed concrete U shaped beams, with an in situ concrete deck slab. The 1.4m deep beams, together with the in situ slab of approximately 250mm average thickness, provide a total structural depth of 1.65m and a total deck width of 7m (6m deck width between parapet rails). The opening bascule span is also of standard construction comprising a single steel box girder with the box top flange (orthotropic steel deck) providing the walkway/cycleway surface for the deck above. The steel deck for this span is required in order to minimise the weight for the bascule lifting apparatus.

The bridge substructure will be of in situ concrete construction. The typical piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.0m) and length of approximately 2.9m. The bascule pier is required to accommodate the opening span lifting devices and equipment, together with the counterweight resulting in substantially increased pier width (approximately 10m) and height dimensions. The bridge deck is detailed as integral (without mechanical bearings) as far as practicable across its length in order to minimise future maintenance needs. Mechanical bearings will be required however at both Quay abutment supports and the northern connection to the bascule pier.

The bridge substructure will be supported on 750mm diameter steel cased bored concrete piles; the number of piles varying to suit the loading requirements. Based on the available ground investigation data at the constraints stage, piles will have an average length of 17 to 18m assuming a bedrock level of 17.7mOD. The proposed bridge layout and cross section of Bridge Option 1 are presented in Figures 3.1 and 3.2 of Volume 3 of this EIAR.

Bridge Option 2 – Aesthetic Opening Bridge

The proposal for this option is an architecturally designed bridge with structural and aesthetic features designed to enhance the user experience of the crossing as well as enhancing the long views from the length of both quays. The perceived length of the 6m wide x 217m long crossing has been reduced with the introduction of feature arches/viewing points at approximately the bridge third points in conjunction with a varying footway vertical profile which forms a smooth curve in elevation. The high point of the footway vertical curve (6.65mOD) is located at the northern arch feature, 70m from the North Quay landing (+6.05mOD). The bridge slopes from this point to tie in to the South Quay landing area level (+3.5mOD) at an average gradient of 2.2% (1 in 45 slope).

The bridge has an overall visible depth (including parapets) in elevation of approximately 1.9m. The parapets form part of load carrying structure resulting in this slender profile of the bridge deck which is constant over the bridge extents with the exception of the portions over the two central pier support locations where the feature arches have been introduced. The arches are located on one side of the deck only at each central pier resulting in an asymmetric bridge in both elevation and cross section at these locations. At the northern bridge end the arch develops on the west side, and at the southern end on the east side of the bridge. These architectural feature arches are provided with a pedestrian parapet with glass panel infill serving to provide unobstructed viewing points of the river and the glass panel providing wind shielding during adverse weather conditions.

The 7 span bridge deck has been laid out symmetrically and comprises a 70m long central span (14m wide opening section), interior spans of 35m and 25m, and end spans of 12.245m length. The opening section of the central span is detailed as a hydraulically operated twin leaf bascule bridge with all hydraulics located within the depth of the bridge deck. A proposed navigational clearance of 25m has been agreed with the Waterford Port Authority and Waterford City and County Council (WCCC) following consultations.

The steel bridge deck has a half through configuration (U shaped) consisting of a varying depth closed box girder over the 6m wide footway (600-800mm deep) connecting two main box shaped girders (1.9m deep) protruding above the deck on either edge. The two edge girders also form the bridge parapet and provide inherent wind protection to users due to their solid nature.

The bridge substructure will be of in situ concrete construction. The main span piers support the deck by means of inclined struts which are integrally connected to the steel deck and converge to a concrete squat pier at their base. The typical piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.2m) and length of approximately 2.9m. The bridge deck is detailed as integral (without mechanical bearings) as far as practicable across its length in order to minimise future maintenance needs. Mechanical bearings will be required however at both Quay abutment supports.

The bridge piers will be supported on large pile caps located below the low water mark. 750mm diameter vertical and inclined steel cased bored concrete piles are proposed with the number of piles varying at each substructure to suit the loading requirements. Based on the available ground investigation data at the constraints stage, piles will have an average length of 17 to 18m assuming a bedrock level of 17.7mOD. The proposed bridge layout and cross section of Bridge Option 2 are presented in Figures 3.3 and 3.4 of Volume 3 of this EIAR.

Bridge Option 3 – Functional Fixed Bridge

The proposed bridge is 217m in length with a constant deck footway/cycleway width of 6m over its length. The deck alignment is straight on plan and follows a constant gradient of 1.2% (1 in 83 slope) rising from the South Quay landing area (+3.5mOD) to the proposed North Quay plaza (+6.05mOD). 1.4m high metal parapets are provided along both edges to suit cycle requirements and will be fitted with wind shielding where required.

The bridge deck layout consists of 7 spans; five interior spans of 33m and two end spans of 26m. The visible depth and profile of the bridge deck parapet support and beams in elevation has been kept constant across all spans (approximately 1.7m) in order to provide uniform structural appearance of modest profile.

The bridge deck is of standard beam and slab construction comprising 3 no. precast prestressed concrete U shaped beams, with an in situ concrete deck slab. The 1.4m deep beams, together with the in situ slab of approximately 250mm average thickness, provide a total structural depth of 1.65m and a total deck width of 7m (6m deck width between parapet rails).

The bridge substructure will be of in situ concrete construction. The typical piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.2m) and length of approximately 2.9m. The bridge deck is detailed as integral (without mechanical bearings) as far as practicable across its length in order to minimise future maintenance needs. Mechanical bearings will be required however at both Quay abutment supports.

The bridge piers will be supported on pile caps located below the low water mark. 750mm diameter vertical and inclined steel cased bored concrete piles are proposed with the number of piles varying at each substructure to suit the loading requirements. Based on the available ground investigation data at the constraints stage, piles will have an average length of 17 to 18m assuming a bedrock level of 17.7mOD.

The proposed fixed bridge has a maximum vertical navigation clearance of 5.1m at daily low water over a 25m navigation channel, allowing the passage of small crafts. The proposed bridge layout and cross section of Bridge Option 3 are presented in Figures 3.5 and 3.6 of Volume 3 of this EIAR.

Bridge Option 4 – Aesthetic Fixed Bridge

This option is as per Option 2 except the central span is fixed (i.e. not opening to allow the passage of larger vessels). The proposed fixed bridge has a maximum vertical navigation clearance of 7.8m at daily low water over a 25m navigation channel, allowing the passage of small vessels. The proposed bridge layout and cross section of Bridge Option 4 are presented in Figures 3.7 and 3.8 of Volume 3 of this EIAR.

Bridge Option 5 – Alternative Aesthetic Fixed Bridge

Bridge Option 5 is an alternative simplified aesthetic fixed bridge with a more conventional deck and pier supports in comparison to Option 4.

The deck alignment is straight on plan and follows a constant gradient of 1.2% (1 in 83 slope) rising from the South Quay landing area (+3.5mOD) to the proposed North Quay plaza (+6.05mOD). The perceived length of the 6m wide x 217m long crossing has been reduced with the introduction of a feature flat arch located centrally in the deck at the bridge central span location. Bespoke 1.4m high metal parapets are provided along both edges to suit cycle requirements and will be fitted with wind shielding where required.

The 5 span steel bridge deck has been laid out symmetrically and comprises of a 80m long central span, two interior spans and two end spans of 40m and 28.5m lengths respectively. The 7m deck structural width is made up of a 2.5m wide main trapezoidal shaped box girder with varying depth transverse cantilevers extended 2.25m either side to the deck edges. The main box girder has a constant depth of 2m over the end spans and a variable depth over the central and interior spans with a maximum depth of 3.6m at the central supports and 2m at midpoint of the central span respectively.

The bridge substructure will be of in situ concrete construction. The piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.2m) and length of approximately 2.9m. The bridge deck is detailed as integral (without mechanical bearings) as far as practicable across its length in order to minimise future maintenance needs. Mechanical bearings will be required however at both Quay abutment supports.

The bridge piers will be supported on large pile caps located below the low water mark. 750mm diameter vertical and inclined steel cased bored concrete piles are proposed with the number of piles varying at each substructure to suit the loading requirements. Based on the available ground investigation data at the constraints stage, piles will have an average length of 17 to 18m assuming a bedrock level of 17.7mOD. The proposed bridge layout and cross section of Bridge Option 5 are presented in Figures 3.9 and 3.10 of Volume 3 of this EIAR.

3.5 Multi-criteria Analysis Applied

Each of the five bridge options proposed are rated based on the following criteria, upon which the preferred bridge option is selected. A detailed description of the criteria is provided in the following sections of the report.

- Aesthetic Merit and Appropriateness;
- Environmental Impact;
- Durability and Future Maintenance Needs;
- Buildability;
- Construction and Whole Life Costs;
- Hydrology and Hydraulics;
- Navigation Considerations;
- Integration with Flood Defence Scheme;
- Disruption/Impact during Construction; and
- Safety.

3.5.1 Aesthetic Merit and Appropriateness

The River Suir Sustainable Transport Bridge is an integral part of the Waterford North Quays Redevelopment Project. An understanding and appreciation of the proposed bridge location, connectivity requirements and tie-in points at both quays is critical in determining a suitable form for the bridge in this urban environment. The bridge must be fully integrated with the North and South Quays forming a continuous link from Barronstrand Street at the 19th Century Gothic Clock Tower, to the central zone of the future North Quays development at a proposed plaza adjacent to the relocated train station.

With due regard to the importance of the bridge's aesthetic merit and appropriateness, Roughan & O'Donovan Consulting Engineers and Knight Architects developed suitable bridge option designs for the aesthetic bridge options 2 and 4 and aesthetic aspects of functional bridge options 1, 3 and 5. The aspiration is to deliver a bridge that acts as a high quality public realm and the appearance of which is simple, elegant and sympathetic to its historical location and topographical setting.

The following subsections describe how aesthetics were taken into consideration for the various bridge options.

Bridge Options 1 (Functional Opening Bridge) and 3 (Functional Fixed Bridge)

Deck aesthetics for this bridge option have been optimized as far as practical using standard cost effective bridge components. The deck beams have been set back from the deck edge to provide a shadow in order to reduce the perceived structure depth and in conjunction with the inclined sides of the U shaped beam construction and a constant deck depth throughout provides an agreeable appearance to the functional bridge deck suitable for the surrounding built environment.

The number of piers have been minimised as far as practicable and are spaced with reducing spans towards the banks to improve the elevation aesthetics. In conjunction with a slender pier profile (with the exception of the opening span bridge support) and patterned recessed concrete finish used to break up the perceived width, the bridge substructure provides a suitable response to the river environment. For option 1, the profile of the opening span bridge support has been reduced as far as practicable and shaped to form a family of pier supports with the other intermediate piers, limiting the aesthetic and river environment impact.

High quality detailing has been employed on the deck environment with bespoke parapets which are open in appearance facilitating views of the river and the city. In addition, discrete glass wind shielding integral with the parapet will be provided in response to the prevailing wind. An integrated parapet handrail and deck Light-Emitting Diode (LED) lighting system will be employed to provide an exciting night time illumination scheme.

An adequate bridge width (6m) has been provided for the envisaged pedestrian and cyclist traffic. The provision of occasional rest stop seating within this width is feasible which in turn will break up the visible length of the crossing. Alternatively, widening of the bridge to accommodate these seating areas is also an option should a constant footway width need to be a maintained. A constant 1.2% fall is provided from the north to the south bank. This has been selected as the best solution for the bridge in terms of creating a balance between both quays while, at the same time, providing a solution to the significant level difference of approximately 2.5m between riverbanks. Alternatives are also feasible with a high point adjacent to the end of the opening span approximately 90m from the north bank providing a 1% fall to the north and approximately 3% to south. The bridge lands at close to the South Quay existing level, minimising the required length of approach structure and therefore will not detract from the adjacent Clock Tower and historic buildings.

This option provides a simple cost effective design solution suitable for the city environment and future development of the North Quays.

Bridge Options 2 (Aesthetic Opening Bridge) and 4 (Aesthetic Fixed Bridge)

Careful consideration has been given to the architectural design of these bridge options and it has been designed to enhance the user experience of the crossing as well as enhancing the long views from the length of both quays.

The perceived length of the 6m wide x 217m long crossing has been reduced with the introduction of feature arches/viewing points at approximately the bridge 1/3 points in conjunction with a varying footway vertical profile which forms a smooth curve in elevation.

The inclined struts of the main span piers which connect in line to the architectural arches above the deck, are the main aesthetic features of these bridge options. Of additional interest is the asymmetric nature of the bridge in both elevation and cross section due to the arches being on either the east or the west side at the central span locations only. These architectural feature arches are provided with a pedestrian parapet with glass panel infill serving to provide unobstructed viewing points of the river and shielding areas for the users during adverse weather conditions. The span lengths increase from the ends to the central span, providing a structured and symmetrical layout. This, in conjunction with a shallow structural depth made possible due to the U shaped configuration of deck, results in a bridge design which is aesthetically pleasing.

The typical piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.2m) and length of approximately 2.9m and provide minimal intrusion into the river environment.

The hidden lifting span mechanics for the opening version of the bridge embedded within the depth of the bridge deck, provide a discrete and interesting solution to the required navigational channel.

High quality detailing has been employed on the deck environment with integrated handrail LED deck lighting system and feature lighting of the arch features. Adequate bridge width is provided for the provision of seating at the arch locations. Alternatively widening of the bridge to accommodate these seating areas is feasible at the arch locations should a constant footway width need to be maintained. A 1% fall is provided to the north of the north main pier and a 1.77% fall is provided to the south of the north main pier. This has been selected as the best solution for the bridge in terms of creating a balance between both quays while, at the same time, providing a solution to the significant level difference at each bank. The bridge lands at close to the South Quay existing level minimising the required length of approach structure and therefore will not detract from the adjacent Clock Tower and historic buildings.

Bridge Option 5 – Alternative Aesthetic Fixed Bridge

A more conventional variable depth beam bridge structure with enhanced aesthetics has been selected for this bridge option. The perceived length of the 6m wide x 217m long crossing has been reduced with the introduction of feature flat arch centrally in the deck at the bridge central span location. This flat arch is adaptable to providing seating for views along the river from this central vantage point.

The span lengths increase from the ends to the central span, providing a structured and symmetrical layout which is pleasing to the eye. The main deck box section has been set back from the deck edge to provide a shadow in order to reduce the perceived structure depth and in conjunction with the box girder inclined sides and curved varying depth profile in elevation provides an agreeable appearance. The piers and abutment supports will have a slender simple wall form (pattern printed) of constant width (approximately 1.2m) and length of approximately 2.9m.

High quality detailing has been employed on the deck environment with a bespoke parapet and integrated handrail LED deck lighting system and adequate bridge width provided for the provision for occasional rest stops. Local widening of the bridge to accommodate these seating areas is also an option should a constant footway width need to be maintained. A 1% fall is provided to the north of the north main pier and a 1.77% fall is provided to the south of the north main pier. This has been selected as the best solution for the bridge in terms of creating a balance between both quays while, at the same time, providing a solution to the significant level difference at each bank.

This option provides a simple aesthetically enhanced cost effective design solution for the town environment and future development.

3.5.2 Environmental Impact

General

The construction of all bridge options will require appropriate environmental controls to be implemented in order to avoid and/or mitigate any adverse effects on the environment. A suite of mitigation measures will be defined to ensure the protection of all environmental aspects during construction and operation of the proposed development, including biodiversity, population and human health, hydrology, hydrogeology, landscape and visual, archaeology and cultural heritage, architectural heritage, air quality and climate, noise and vibration and material assets. The TII Environmental Assessment and Construction Guidelines will be followed to avoid where possible, and minimise, impacts and specific mitigation measures will be adhered to during the development of the proposal in order to reduce the impacts on all environmental receptors and particularly receptors associated with the Lower River Suir SAC (and any other potentially affected European Sites) including underwater ecology.

The overall purpose of the options stage assessment was to evaluate the potential environmental impacts associated with the bridge and to determine the varying degrees at which each of the proposed bridge options would affect the key environmental aspects.

Population and Human Health

In terms of the proposed bridge itself, it was considered that all bridge options can be considered equally beneficial as during operation they will have many positive impacts for the local community in terms of the improved pedestrian and cycle connectivity from the North Quays and Ferrybank/Bellfield areas to the City Centre and will provide opportunities for economic development of the unused Brownfield sites close to the city. The fixed bridge options would have potential adverse effects on the economy through the closure to the river upstream to navigation.

There may be some temporary adverse effects during construction; however with the application of appropriate mitigation strategies these should be minimised to an acceptable level for all bridge options. The human health and population impact of the proposed bridge on existing businesses within the city and those located along the South Quays, adjacent to the proposed development, do not vary between bridge options given that the bridge landing points are the same for all options considered.

Biodiversity

The majority of the potential adverse effects resulting from the bridge construction and associated temporary works of all bridge options will be short term and will be reversible over time. However, some aspects of the construction have the potential to have a lasting effect on biodiversity such as the permanent bridge piers which are located within the Lower River Suir SAC, the bridge deck aspect and the lighting scheme.

<u>Lower River Suir SAC</u>

The Lower River Suir SAC (Site Code 002137) is a designated site within the immediate study area. The comparison of impacts on the Qualifying Interests of the SAC due to the alternative bridge options is based on the proposed footprints of the bridge options within the SAC and the level of disturbance likely to be caused to the Qualifying Interests. Bridge options 1 to 4 each have 8 no. permanent piers in the SAC, thereby having the greatest impact on habitats and species in the SAC. In comparison, Option 5 has 6 no. permanent piers in the SAC. Therefore, it is expected that Option 5 would have the smallest footprint in the SAC during the operation phase. It is expected that Option 1 would have the greatest footprint in the SAC due to the requirement for 8 piers in the SAC and the requirement for a wide pier (approximately 10m) to house the opening bridge span. Option 3 is found to have the most straightforward construction phase due to the reduced width of the proposed cofferdams and due to the use of prefabricated superstructure elements and therefore is expected to have the least impact on the SAC during construction. Regarding impacts on the Lower River Suir SAC, it is predicted that Option 5 has marginally less impact in terms of protecting the Qualifying Interests of the SAC, followed by Options 3, 2, 4 and 1 respectively. However, see Section 3.6 on the suitability of the fixed bridge options, and Section 3.7.5 on the reduction of bridge intermediate bridge piers in the developing design.

<u>Bats</u>

There is the potential for impacts to bat roosts due to disturbance during the construction and operation phase and due to the lighting design. All bridge options have an equal deck width and will have similar levels of lighting. Therefore, for the purposes of this option evaluation study, all options are considered to have comparably equal potential impact to bat roosts.

<u>Birds</u>

The estuary is very attractive to fowl including swans, herons, ducks, lapwings, seagulls and geese. There is a potential risk posed to the flight path of birds due to the construction and operation of the proposed bridge. Options 1, 3 and 5 are relatively low lying structures (max 10m above the low water mark) and should not pose any significant barrier to the movement of birds. Options 2 and 4 are slightly higher due to the integration of arch structures however this is marginal, as the top of arch extends only 3m above the bridge parapet line (maximum 12.5m above the low water mark).

<u>Wetlands and Watercourses</u>

At option selection stage, predicted impacts or changes due to hydrological changes could include impacts on the river bed and channel likely to occur during construction and the operational phases. These impacts/changes have the potential to negatively affect the flora, fauna and water quality in the immediate vicinity of the bridge as well as downstream.

Bridge options 1 to 4 have equal numbers of permanent piers in the river (8 number). Option 5 has a total of 6 number permanent piers. It is possible that option 5 would have the least impact on the watercourse during the operational phase followed by options 3 and options 2 and 4 respectively. Option 1 would have the greatest impact due to the requirement for a wide pier (approximately 10m) to house the opening bridge span.

During construction, all bridge options would involve the installation of sheet pile cofferdams at the permanent pier locations to allow their construction. Therefore, the largest impact on the river would be during the construction phase which is likely to span a 20 – 24 month period. The cofferdam construction required for the slender 1.2m piers of all options would generally be narrow structures and would have the least impact on the river. The cofferdam construction width required to construct the central piers for options 2, 4 and 5 and the pier for the opening span for option 1 would be large structures in the order of 12-14m wide and could potentially have a significant impact on the river. Therefore, option 3 was found to have the least potential for impact on the river during construction followed by options 1 and 5 and options 2 and 4 respectively.

In addition, secondary temporary piers would be required for construction of the deck for the aesthetic bridge options (options 2, 4 and 5), however the effect of these on the watercourse is considered negligible given these would be constructed without cofferdams and would consist of small diameter piles.

Soils and Geology

It is not anticipated that there will be any significant impacts on soils and geology associated with the construction or operation of the proposed bridge and negligible difference between the options.

Hydrogeology

It is not anticipated that there would be any significant impacts on hydrogeology associated with the construction or operation of the proposed bridge and negligible difference between the options.

Hydrology

The principal potential impacts to surface water are associated with changes to the watercourse and discharges to the receiving watercourse. The varying degrees of potential impact of the proposed bridge options on the river conveyance, water levels, bed and channel (i.e., changes to the watercourse) during the operational and construction stages is based on the number and size of piers in the river channel. Bridge options 1 to 4 have equal numbers of permanent piers in the river (8 number). Option 5 has a total of 6 number permanent piers. It is possible that option 5 would have the least impact on the watercourse during the operational phase followed by options 3 and options 2 and 4 respectively. Option 1 would have the greatest impact due to the requirement for a wide pier (approximately 10m) to house the opening bridge span.

During construction, all bridge options would involve the installation of sheet pile cofferdams at the permanent pier locations to allow their construction. Therefore, the largest impact on the river would be during the construction phase which is likely to span a 20 – 24 month period. The cofferdam construction required for the slender 1.2m piers of all options would generally be narrow structures and would have the least impact on the river. The cofferdam construction width required to construct the central piers for options 2, 4 and 5 and the pier for the opening span for option 1 would be large structures in the order of 12-14m wide and could potentially have a significant impact on the river. Therefore, option 3 was found to have the least potential for impact on the river during construction followed by options 1 and 5 and options 2 and 4 respectively.

In addition, secondary temporary piers would be required for construction of the deck for the aesthetic bridge options (options 2, 4 and 5), however the effect of these on the watercourse is considered negligible given these would be constructed without cofferdams and would consist of small diameter piles.

During the operation phase it is considered that there will be no impact on the existing water quality of the receiving environment resulting from discharges to the River Suir watercourse from the bridge structure. All options during construction would have a similar potential effect on the water quality. The control of this is addressed using the standard guidelines.

Air Quality and Climate

All bridge options would have similar impacts on air quality and climate during both construction and operational phases and there would be negligible difference between the options.

Noise and Vibration

It is considered that the operation of the proposed bridge would have no significant noise impacts. Potential was found for short term noise impacts at sensitive receptors during the construction phase. The sensitive receptors primarily identified were the Granville Hotel, the Cathedral of the Most Holy Trinity and shops in the vicinity of the site on the South Quays, as well as garage, dwellings and shops in the vicinity of the site at the North Quays. At the North Quays the nearest residential area is within 50m of the site; thus there would be a significant risk of site work causing noise and vibration to impact on these receptors.

All bridge options would have a similar extent of work (and therefore noise and vibration) required to complete the bridge abutments and bridge piers closest to the river banks. The bridge decks for all options would be prefabricated off site to a large extent. A larger number of vehicular traffic movements would be expected for bridge options 1 and 3 given the larger number of individual beams and in-situ deck operations.

Archaeological and Cultural Heritage

Waterford is Ireland's oldest city, founded by the Vikings, with the River Suir estuary developing into a busy port. Waterford City is home to rich archaeology and cultural heritage. All bridge options are largely similar in terms of footprint and potential for impact on unknown archaeology. Options 1-4 have 8 foundations whilst option 5 has 6 foundation locations. Therefore, Options 1-4 have a slightly greater footprint with increased potential for coming across buried or uncovered remains or artefacts.

Architectural Heritage

Waterford City is home to rich architectural heritage. The Quays are of particular significance to Waterford City, as they formed the hub of the City's prosperity and impetus for development. The South Quays are designated as two separate Architectural Conservation Areas (ACA); namely the "South Quays" ACA and the "Trinity Within" ACA. The proposed bridge is within the South Quays ACA. All options are considered to have similar impacts and therefore there is negligible difference between the options.

Landscape and Visual Impact

For the proposed bridge, the project brief calls for:
"*A simple, elegant solution that is sympathetic to its historic location and topographical setting as well as enhancing the long views from the length of both quays*".

<u>Bridge Options 1 (Functional Opening Bridge) and 3 (Functional Fixed Bridge)</u>

The fixed bridge options 1 and 3 are of simple form, so as not to distract from the current urban environment in which they will be located.

<u>Bridge Options 2 (Aesthetic Opening Bridge) and 4 (Aesthetic Fixed Bridge)</u>

In terms of visual impact, the aesthetic bridge options 2 and 4 provide a solution with two main aesthetic features: the inclined piers; and the architectural arches over the two main piers. Aside from these features, the bridges are of simple form. These bridges also incorporate two viewing bays along their spans – one west and one east, enhancing the user experience of the surrounding environment.

Bridge Option 5 (Alternative Aesthetic Fixed Bridge)

In terms of visual impact, the aesthetic bridge option 5 provides a solution with the main aesthetic feature being the tapered bridge deck which increases in depth over the two main piers. Aside from this, the bridge is of simple form.

Therefore, it is considered that the aesthetic options of Option 2, 4 and 5 are preferred to the functional options of Options 1 and 3.

Material Assets

As the proposed development is within Waterford City, no impacts on agronomy will occur as a result of any of the proposed bridge options. As noted in the paragraph above on Population and Human Health, the impact of the proposed bridge on existing businesses within the City and those located along the South Quays, adjacent to the proposed development are also equal given that the bridge landing points are the same for all options considered. All of the lands on both the North and South Quays are owned by WCCC, therefore the only affected lands are the riverbed which will be the subject of a separate foreshore lease and the marina (Pontoon C) at the location of the proposed bridge crossing. All options are considered to have a largely similar effect.

Environmental Conclusion

Generally, all options have similar impacts on the SAC. Option 5 has marginally better environmental characteristics and would be the preferred option, followed by Options 3, 2, 4 and 1 respectively. However, see Section 3.6 on the suitability of the fixed bridge options, and Section 3.7.5 on the reduction of bridge intermediate bridge piers in the developing design.

There are no differing impacts predicted between the options on many of the environmental topics including population and human health, bats, soils, geology, hydrogeology, hydrology, air quality and climate and architectural heritage and material assets.

3.5.3 Durability and Future Maintenance Needs

Access during future maintenance and inspections can constitute a large percentage of the total cost of these operations. For this reason adequate access provisions have been considered for the bridge options during their initial development. This has been ensured through the provision of adequate deck width and load carrying capacity to accommodate suitable mobile access or under-slung platforms to allow work to be carried out safely and cost effectively without the requirement for bespoke scaffolding or other means of access.

All of the options considered and presented in this report will be designed to be durable in order to achieve the required 120 year design life. The major bridge components will however need maintenance/ replacement during this period.

The specification of suitable materials and detailing will enhance durability and reduce the maintenance liability. The following measures are proposed where relevant for each bridge option;

- Provide high strength concrete with a minimum of 50% ground granulated blast-furnace slag (GGBS) cement replacement which increases the durability in a marine environment.
- Exposed concrete may be surface impregnated with a hydrophobic pore liner where stainless steel reinforcement is not provided to reduce the potential for the ingress of water and corrosion of the reinforcing steel.
- Buried concrete surfaces will be waterproofed.
- The provision of stainless steel reinforcement in elements that are subject to the tidal river and splash zone and footway de-icing salts may be considered. Alternatively, higher strength concretes and increased cover to concrete give excellent durability characteristics.
- Provision of a through deck drainage system which will significantly reduce maintenance requirements.
- Bridge deck to be waterproofed with a spray applied system.
- A painting system will be applied to all exposed structural steelwork, which gives a minimum period to major maintenance of 25 years.
- The provision of integral connections between the bridge deck and substructure removing the need for bearings where practicable which are a maintenance issue and require replacement in order of every 20-30 years. Typically structures in excess of 60m are articulated with bearings however it is deemed feasible to make the bridge integral over the majority of the pier supports as described in detail below.
- The concrete pile supports could be steel cased and designed without the inclusion of the steel casing capacity. This steel casing will significantly reduce the length of time the concrete pile will be potentially exposed during the bridge design life therefore increasing the structure durability.

Bridge Options Maintenance Requirements

Substructure – The substructure for all bridge options consists of reinforced concrete. The reinforced concrete will be designed for durability with provision of stainless steel reinforcement or higher-grade strength concrete and enhanced cover in tidal and splash zones, and therefore should not incur any substantial maintenance requirements. Bridge option 1 has the greatest substructure concrete surface area to maintain followed by options 2 and 4, option 5 and option 3 respectively.

Bearings and Joints – All bridge options are provided with bearings and movement joints at their abutments. It is anticipated that 4 number bridge bearings (2 number at each abutment) will be required. Option 1 will have the additional maintenance liability of bearings at the two opening span pier support points. The bridge will be designed to accommodate their regular replacement. The provision of these components at the end supports will require the provision of abutment galleries in accordance with National Road Authority (NRA) BD57/01 to allow full inspection, maintenance and replacement. The remaining connections between the intermediate piers and deck will be made integral.

Superstructure – The concrete elements of Options 1 and 3 are expected to require minor concrete repairs every 15-20 years over the life span of the bridge. Major maintenance is not expected over the life of the bridge. The concrete bridge elements will have a reduced maintenance liability in comparison to the steel structure options. The steel elements of bridge options 1, 2, 4 and 5 are expected to require minor maintenance after 12 years with complete replacement of the paint finish after 25 years. The extent of maintenance repairs are likely to be more substantial and frequent for Option 5 given that sections of span are located within the river tidal range. Access will also be more difficult at these locations. It is envisaged that the interior of the steel deck box options will be protected against corrosion by utilising a dehumidification system which will be subject to a regular maintenance regime.

Parapets – Options 1, 3 and 5 will have parapets fabricated from aluminium or stainless steel construction, limiting maintenance to local repairs of the system over the life of the bridge. The parapets for Options 2 and 4 form part of the structure and will require painting in line with the remainder of the deck superstructure.

Lifting Span Mechanical and Electric Equipment (Option 1 and 2 only) – The equipment will require regular maintenance. The principle mechanism is expected to last for the life of the bridge with component replacement as required. Access for maintenance and repair for Option 1 will be more straightforward via access into the bascule pier as opposed to Option 2 which will require the use of mobile access or under-slung platforms.

3.5.4 Buildability

Construction of any structure requires careful consideration of the anticipated construction sequence to ensure that risks that may arise from the preferred design are either eliminated or, where this is not possible, they are mitigated to reasonably practicable levels and identified to the Project Supervisor for the Construction Stage so they can be effectively managed. This section provides an outline indicative construction sequence to inform the feasibility or otherwise for each of the options considered.

Based on the available ground conditions information at the constraints stage, it was assumed that pier and abutment structure would require piled foundations for all options. The assumption was that these would be in situ reinforced concrete bored piles constructed using a steel liner. For all bridge options, sheet pile cofferdams are envisaged for the construction of all piers. The installation of the cased bored piles will be carried out within the confines of the cofferdam. Temporary deck supports will be required for Bridge Options 2, 4 and 5 to facilitate the construction of the larger central span sections.

The functional bridge options (Bridge Options 1 and 3) require temporary deck supports at each integral pier until the in-situ concrete diaphragms are cast. These will utilize the pier pilecaps located within the cofferdam structures. At the south bank, it is required to perform some excavation works for the construction of a bankseat or piled abutment structure. This also requires the demolition of part of the existing quay wall to accommodate the foundations. At the north bank, the foundations will be constructed as an abutment wall resting on a pile cap above bed level, and will tie in to the existing quay structure. The future North Quays development plaza will tie in with the north bridge landing.

Earthworks import and removal volumes relating to all bridge options will be small in scale and limited to the South Quays works.

The assumed construction sequence was outlined for each bridge option, outlining the works proposed for the South Quays, North Quays, in river works (to include permanent piers and deck construction) and bridge finishes works.

Whilst all options are buildable using standard forms of construction, Options 1 and 3 have a greater ease of construction due to more straightforward site connections and more manageable prefabricated superstructure elements in comparison to Options 2, 4 and 5.

3.5.5 Construction and Whole Life Costs

The estimates of construction cost are based on measurement of quantities of the developing bridge design options determined following initial review and analysis of the structural forms.

The cost estimating is on a unit-price type estimate; whereby the unit price values were derived from a combination of historical price information from other similar river crossing projects and project specific price information from potential suppliers. The unit prices (for items such as cubic meter cost of concrete, steel, etc.) reflect the manner in which construction projects such as this are bid. These costs, therefore, reflect a summary of a large number of items related to that particular element of construction. Some judgment was applied in the use and adjustment of historical unit costs to account for differences between past projects and the specific conditions for the proposed River Suir Sustainable Transport Bridge.

A comparative summary of the initial construction costs for the various bridge options are shown in Table 3.1 and Table 3.2. It is also necessary to consider operational and maintenance costs to determine the life-cycle costs involved for the proposed River Suir Sustainable Transport Bridge. Life cycle cost represents the future anticipated expenditures to maintain the bridge over its service life of 120 years. The future expenditure includes such items as routine inspection costs, replacement of bridge elements that wear out and need to be replaced, such as the bearings, joints, etc. Other items that have a service life less than the bridge and will need to be replaced are also included. An additional allowance is included for general maintenance and repairs over time are also included. The life cycle cost in this evaluation follows best international practice.

The Whole Life Costs Comparison, initial capital investment; i.e., construction costs and life cycle costs, for the bridge options are illustrated in Table 3.1 and Table 3.2 below.

Bridge Options 1 (Functional Opening Bridge) and 3 (Functional Fixed Bridge)

These options have the lowest initial capital costs, due to their simplicity of construction and modest functional structural form. Bridge Option 3 is the most economic solution due to the fact that it is a fixed bridge with no opening span, negating the need for expensive lifting mechanisms. The cost related to any third party agreements required to close the channel to navigation have not been included in this cost estimate. Bridge Option 1 is next in line in terms of construction cost however, as can be seen from Table 3.1, it is in the region of 64% more expensive than Option 3 due to the provision of an opening span and associate large bascule pier required to house the lifting mechanisms. The 93% difference in whole life costs estimates between options 3 and 1 relate mainly to the operation and servicing of the opening span.

Bridge Options 2 (Aesthetic Opening Bridge), 4 (Aesthetic Fixed Bridge) and 5 (Alternative Aesthetic Fixed Bridge)

These options have higher initial capital costs due to their complexity of construction and importance given to aesthetic design. Additional construction costs relating to Option 2 are due to the opening functionality of the bridge. Whole life costs for Options

4 and 5 are comparable with an increase noted for Option 2 relating mainly to the operation and servicing of the opening span.

Table 3.1 Construction Cost and Whole Life Cost Comparison

Item	Cost Comparison				
	Option 1	Option 2	Option 3	Option 4	Option 5
Total Construction Cost	+64%	+133%	Most Economical	+90%	+81%
Whole Life Cost	+93%	+128%	Most Economical	+53%	+41%
Construction + Whole Life Cost	+66%	+132%	Most Economical	+88%	+79%

Table 3.2 Construction Cost and Whole Life Cost Ranking (Ranking: 1 most economical – 5 least economical)

Item	Cost Ranking				
	Option 1	Option 2	Option 3	Option 4	Option 5
Total Construction Cost	2	5	1	4	3
Whole Life Cost	4	5	1	3	2
Construction + Whole Life Cost	2	5	1	4	3

3.5.6 Hydrology, Hydraulic and Navigation Considerations

The bridge must be capable of passing a fluvial flood flow with a 1% annual exceedance probability (AEP) or 1 in 100 year flow. In addition to the above fluvial flood flow standard, as the bridge is within a tidal zone, it must cater for a tide level with a 0.5 % AEP or 1 in 200 year flow without significantly changing the hydraulic characteristics of the watercourse. In addition, it must be demonstrated that the new structure does not increase the risk or magnitude of flooding upstream or downstream of the proposed structure.

The design flood level (200 year tide and 100 year fluvial flood) for the River Suir at Waterford North Quays is 3.47mOD as outline in the report "Waterford North Quays Strategic Flood Risk Assessment (SFRA), October 2017".

The various bridge options considered affect the hydraulic and navigational functionality of the river to varying degrees and are outlined in the following subsections.

Navigational Functionality

Bridge Option 1 performs best in terms of navigational considerations, providing the greatest opening span clearance of 26m, with no vertical clearance restrictions, allowing for the passage of large crafts.

Bridge Option 2 performs well in terms of navigational considerations, providing an opening span clearance of 14m, with no vertical clearance restrictions. Options 3, 4 and 5 are fixed bridges with no opening span, and therefore have limited navigational clearances. The passing of small crafts will only be feasible with vertical clearances to the underside of the deck at low tide of 5.1m, 7.8m and 5.2m for Options 3, 4 and 5 respectively.

Impact on River Hydrology and Hydraulics

In terms of hydrology and hydraulics, Option 1 will have the worst performance due to the 6 number intermediate piers, an abutment structure and a large bascule pier within the river channel. Although the bridge substructure provides an obstruction to flow, the overall reduction of river cross section is only in the region of 8%. Therefore, it is not anticipated to have any marked impact on conveyance or estuary levels upstream or downstream of the bridge.

Bridge Option 5, although having few supports, has an approximately similar impact due to the tapered nature of the bridge deck structure. Bridge Options 2 and 4, with 8 pier/abutment structures of a smaller scale, have a slightly lesser impact than Options 1 and 5 with an overall reduction of river cross section in the region of 5%.

Bridge Option 3 performs the best due to the use of narrow piers at all internal supports.

3.5.7 Integration with Quays and Flood Defence Scheme

South Quays

All bridge options will integrate with the South Quay landing area (current Clock Tower carpark) and flood wall system in a similar fashion. Traffic access protection bollards shall be provided at the access point to the bridge at the South Quays tie-in.

To allow for the bridge abutment and approach ramp construction, sections of the quay wall and its glass flood barrier system will need to be altered. Depending on the plan extents of the bridge approach structure, it is expected that the extents of quay wall affected will be in region from 10 to 40m. The line of the bridge affects the existing jetty structure just north of the quay wall. Remedial works to the jetty and its access points or full demolition of the jetty will be required. In addition there are several small buildings adjacent to the Clock Tower which may require demolition to accommodate the bridge approach structure. The structure will consist of a system of ramps (maximum of a 1 in 20 slope) and stairs to accommodate the level difference of approximately 1.3m between the bridge end and the existing carpark level. The reinstated quay and glass flood wall (top of wall approx 4mOD) will tie in with the bridge approach structure and bridge parapets to reinstate the flood wall system. The structure will integrate with future street upgrade proposals for Barronstrand Street, the bridge lighting scheme/ detailing will comply with all current WCCC streetscape standards and building regulation.

North Quays

The North Quays landing level of 6.05mOD is well above the 1 in 200 flood level and poses no issue to any flood defences along these Quays constructed as part of the future development. The north approach will form part of the future development and will need to be integrated with the bridge proposals and accommodate all future bridge maintenance and inspection requirements (i.e. bridge movement joints, bearings and abutment structure). Traffic access protection bollards shall be provided at the access point to the bridge at the North Quays tie-in.

3.5.8 Disruption/Impact during Construction

It is considered that an 18-24 month construction period would be required for the bridge construction, subject to the form of structure progressed to design. Construction activities on the South Quays will be arranged to limit disruptions to road traffic and pedestrian along the South Quay.

The vast majority of the construction traffic activity will be concentrated on the north side of the river with access likely limited to routes from the N25/N29 along the R448 or R711. Access to the south side site will likely be from across Rice Bridge and then along Meaghers/Merchant Quay (R680).

All options will have a similar level of impact to road traffic with similar levels of vehicle movements expected from each site on the north and south of the river.

Impact on river traffic during construction will be dependent on the type of bridge (fixed or opening) selected by WCCC. The provision of an appropriate navigational channel in the 220m wide estuary should not be an issue during construction.

3.5.9 Safety

During the development of the options, particular risks have been identified and, where possible, these have been eliminated. Residual risks that have not been eliminated are given below.

The following risks have been identified in the second Schedule of the Safety, Health and Welfare at Work (Construction) Regulations:

- work which puts persons at work at risk of falling from a height;
- work which puts persons at work at risk of burial under earthfalls;
- work which puts persons at work at risk of engulfment in swampland;
- work which puts persons at work at risk from chemical or biological substances;
- work exposing persons at work to the risk of drowning; and
- work involving the assembly or dismantling of heavy prefabricated components.

Further residual risks resulting from the proposed options identified at this stage include the following:

All Options

- Transportation and lifting of significant prefabricated elements;
- Traffic Management;
- Unauthorised access to the site;
- Diversion of services;
- Noise and Vibration;
- Handling;
- Exposure to construction plant;
- Installation and testing of piles;
- Stability of structure in temporary condition during construction;
- Deck construction over the river in a tidal zone;
- Installation of parapets/pedestrian guardrails over the river;
- Demolition activity in relation to existing quays in vicinity of the proposed bridge;
- Risk of flooding during construction works;
- Risk of Weil's Disease and other mammal borne diseases;
- Activities involving exposure of workers to excessive noise;
- Risk of vessel impact under both temporary and permanent conditions;

- Offsite and onsite fabrication;
- Maintenance of concrete substructure in a tidal river;
- Extensive temporary works in river required or bridge construction;

Bridge Options 1 and 3 – Functional Opening and Fixed Bridges

- Application and maintenance of protective finishes to steelwork over water - (option 1 only);
- Construction of a large deep pier for bascule span (option 1 only);
- Maintenance/replacement of bridge bearings over water;
- Stability of large beams during erection;
- Construction of in-situ concrete deck over water;
- Temporary support of large deck sections until integral connections made.

Bridge Options 2 and 4 – Aesthetic Opening and Fixed Bridges

- Application and maintenance of protective finishes to steelwork over water - Exposure reduced adopting steel boxes;
- Temporary support of large deck sections until integral connections made with supports;
- Stability of asymmetric deck sections with arches during erection;
- Risk of accidents from people attempting to climb the arches – a suitable detail at the base of the arch would need to be developed;
- Construction large inclined pier elements;
- Temporary tie support of inclined piers until connection is made with deck.

Bridge Option 5 – Alternative Aesthetic Fixed Bridge

- Application and maintenance of protective finishes to steelwork over water - increased risk over other options due to steelwork within the tidal zone. Exposure reduced adopting steel boxes;
- Temporary support of large deck sections until integral connections made;
- Multiple deck butt weld points require due limited capacity to lift from jack up barges;
- Stability of large deck sections during erection.

3.6 Options Evaluation Summary

In order to determine the preferred bridge option, all the bridge designs were evaluated in relation to the various multi-criteria identified. The options have been evaluated using the simple scale of least preferred, intermediate and preferred. Where all options are equal this is noted. The evaluation of bridge options is summarised in Table 3.3 and Table 3.4. The colours are included in the table as a visual aid to clarify this selection process.

On examination, Table 3.3 reveals that Option 2 and Option 3, are the preferred options for the opening and fixed bridges respectively. However, following consultation with river users and a number of Consultees during the option evaluation process, it was agreed with WCCC, that navigation on the river could not be eliminated and therefore an opening bridge should be selected to allow unrestricted passage for vessels. As a result, Option 2 was therefore selected by WCCC in January 2017 as the preferred option to progress to the preliminary design stage.

In conclusion, the MCAMCA has identified Option 2 as the preferred bridge option for the River Suir Sustainable Transport Bridge as it is the preferred option on all grounds (with the exception of navigation) including most critically from an Environmental perspective.

Table 3.3 Summary Comparison of Bridge Options Considered (Stage 1 Assessment – All options)

Criteria	Bridge Options				
	Opening Bridges		Fixed Bridges		
	Option 1	Option 2	Option 3	Option 4	Option 5
Aesthetic Merit and Appropriateness	Least Preferred	Preferred	Intermediate	Preferred	Intermediate
Environmental Impact	Least Preferred	Intermediate	Intermediate	Intermediate	Preferred
Durability & Structure Future Maintenance	Least Preferred	Intermediate	Preferred	Preferred	Intermediate
Buildability	Intermediate	Intermediate	Preferred	Intermediate	Least Preferred
Whole Life Costs	Least Preferred	Least Preferred	Preferred	Intermediate	Intermediate
Hydrology and Hydraulics	Least Preferred	Intermediate	Preferred	Intermediate	Least Preferred
Navigation Considerations	Preferred	Intermediate	Least Preferred	Least Preferred	Least Preferred
Integration with Flood Defence Scheme	Equal	Equal	Equal	Equal	Equal
Disruption/Impact during Construction	Equal	Equal	Equal	Equal	Equal
Safety	Intermediate	Intermediate	Preferred	Intermediate	Least Preferred
Overall Rank	**Least Preferred**	**Intermediate**	**Preferred**	**Intermediate**	**Least Preferred**

See Table 3.4 overleaf for Stage 2 Assessment.

Table 3.4 Summary Comparison of Opening Bridge Options Considered (Stage 2 Assessment – Opening Bridge options)

Criteria	Bridge Options	
	Opening Bridges	
	Option 1	Option 2
Aesthetic Merit and Appropriateness	Least Preferred	Preferred
Environmental Impact	Least Preferred	Preferred
Durability & Structure Future Maintenance	Least Preferred	Preferred
Buildability	Equal	Equal
Whole Life Costs	Equal	Equal
Hydrology and Hydraulics	Least Preferred	Preferred
Navigation Considerations	Preferred	Least Preferred
Integration with Flood Defence Scheme	Equal	Equal
Disruption/Impact during Construction	Equal	Equal
Safety	Equal	Equal
Overall Rank	**Least Preferred**	**Preferred**

3.7 Design Development of Preferred Option 2 to Preliminary Design

3.7.1 Navigational Clearance

Design Option 2 provided an opening span with a navigational channel width of 14m. Further to consultations with river users and Consultees, and approved with WCCC, the developing design navigational channel provision was increased to be an opening clearance not less than that of the upstream Rice Bridge. A revised horizonal navigational clearance of 25m was therefore progressed to the Preliminary Design Stage.

3.7.2 Bridge Width and Functionality

Following consultation with the NTA and WCCC, it was recognised that the bridge crossing should be utilised to accommodate an electric bus route (see Section 3.8). In addition, instead of the shared-use bridge deck, it was determined to segregate a pedestrian corridor from cyclist and buses. This resulted in a pedestrian corridor of minimum 3.0m width with a 0.5m urban designed planter buffer zone. The combined cyclist and bus corridor shall have a minimum width of 4.5m. The developing design shall have a combined minimum total width of 8m.

Additionally, to enhance user comfort and user safety conditions, the bridge deck shall provide tapered bridge access, localised viewing platforms and sheltered seating arrangements. These localised widened deck features shall allow users to observe the surrounding sites along the north and south quays thereby enhancing the users experience of the bridge, as well as allow for greater user accessibility.

3.7.3 South Quay Plaza Urban Design

At the South Quay Plaza it was initially assumed, at the early options appraisal stage, that the bridge landing access would provide an integrated design with existing parking. However, this design concept has been replaced with the provision of landscape areas and urban design features at the South Quay Plaza. A plant room / building was also developed for the South Quays.

3.7.4 North Quay Tie-in Level

At the North Quay Plaza it was an initial design requirement, at the options stage, that the bridge tie-in level should be +6.05mOD. However, following consultation with the SDZ developer, to accommodate the future development of the North Quay Plaza a revised tie-in level of +8.00mOD was deemed required.

In order to accommodate the higher +8.00mOD North Quay tie-in level the vertical alignment of the bridge was required to be altered from that at the options stage. The options design vertical alignment had a crest curve. For the developing design, a longitudinal fall is introduced from the high level of +8.00mOD on the North Quay tie-in to +4.425mOD on the South Quay.

The above deck arch feature in relation to the revised longitudinal fall had a negative aesthetic implication on the developing design. As part of the design development the arch feature was replaced with below deck V-shaped deck to pier structures at preliminary design gridlines C and D. The removal of the arches eliminates visual clutter and provides a more streamlined bridge structure whilst also reducing potential environmental effects in relation to possible bird strikes.

3.7.5 Intermediate Pier Support Reduction

Design Option 2 provided 6 intermediate pier supports. In order to reduce impacts on the Lower River Suir SAC and following consultations with river users, and agreed with WCCC, it was deemed necessary to reduce the number of pier supports in the river channel. The developing design has been refined to 4 intermediate pier supports in the river channel. This was considered as an enhancement from an environmental perspective.

3.8 Bus Route Options Considered

Three alternative bus routes for the public transport vehicle were considered and assessed. These route options included:

- a route which crosses the proposed bridge, travels up Barronstrand Street and Broad Street, turns left onto Peter Street, turns right into Bakehouse Lane, turns right into Lady Lane, turns right onto Michael Street and reconnects to Broad Street/Barronstrand Street, as presented in Plate 3.1;
- a route which crosses the proposed bridge, travels up Barronstrand Street, Broad Street and Michael Street and turns at the junction of Michael Street and New Street, as presented in Plate 3.2;
- a route which travels over and back across the bridge only with the future ability to turn left onto Merchant's Quay from the bridge and to turn left onto the bridge from Merchant's Quay, as presented in Plate 3.3.

Plate 3.1 **Alternative Route Option incorporating Bakerhouse Lane**

Plate 3.2 **Alternative Route Option to junction with New Street**

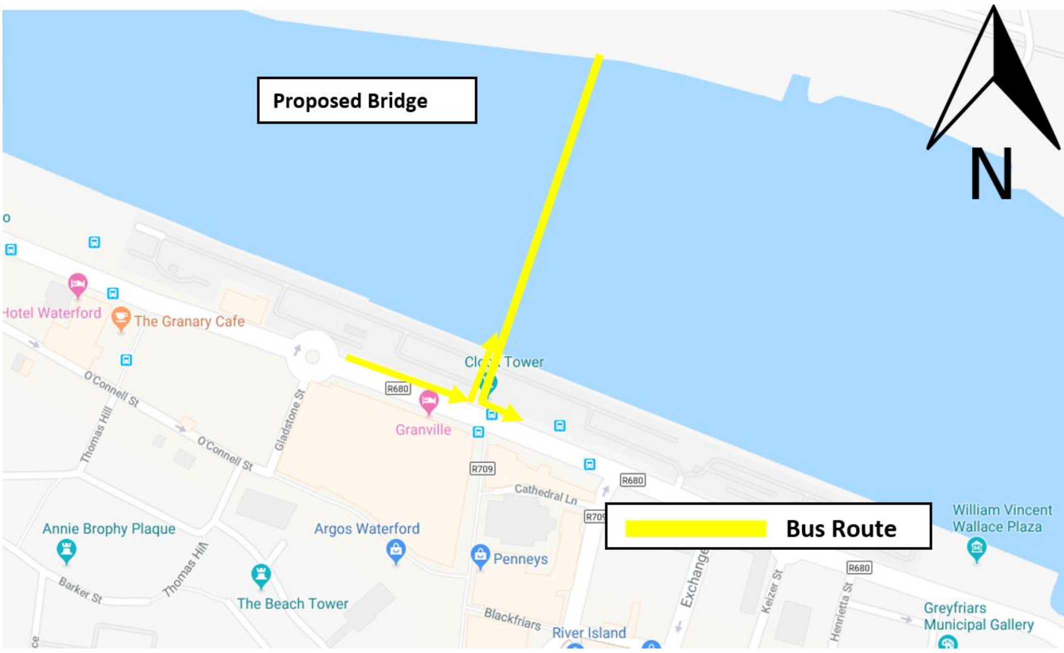

Plate 3.3 **Alternative Route Option across the proposed bridge with left hand turn onto the bridge from Merchant's Quay and a left hand turn onto Merchant's Quay from the bridge**

The route which travels over and back across the bridge emerged as the preferred electric shuttle bus route option, as presented in Plate 3.3. The turning movement of the electric vehicle on the south quay is presented in Figure 4.6 of Volume 3. An objective of the project is to link the north and south quays and this route fulfils this objective with the least disturbance to the surrounding area. The proposed bus route will connect Waterford City centre with the North Quays SDZ, thereby connecting two key retail facilities. The proposed bus route will provide a connection between these areas for the young, old and mobility impaired, for whom cycling and walking are not available.

This route option has been assessed in this EIAR, however there is potential for the bus route to be extended to service a wider catchment area in the future, for example to the Viking Triangle tourist attraction to the south and to schools, houses and community facilities in Ferrybank to the north.

The Selected bus route is not considered to have any adverse effects on the environment and with the future ability to

3.9 Electric Vehicle Options Considered

The following seven bus types were considered as options for the mode of public transport crossing back and forth across the proposed bridge:

- MotoEV Electro Transit Buddy 15 passenger hard door Americans with Disabilities Act (ADA) shuttle;
- MotoEV Electro Transit Buddy 12 passenger hard door shuttle-short;
- MotoEV Electro Transit Buddy 15 passenger XE hard door shuttle;
- A CitEcar Electro Transit Buddy 15 passenger hard door ADA Shuttle;
- Bintelli ADA Enclosed Shuttle 11P 1WC;
- Phoenix Zeus Electric Shuttle Bus; and
- EasyMile EZ10

These options are discussed and compared and their suitability for use on the proposed bridge is identified.

3.9.1 MotoEV Electro Transit Buddy 15 passenger hard door ADA shuttle

The wheelchair accessible, 15 passenger MotoEV Electro Transit Buddy is a manual, electric vehicle with a range of 80km at full capacity. The vehicle is approximately 5m in length, 1.5m in width and 2m in height and has a turning radius of approximately 5.5m. An image of the vehicle is presented in Plate 3.4.

Plate 3.4 MotoEV Electro Transit Buddy 15 Passenger Hard Door Wheelchair-Friendly Shuttle

3.9.2 MotoEV Electro Transit Buddy 12 Passenger Hard Door Shuttle-Short

The manual, electric MotoEV Electro Transit Buddy is capable of carrying 12 passengers. The vehicle is not accessible to wheelchairs. It is approximately 4.2m in length, 1.5m in width and 1.9m in height and has a turning radius of approximately 4.6m. The vehicle has a range of 80km at full capacity. An image of the vehicle is presented in Plate 3.5.

Plate 3.5 MotoEV Electro Transit Buddy 12 Passenger Hard Door Shuttle-Short

3.9.3 MotoEV Electro Transit Buddy 15 Passenger XE Hard Door Shuttle

The manual, electric MotoEV Electro Transit Buddy is capable of carrying 15 passengers. The vehicle is not accessible to wheelchairs. It is approximately 5m in length, 1.5m in width and 2m in height and has a turning radius of approximately 5.5m. The vehicle has a range of 80km at full capacity. An image of the vehicle is presented in Plate 3.6.

Plate 3.6 MotoEV Electro Transit Buddy 15 Passenger XE Hard Door Shuttle

3.9.4 CitEcar Electro Transit Buddy 15 Passenger Hard Door ADA Shuttle

The manual, electric CitEcar Electro Transit Buddy is capable of carrying 15 passengers. The vehicle is accessible to wheelchairs. It is approximately 5.1m in length, 1.5m in width and 1.9m in height and has a turning radius of approximately 5.5m. The vehicle has a range of 80km at full capacity. An image of the vehicle is presented in Plate 3.7.

Plate 3.7 CitEcar Electro Transit Buddy 15 Passenger Hard Door ADA Shuttle

3.9.5 Bintelli ADA Enclosed Shuttle 11P 1WC

The manual, electric Bintelli ADA Enclosed Shuttle is capable of carrying 11 passengers. The vehicle is accessible to wheelchairs. It is approximately 5.1m in length, 1.5m in width and 2m in height and has a turning radius of approximately 5.5m. The vehicle has a range of 80km at full capacity. An image of the vehicle is presented in Plate 3.8.

Plate 3.8 Bintelli ADA Enclosed Shuttle 11P 1WC

3.9.6 Phoenix Zeus Electric Shuttle Bus

The manual, electric Phoenix Zeus Electric Shuttle Bus is capable of carrying 12-20 passengers. The vehicle is accessible to wheelchairs. It is approximately 7.1m in length, 2.7m in width and 2.9m in height. The turning radius is not identified. The vehicle has a range of 160km at full capacity. An image of the vehicle is presented in Plate 3.9.

Plate 3.9 Phoenix Zeus Electric Shuttle Bus

3.9.7 EasyMile EZ10

The autonomous electric EasyMile EZ10 is capable of carrying 8 passengers. It is not clear whether the vehicle is accessible to wheelchairs. It is approximately 4m in length, 2m in width and 2.3m in height. The turning radius is not identified. The vehicle has a range of 14 hours at full capacity. An image of the vehicle is presented in Plate 3.10.

Plate 3.10 EasyMile EZ10

3.9.8 Vehicle Option Comparison and Preferred Option Selected

The MotoEV Electro Transit Buddy 12 Passenger Hard Door Shuttle-Short and the MotoEV Electro Transit Buddy 15 Passenger XE Hard Door Shuttle are not viable options as they do not have wheelchair access. The CitEcar Electro Transit Buddy 15 Passenger Hard Door wheelchair accessible shuttle and the Bintelli ADA Enclosed Shuttle 11P 1WC are not as aesthetically pleasing as the other options and therefore were both ruled out. The Phoenix Zeus Electric Shuttle Bus is a larger vehicle in comparison to the other options and is too cumbersome considering the proposed purpose and turning requirements at either end of the bridge. Therefore, this option is ruled out as a viable option. The EasyMile EZ10 is an automonous bus and therefore is not considered appropriate considering the safety risk due to the shared space between cyclists and the vehicle. Furthermore, the EasyMile EZ10 only accommodates 8 people and therefore this option was ruled out. The 15 passenger MotoEV Electro Transit Buddy 15 Passenger Hard Door ADA Shuttle is the preferred option as it is wheelchair accessible, aesthetically pleasing, manual and accommodates a sufficient number of passengers.