URS

KILKENNY CITY

PEDESTRIAN BRIDGE

Preliminary Options
Report –

Bridge Types

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1. INTRODUCTION

Kilkenny Borough Council proposes to construct a pedestrian footbridge in Kilkenny City as part of the 'Smarter Travel Plan'. The location of the bridge between Bateman's Quay and John's Quay on the River Nore will provide a practical and direct route which will be regularly used, linking areas west of the River Nore, including High Street and Kieran Street, to areas east of the river including John's Street, John's Green, Michael Street and McDonagh Junction.

It is a key sustainability principle of the Kilkenny City Local Area Plan to improve the accessibility of the City Centre for pedestrians and cyclists and to provide: 'a practical level of accessibility for all, regardless of age, mobility or availability of mode choice and the [transport] network must pragmatically cater for all trips that have an origin or destination in the City Centre'.

The following is an overall review of various structural options that have been considered for the Kilkenny City Pedestrian Bridge.

Environmental impacts have not been considered in detail for this option at this stage as part of this review.

2. LOCAL CONTEXT

2.1 Location

The bridge site has been identified by Kilkenny Borough Council, and is identified on drawing reference (47061456/P8/100-2).

The location spans the River Nore in a West to East orientation, crossing from Bateman's Quay on the West side to Johns Quay on the East side. The site is close to the existing Carnige Library on the east and connects to the pedestrian route through park land, Back Lane and on to John's Lane. On the west side the bridge connects to the pedestrian route which runs to the north of Dunne's Stores to connect with Kieran's Street and High Street.

2.2 Adjacent Bridges

The following are the current existing crossings of the River Nore in the direct vicinity to the proposed location:

- Johns Bridge 200m down stream
- Greens Bridge 500m upstream

It is also noted that the proposed Central Access Scheme Bridge is located 360m upstream at the north side of the Diageo Brewery.

3. SITE CONSTRAINTS

3.1 River Nore Flood Levels

3.1.1 OPW Section 50

As required by the Arterial Drainage Act 1945, the proposed bridge crossing will be the subject of an application to the Commissioners of Public Works for Section 50 consent prior to construction.

Matters such as profile of piers, structural integrity and durability and hydraulic performance in flood events will be addressed in detail as part of that process. It is proposed to use existing hydraulic modelling information used for the design of the current flood defences and river channels to define the minimum clearance required for the pedestrian bridge. It is also noted that it is currently proposed to place the pedestrian bridge soffit level above the required flooding levels. As such it is not proposed to complete detailed hydraulic modelling for the pedestrian bridge.

3.1.2 River Nore Drainage Scheme Flood Model

In the case of the City of Kilkenny, flood defences were constructed in 2004 as part of the River Nore Drainage Scheme (RNDS) which was funded by the Office of Public Works (OPW). During the preparation of the design of these flood defences, the OPW had developed and calibrated a mathematical model of the flows in the River Nore channel. The original model was developed using the HECRAS software and was calibrated and validated using various historic flood data. The results also compared favourably with those derived from a physical model constructed by others on behalf of the OPW.

The original model extended upstream from Greens Bridge and the related flood defence works provided protection to all properties considered vulnerable to flooding for flood levels equal to the predicted 100 year flood level plus a design freeboard of 300mm.

For the purpose of the assessment of the impacts arising from the proposed bridge, a copy of the model, which contained the final profiles of the river channel after construction of the Drainage Scheme in 2004, was obtained from the OPW as part of the work completed for Kilkenny County Council on the Central Access Scheme bridge preliminary design.

3.1.3 Application of Flood Model for Pedestrian Bridge

This model has been taken and interpreted for the proposed location of the pedestrian bridge. Two sets of data were available 1) 100 yr flood level (44.48mOD), 2) 100 yr flood level +20% allowance for climate change (44.69m).

Based on the cross section from this model a preliminary design level has been chosen for the purposes of generation of bridge visualisations and initial design drawings. This level is based on the higher level allowing for 100 yr flood level with the additional 20% added for climate change.

The current design level based on the above is 44.69mOD plus the typical allowance of 300mm freeboard that is required by the OPW giving a **bridge level of 44.99mOD.**

Based on this level and latest survey information the proposed bridge should be located at a level approximately 300mm above current wall levels on the east bank (Johns Quay), and approximately at the footway level on the west bank.

3.2 Kilkenny City & Environs

As part of the initial design the overall character and tourism elements of the city have been considered as part of the review of existing conditions and the following noted:

- The overall character of the City and in particular the heritage townscape of the historic centre.
- Kilkenny offers a unique selection of historic sites and buildings from the 7th century onwards reflecting a tradition of monastic settlement, and has a number of high quality buildings of historic and architectural significance such as Kilkenny Castle, St. Canice's Cathedral, Rothe House, St. Francis Abbey and Black Abbey.
- The City is compact enough for tourists to explore on foot.
- The natural beauty of the River Nore Valley, and the linear park along the eastern banks of the River Nore in Central Kilkenny.
- The services provided in the City hotels, guesthouses, restaurants, shops, design centre, theatre, galleries and cultural events.
- The reputation of the City for arts, culture and crafts.
- It is a specific tourism objective of the Kilkenny Local Authorities to promote and encourage tourism development, and to facilitate improved access to and from the City and Environs.

3.3 Bank/Wall Foundations (RNDS)

The River Nore channel and river wall, banks and other physical infrastructure within the river corridor underwent substantial construction works as part of the River Nore Drainage Scheme. The aim of which was to protect the centre of Kilkenny City for major flooding events.

A number of as built documents and drawings have been provided to URS by Kilkenny County Council outlining the work completed as part of these construction works. The designers of these works were engineering consultants Mott MacDonald.

The primary area of interest for the pedestrian bridge is the forms of both of the river walls at the proposed bridge location. The following is a brief extract of the currently available information on the river walls.

As built drawings provided as part of the RNDS safety file provide an indication of what the current river walls are founded upon. Drawing numbers 24203/MAR/041, 042, and 043 provide the clearest information on foundation type. The walls are founded on a ground anchor/sheet pile arrangement, with an expected anchor spacing of 3m. Extracts of these drawings have been reproduced below for clarity.

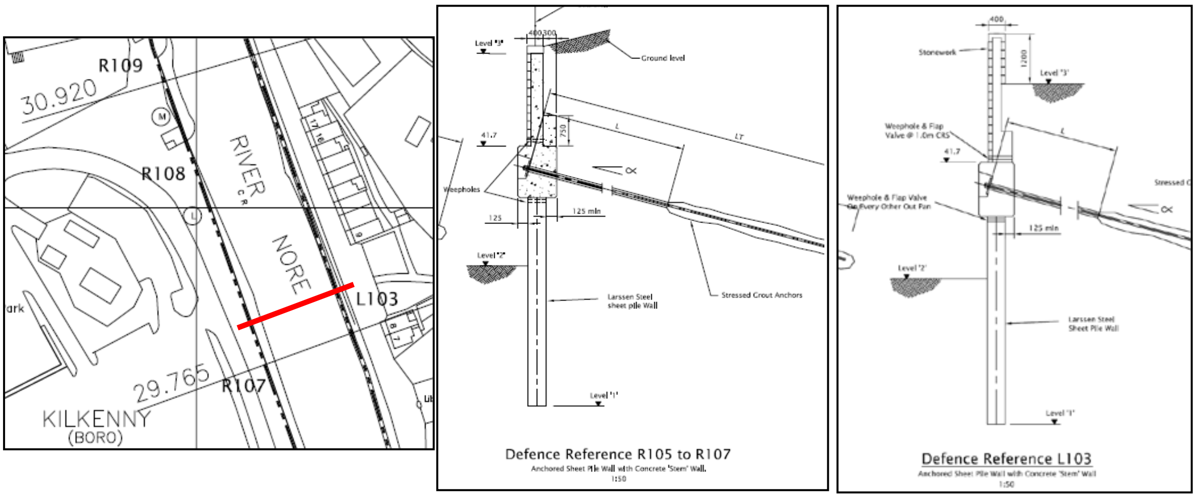

Figure A - RNDS Plan & Sections

The above figures indicate the general arrangement of the walls at the proposed bridge location. It is noted that the ground anchors pass to significant depths beyond the back of the current footway and road carriageways on both sides of the river.

The following tables from the RNDS safety file indicate the ground anchor details – angle, spacing, inclination and lengths. It is noted that from initial surveys there are significantly larger numbers of anchor heads cast into the capping beam for the sheet pile wall.

This may lead to difficulty with positioning of foundation piles unless they are clearly identified, it will be investigated further as part of the detailed design and will depend on the bridge option chosen.

Table 1 - West Bank Ground Anchor Details

Anchored Sheet Pile Walls													
Defence reference	Start Ref.	Finish Ref.	Significant Elevations				Anchor Details					Capping beam type	Pile type
			Level '1' (mAD)	Level '2' Start of defence (mAD)	Level '2' End of defence (mAD)	Level '3' (mAD)	Working Load (Tw) (kN)	Inclination ∝ (deg.)	Free length 'L' (m)	Total length 'LT' (m)	Anchor Spacing (m c/c)		
R102b	E	F	35.5	38.7	38.8	41.7	363.0	30.0	8.0	17.0	3.0	A3	Larssen LX20
R103	F	G	35.5	38.8	38.9	41.7	340.0	30.0	8.0	17.0	3.0	A3	Larssen LX20
R105	I	J	32.0	38.9	39.0	43.2	399.0	45.0	8.0	17.2	3.0	A13	Larssen LX25
R106	J	K	32.0	39.0	39.0	43.75	399.0	45.0	8.0	17.2	3.0	A13	Larssen LX25
R107	K	L	30.0	39.0	39.1	43.75	471.0	45.0	8.0	18.2	3.0	A13	Larssen LX20

Table 2 - East Bank Ground Anchor Details

Anchored Sheet Pile Walls													
Defence reference	Start Ref.	Finish Ref.	Significant Elevations				Anchor Details					Capping beam type	Pile type
			Level '1' (mAD)	Level '2' Start of defence (mAD)	Level '2' End of defence (mAD)	Level '3' (mAD)	Working Load (Tw) (kN)	Inclination ∝ (deg.)	Free length 'L' (m)	Total length 'LT' (m)	Anchor Spacing (m c/c)		
L102	e	f	34.5	38.8	38.9	41.7	370.0	45.0	12.0	20	2.0	A11	Larssen LX25
L103	f	g	34.5	39.2	39.4	43.5	417.0	45.0	8.0	17.2	3.0	A12	Larssen LX25
L104	g	h	34.5	39.2	39.4	44.0	405.0	45.0	8.0	17.2	3.0	A13	Larssen LX25

3.4 Particular Site Constraints

3.4.1 West Bank

Current design levels are suitable for landing bridge at or close to existing footway/road levels, thus eliminating the need for major ramps or steps to bridge crossing.

The following are the main constraints that were identified with regard to bridge structural form on the west bank:

- Proximity to existing road way – Bateman Quay (6m)
- Shopping and parking facilities located in the Market Yard area directly east of the proposed location.
- Vehicle entrance to Dunne's' Stores and adjacent car parks.
- Need to integrate with existing pedestrian route, which is currently located at an uncontrolled unmarked crossing 20m to the north of the current position.
- Recently refurbished "Tea Houses" located just to north of proposed location.

3.4.2 East Bank

- Linear walk way along River Nore to be maintained or integrated into the proposed bridge.

- Close proximity to existing terraced houses. North and south of proposed location, 9 to 17 Bateman Quay, and 7 and 8 Bateman Quay respectively.
- Close proximity to Carnegie Library.
- Need to integrate ramps/steps with existing pedestrian and cyclist routes. Some consideration of future routes may be necessary or improvement to existing routes.
- Level difference of 1.6m (bridge landing at 44.99mOD, existing ground level 43.4mOD).
- Current width area available for bridge landing and ramp layouts between river wall and existing kerb line is 5.7m. If high quality open ramps suitable for pedestrians are used it is expected that this width will be insufficient.

3.5 Environmental

The River Nore carries a large volume of water during flooding; it is also a Special Area of Conservation (SAC), and a very important game-fishing amenity. It was proposed that the new bridge associated works should not restrict the natural flow of the river, particularly during flooding, and the construction and future operation of the bridge should have no adverse environmental impacts.

Also the form of the bridge should be such that it does not impair the current views along the river. This approach suggested that options which required significant heights may not be acceptable. Furthermore it was recognised that the new bridge presented an opportunity to provide a focal point for the future development of the river frontage, and therefore its appearance was important.

River Nore SAC has multi-habitat, multispecies interests:

- Otters & Bats
- Pearl Mussel, Crayfish, Lamprey, Twaite Shad, Atlantic Salmon

4. BRIDGE OPTIONS

4.1 Bridge Dimensions for Preliminary Design

Span

Bank to bank clear span at proposed bridge location is 34.5m. Actual span may change depending on location of foundations, bridge type, and other constraints on either bank.

Deck Width

3m to allow for shared pedestrian cyclist space across deck.

Parapet Height

In order to cater for cyclists a railing height of 1.4m has been used for the preliminary design.

It is noted the recently published National Cycle Manual indicates a range of railing heights for bridges catering for cyclists from 1.2m to 1.4m.

Ramp Rest Areas (East Bank)

Minimum required of 1.5m. For preliminary design 2m has been allowed.

Ramp Turning Circle for Cyclist

An initial cycle turning circle on ramps has been provided with a 3m envelope. Review of the National Cycle Manual does not indicate a recommended value, however the UK Department of Transport guidance document "Designing Cycle Infrastructure" gives an indication of a requirement for a 3.3m overall turning circle requirement for a conventional bicycle.

This issue will be investigation further depending on the preferred bridge option chosen, and where necessary the east bank ramp arrangement will be adjusted to provide suitable turning space for cyclists to meet design guidance. For the purposes of preliminary design envelop of 3m has been allowed for.

4.2 Bridge Types Considered

The following are the types of options that have been considered as part of the preliminary design and optioneering for the proposed pedestrian bridge.

- Option 1 Beam
- Option 2 Arched Beam/Truss
- Option 3 Lattice Truss
- Option 4 Vierendeel Arch
- Option 5 Vierendeel Half Through Truss
- Option 6 Box Girder with Truss
- Option 7 Cable Stayed
- Option 8 Wooden

4.3 Option 1 – Beam

4.3.1 Structural Form

General

The straight beam option is a practical and economical structural solution. The following are general comments relating to the primary structural elements.

- The vertical loading is transferred to the piled foundations by two Structural Steel Universal Beams.
- Transverse Universal Beams connected perpendicular to the two primary Universal Beams support the 3m wide deck.
- CHS bracing at intermediate locations will provide lateral and torsional restraint.
- Profiled fin plates are bolted directly to the main longitudinal beams at 4m intervals.
- Curved sheet cladding will conceal all structural members and bolted connections.

Figure B - Typical Beam Bridge (Birmingham)

Figure C - Short Span Beam Bridge (Germany)

Beam Sizes

This structural form consists of structural steel Universal Beams spanning both longitudinally and transversely. The longitudinal span beams will be approximately 1m in depth.

The deck is supported on transverse steel Universal Beams of approximately 0.3m in depth. The transverse beams are bolted to the primary longitudinal beams at specified intervals.

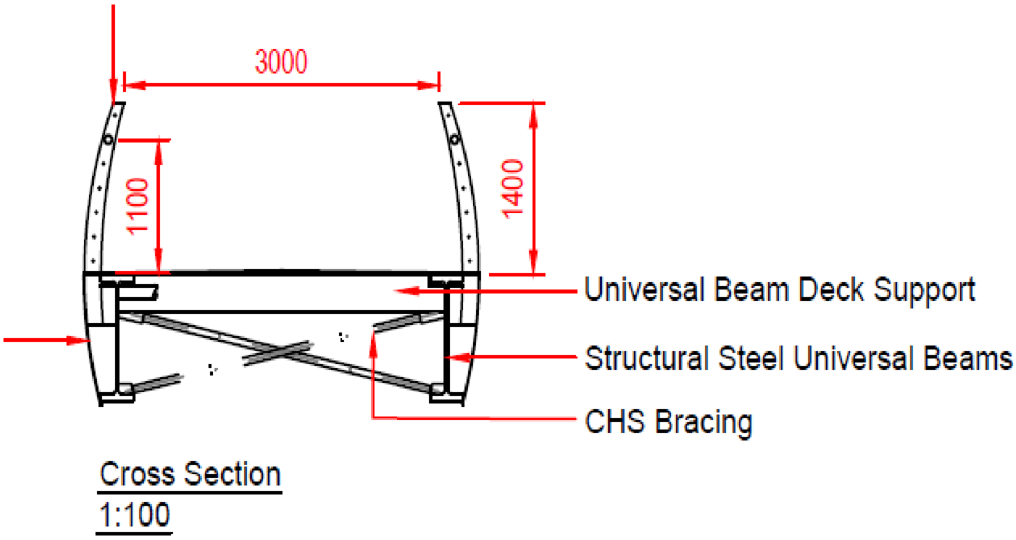

Figure D - Indicative Section for Beam Bridge

Lateral Stability

Lateral and torsional stability of the structure is catered for through inclusion of cross bracing at intermediate locations longitudinally.

Railings and Cladding

Railings are bolted onto profiled fin plates which in turn are bolted to the main longitudinal beams at 4m intervals. All bolted connections and structural members will be concealed using curved sheet cladding to give a streamlined and curved finish.

4.3.2 Foundations

The foundation solution for this option is similar to the foundation solutions for each of the other bridge options. Piled foundations are required to transfer the foundation support loading to a level below the existing quay wall. This will prevent any additional loading (vertical and horizontal) acting on the anchored quay walls. The self-weight of the bridge and imposed loading will be transmitted directly to the piled foundations which will consist of between 2 and 4 piles on both the East and West banks of the river.

4.3.3 Visual Issues

Large depth of beam creates heavy structure raised significantly above the river and adjacent banks. Lighter railings and surface fixtures can be used to mitigate this as no structural support is required from railings. All bolted connections and structural members will be concealed using curved sheet cladding. As well as concealing the structural members, the curvature can provide the illusion of a shallow structural depth.

4.3.4 Cost Estimate

This is an economic solution with an estimated cost of €2,400 / m^2 of deck.

Due to the significant abutment works on the East Bank the total cost of the structure is therefore estimated at €470,000, this is primarily due to the additional works required on either bank due to the 1m height increase.

These estimates are based on a 37.5m span and a 3m deck width.

4.3.5 Summary

- Efficient solution.
- 37.5m span primary longitudinal beams approximately 1m in depth, raising the bridge significantly above the river and creating further issues with tie in at both west (>1m level difference) and east (>2.6m level difference).
- Transverse beams supporting deck.
- Allows use of light railings and deck features.
- The proposed location of the bridge is considered a visually and environmentally sensitive area. From a visual perspective, a simple beam bridge is considered not particularly suitable.

4.4 Option 2 – Arched Beam/Truss

4.4.1 Structural Form

General

The tapered beam option is visually and structurally quite different from the simple beam option. The tapered beam consists of a steel hollow box section. The depth of the beam reduces significantly towards the middle of the span giving an aesthetically appealing structure. Due to the curvature of the bridge, horizontal forces develop at the supports on both banks which must be resisted and considered as part of the foundation solution. Figure C is an example of a typical tapered beam bridge.

Figure E - Typical Tapered Beam Bridge

Figure F - Tapered Truss (Millennium Bridge)

4.4.2 Foundations

The foundations required for a tapered beam bridge must resist both horizontal and vertical forces and may require significantly larger works on both banks.

Figure G - Foundation Example

It is anticipated that some build out of the banks may be required. It is expected that this option would significantly impact on the existing River Nore Drainage Scheme river walls, sheet piling and ground anchor arrangement, which would require further detailed review in order to define suitable foundation options.

4.4.3 Visual Issues

Increased depth on approach to bridge abutments would have a similar effect to that of the simple beam in increasing the overall height of the bridge due to the requirement to keep above river flood levels. This will increase height of bridge significantly.

Slender central section of bridge increases visual permeability of the bridge, and creates an elegant solution to the river crossing, which may help to mitigate the increase in height.

4.4.4 Cost Estimate

It is estimated that this bridge form would be considerably more expensive than a beam bridge due to costs to fabricate the tapered box section or the tapered truss.

Foundation costs will also increase due to significant horizontal reactions. Raked piles may not be achievable due to existing ground conditions / obstructions. Some in-stream works may also be required at the river walls directly below the landing position.

The estimated basic cost of the bridge structure and foundation works is €3,000 / m^2. The West and East Bank works would be similar to those for the Beam option described above.

Additional costs would be incurred due to the complex abutment construction. The total cost is therefore estimated at approximately €800,000. A more detailed cost estimate would be required if this option was to be considered further.

The recently constructed Millennium Bridge on the River Liffey in Central Dublin is an example of similar form of bridge using a tubular truss arrangement (also tapered across the span) rather than a beam/girder. It is understood that this recently constructed bridge cost in the region of €1.5m.

4.4.5 Summary

The tapered beam option is an elegant solution, however horizontal forces must be resisted on both banks which will increase the size and complexity of the piled foundations. This is unfavourable due to the constraints imposed on site by the ground anchors.

It is also considered that this structural option would be outside of the overall funding available to Kilkenny Borough Council.

4.5 Option 3 – Lattice Truss

4.5.1 Structural Form

General

A bridge made from narrow structural members which act together to act as a structural frame. The truss acts in the same way as a deep beam but can span similar distances with a lighter and more aesthetically pleasing structure.

Figure H - Lattice Truss

This formation allowsa low landing profile at both east and west banks as the deck can be formed at the lower chord of the truss. This therefore reduces the overall height and size of ramps on the east bank, and a smooth transition on west bank.

Figure I - Double Lattice Truss

Structural Sizes

The following figure gives an indication of the structural elevation and section of a suitable lattice truss arrangement for the proposed span.

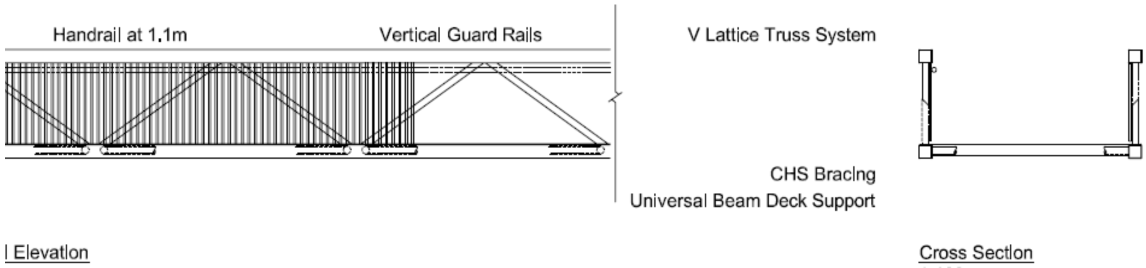

Figure J - Lattice Truss Typical Elevation & Section

Main structural section sizes are 250 x 10 SHS truss members. This may be revised in detailed design to provide some variation in section sizes to help with visual impact of truss.

The estimated steel weights for a 250 x 10 SHS are 75kg/m.

4.5.2 Foundations

Foundations consist of piled foundations which should have a relatively low impact on underlying ground anchored walls.

4.5.3 Visual Issues

Box section truss may result in an “industrial” bridge; however specific treatments, finishes and lighting of bridge can significantly reduce this affect.

Low profile of bridge is particularly suitable for bridge location, and is considered to fit well with the medieval history of Kilkenny City, particularly the nearby Kilkenny Castle.

Horizontal guard rails are not recommended. Vertical guard rails can be utilised to prevent climbing.

Low arching of this option can provide a suitable partner for Johns Bridge located directly to the south and is deemed preferable than straight option. Arching of the truss bridge will lead to a more aesthically pleasing and less industrial looking footbridge but will increase the fabrication costs. It may also increase foundation costs due to horizontal loading applied to the foundations by the curvature of the deck.

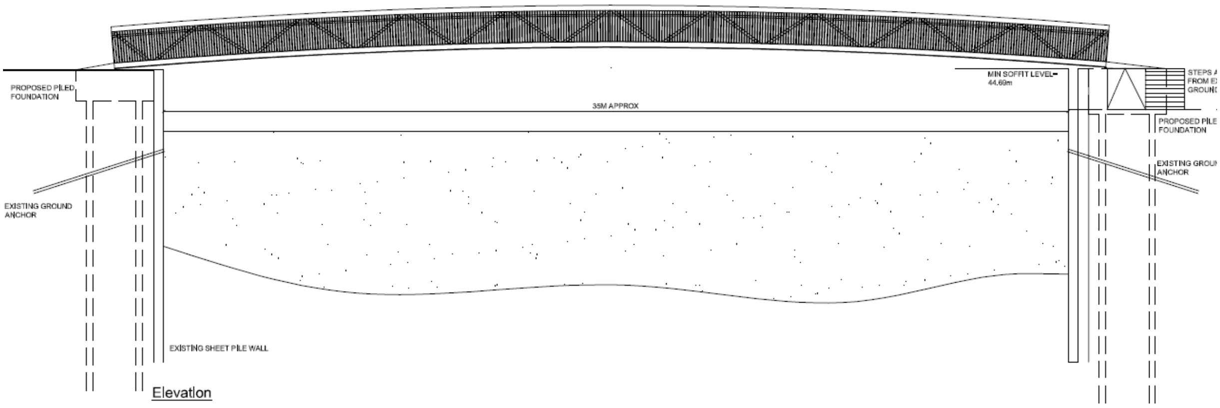

Figure K - Arched Lattice (Basic GA)

4.5.4 Cost Estimate

This is one of the most economic solutions with an estimated cost of €2,400 / m2 for the basic structural costs.

Including the various costs at both abutments this option would have estimated total cost of €410,000.

These estimates are based on a 37.5m span and a 3m deck width.

It is noted that this option will also create significant savings on the construction requirements on the east bank through significant reduction of ramp heights and lengths in comparison to all other bridge types (bar similar truss variations).

4.5.5 Summary

- Detailing required to ensure visually pleasing bridge for all users, particularly with regard to vertical guard rails.
- Arched version considered to be more visual pleasing than straight.
- Low depth of overall structure is suitable to the site constraints on either bank and also does not contrast with other key features of Kilkenny City such as St Canice's Kilkenny Castle.
- Considered to be the most economic structural solutions in terms of overall cost.

4.6 Option 4 – Vierendeel Arch

4.6.1 Structural Form

General

The Vierendeel Arch structure is a visually impressive structure. It consists of an upper arched member with vertical members connecting to the lower horizontal member. The deck is supported within the truss system itself with the arched members rising above deck level.

Figure L - Vierendeel Arch Designed by URS

Figure M - Vierendeel Arch Bridge Deck

Lateral Stability

Lateral stability of the structure is achieved using horizontal cross bracing members below deck level.

Guard Rails

Guard rail posts are bolted to the main truss frame. The horizontal guard rails are splayed inwards (towards the centre of the deck) to prevent climbing,

Vierendeel Truss System

The deck is supported and contained within the Vierendeel Truss. The members spanning between the lower and upper arched members are splayed. The truss height about deck level is approximately 2.8m.

The vertical members are connected using fixed joints. This results in larger joints and members to resist the bending moments which occur at each joint.

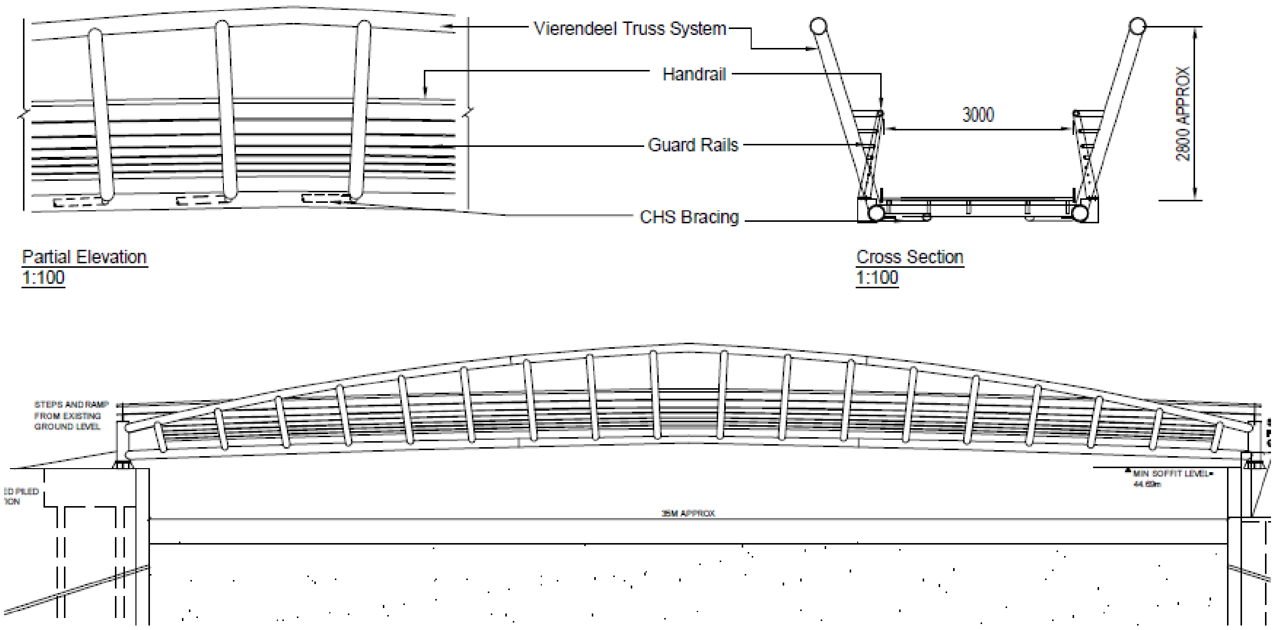

Figure N - Vierendeel Truss (GA)

4.6.2 Foundations

Supports for the Vierendeel Truss option consist of piled foundations and is similar to that required for both simple truss and beam options.

4.6.3 Visual Issues

Creates a statement structure with clear appealing visual elements, particularly when viewed from afar. Vertical members create and frame views for users.

Considered out of character with Kilkenny City, however arched form of bridge ties shape back to the form of Johns Bridge located directly downstream of the proposed crossing point.

Height of arch would be significantly above deck level. Initial design indicated height of approximately 2.8m.

4.6.4 Cost Estimate

Estimated cost of €2,700 / m2. The West and East Banks works would be of similar value to the lattice truss discussed above.

The total cost of the structure is estimated at €440,000. These estimates are based on a 37.5m span and a 3m deck width.

4.6.5 Summary

- Provides a significant statement structure.
- Low vertical profile in terms of clearance above river flood levels and impact on landing position on east bank due to majority of structural form above soffit level.
- Low impact on foundations.
- Considered to be in conflict with the overall nature of the site and historic nature of Kilkenny City.

4.7 Option 5 – Vierendeel Half Through Truss

4.7.1 Structural Form

General

This option is very similar to Option 3 – Lattice Truss discussed above. It differs with the elimination of diagonal members and inclusion of closer spaced vertical members. (Note – vierendeel typically refers to inclusion of vertical truss members).

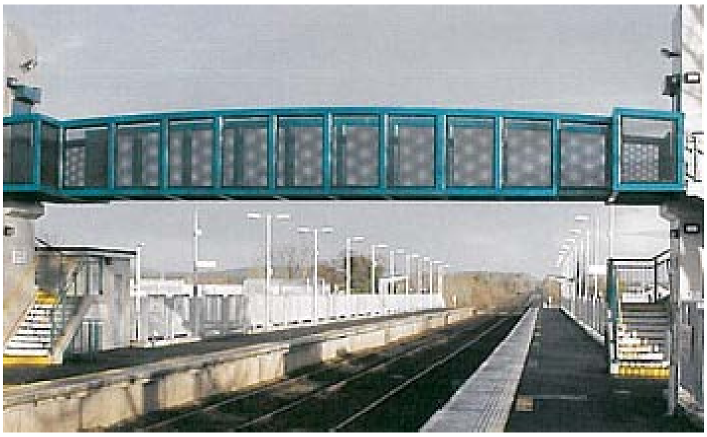

Figure O - Typical Vierendeel Truss (Monasteriven)

The following are general comments on the overall form.

- Vertical members can result in a more pleasing rectangular configuration, avoiding the need for diagonal members.
- Joints are required to be rigid and are larger due to requirement to transfer moments through the joint (i.e. not simple pinned connections used in the lattice truss option already proposed). The structural members of Vierendeel trusses become subject to bending moments and shear forces in addition to direct tension or compression.
- The resulting joints are often very heavy in appearance and can be more costly to fabricate.
- If the structure is clad on outside the truss from will be hidden – therefore lattice would be preferred on cost basis.

A vibration analysis has not been carried out at this stage as this will be looked at in detail once a bridge option is chosen.

Depth of structure, size of members, deck depths

The depth of the structure may not necessarily increase, though the dimensions and/or weight of the members may increase to resist the additional bending and shear stresses. Deck depth is determined by the structure spanning between the two Vierendeel trusses. This is unlikely to be affected.

The following are indicative member sizes:

- 300 x 10 SHS or 250 x 16 SHS. (Heavier steel thickness and thus more expensive).

The following are estimated steel weights:

- Keeping the same section overall size an increase from section size from 250 x 10 SHS (75kg/m) to 250 x 16 SHS (115kg/m) would be required.
- Therefore approximate 40% increase in steel weight from the lattice truss option.

4.7.2 Foundations

There is no significant difference to the bridge supports if using a half through Vierendeel truss compared to the lattice truss.

4.7.3 Cost

It is expected to be more expensive than the lattice truss option. Cost will be increased due to larger structural members and more complex connections. The connection requirements alone may add a further 10% of the overall fabrication costs due to the need to transfer moments through the joints. Estimated 40% increase in total compared to lattice truss.

The estimated cost of the structure is €3,000/m2, and it is estimated that a cost of €490,000 is likely when all abutment works have been included. This has been based on 37.5m span and 3m wide deck.

4.7.4 Summary

The vertical truss members may have move visually pleasing form than the diagonals of the lattice truss; however it is likely that the heavier joints of the Vierendeel Truss may reduce this improved visual affect.

To achieve similar design deflection and ensure structural efficiency a significant increase in structural steel weight is required. A further additional cost is also required in the manufacture of joints within the Vierendeel truss due to the need to transfer moments through the joint. Therefore the structural form is less economic than lattice truss. Overall these impacts would result in a cost increase of over 40% when compared to the Lattice Truss option.

This option could be considered further in tandem with the lattice truss option; however it is considered that the lattice truss would be a more economic solution with a similar visual impact.

4.8 Option 6 – Box Girder

4.8.1 General

The aim of the box girder is to provide additional strength to the bridge to allow for smaller members on the upper section of the bridge or to increase the allowable span. It acts in a similar manner to the beam option.

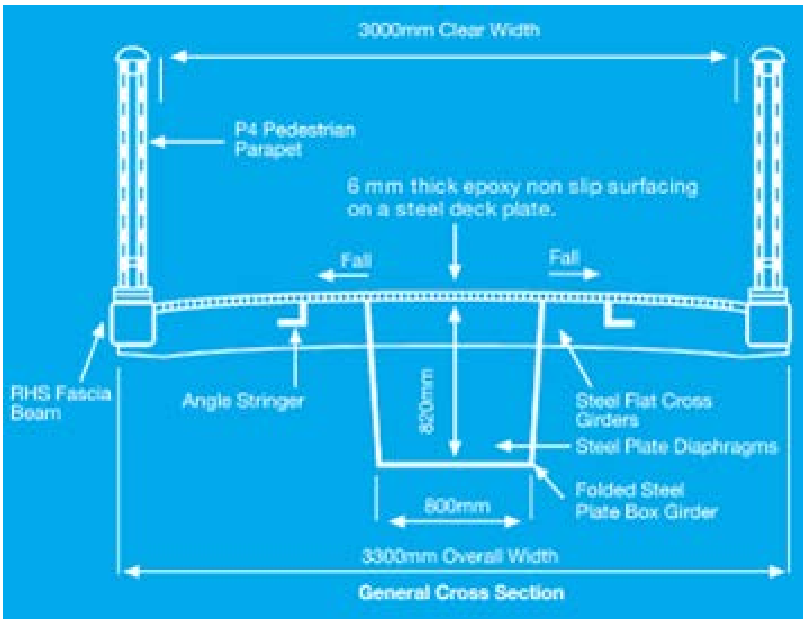

Figure P - Box Girder Typical Section

4.8.2 Cost

The estimated cost is €3,000 / m^2 with a base cost of €337,500.

The total cost of the structure totals €540,000 due to the increased depth of structure and consequential abutment and bank works. This is based on a span of 37.5m and a 3m deck width .

4.8.3 Summary

This option will raise the deck similar to beam option.

Likely to be more expensive due to the fabrication costs of the box girder, cantilevered deck and the requirement for moment connections.

Overall - not considered suitable.

4.9 Option 7 – Cable Stayed

4.9.1 Structural Form

General

In this form of bridge, the main deck support beams or girders are given additional support at intervals along their length by inclined tension members (cable stays) connected to a high mast or pylon.

Cable stayed construction is sometimes used for footbridges (typically spans of 35m and above) to give support and stiffness to an otherwise light structure. The existing span of the River Nore at the proposed crossing location is approximately 37.5m, and therefore suitable for considering a cable stayed option.

Deck

The deck girders thus sustain both bending and compression forces and therefore will continue to require sufficient stiffness to resist these forces. The deck is 'suspended', in the sense that it relies on the tensile stays to provide some of the vertical support.

Cable stayed bridges are relatively flexible and more prone to oscillation under wind or under deliberate excitation by users. A detailed check of the dynamic response of any proposed bridge will need to be carried out at detailed design stage.

Cable stays can be used with any of the forms of bridge deck construction previously considered for the Kilkenny Foot Bridge (e.g. lattice truss, vierendeel truss, and beam).

The deck supporting stays are in general anchored at floor level to the longitudinal structure. Whether beams or trussed, the longitudinal structure will need to be stiff and strong enough to span between cable anchor points and they may need substantial depth to resist design forces.

To provide a lighter appearance, with shallow beam/floor depth, cables supporting a vierendeel girder and half-through construction may be considered. This would minimise the depth of the deck structure, hence preventing further increase in height of the proposed pedestrian bridge above the River Nore banks. It is anticipated that a deck depth of 400 to 500mm would be required if a truss format was not chosen.

The cable supports are generally provided to the main deck support beams at approximately 10m to 15m spacing.

Structural sizes cannot be determined at this stage as they depend heavily on the form of the cable stayed bridge particularly the cable and pylon arrangements which are discussed in more detail below.

Pylon and cable arrangement

At least two forestays should be provided in each plane as it is difficult to validate the need for one single stay on economic and/or appearance grounds. The minimum span for a cable stayed bridge with two forestays is around 35m (therefore deemed a suitable option for the proposed Kilkenny Footbridge).

A single backstay is usually sufficient for smaller spans. The backstay is typically anchored to a reinforced concrete abutment (generally 1/3 of bridge span from the pylon). Further backstays are required if the back span is long and requires intermediate support.

Backstays may require the diversion of existing vehicular and pedestrian traffic routes on Bateman's Quay.

The cable stays are normally made from wire rope or spiral strand and can be arranged transversely via a central or twin suspension arrangement (see advantages and disadvantages below).

For most footbridges, twin planes of cable stays in a lateral arrangement will normally be used, one to each side of the bridge deck The central arrangement will require a stiffer deck structure.

Transverse Positioning (Cables)

Central Suspension (cable stays anchored to a central spine beam/girder supporting the bridge deck).

Advantages:

– This option is aesthetically superior.

Disadvantages:

– The deck requires higher torsional rigidity and the bending stiffness of the deck is not exploited to its capacity.

Figure Q - Cable Suspension Types (Central & Twin)

Twin Suspension (cables supporting both edges of the deck). Note that this configuration can be from either a single pylon or twin pylons.

Advantages:

- This option provides improved stiffness and stability of the deck,
- This option provides greater aerodynamic stability to the structure.

Disadvantages:

- Head room clearance may be restricted.
- Erecting A-frame pylon is generally more complicated.

Longitudinal Cable Arrangements

There are two main longitudinal configurations of cables – fan and harp. A combination of both configurations can be used for more complex cable stayed bridges.

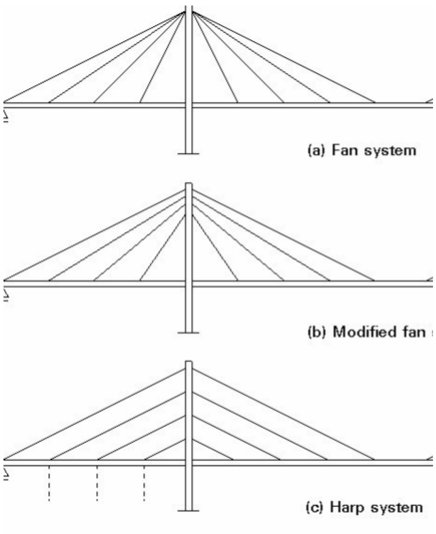

Figure R - Cable Configurations

Harp

Advantages:

- This option is aesthetically superior.

Disadvantages:

- This layout is not the best from the static loading or economic point of view.

Fan

Advantages:

- This layout is advantageous from the static loading point of view.

Disadvantages:

- This option is aesthetically poor.
- Leads to reduction in deck area for pedestrian/cyclists when located along centre line of bridge deck.

Option – 3 Semi Harp

Semi Harp is an intermediate solution, between extremes of Harp and Fan patterns. This pattern combines the advantages of both these systems, whilst minimising their disadvantages.

Pylon arrangement

The cables are supported by pylons; generally one single pylon at one end of the main span will suffice up to approximately 100m span. If a cable stayed bridge is chosen, it is envisaged one pylon be considered for the Kilkenny Footbridge, positioned on Bateman's Quay – the western bank of the Nore River.

Figure S - Pylon Arrangements

[Top Left: A Frame, Twin Cables. Top Right: Inclined Single Pylon, Harp Cables. Btm Left: Goal Post Pylons. Btm Left: Single Pylon, Back Stay, Twin Cables]

There are varying shapes of pylons including the following:

- 'A' frame pylons, with the two stay planes inclined;
- Individual pylon legs for each cable plane;
- "Goal-post"- the stays can then lie in a vertical plane.
- Bespoke cantilevered – inclined to omit the need for back stays

Footbridge pylons are usually A Frame or Goal posts comprising steel box or circular sections. These structural forms are chosen for slender appearance, ease of construction and economy.

Inclined reinforced concrete cantilevered pylons can be used where back stays may not be achievable. These tend to be aesthetically pleasing and can provide iconic structures. However, these are generally used for large/multi span bridges and can attract higher construction costs.

Pylon heights will vary depending on the various structural forms that are available. Typically for cable stayed pedestrian footbridges of similar span pylons are of the order of **12 to 15m** in height. Shorter pylon towers can cause significant cable sag while taller pylons may require larger/heavier cables as they are less structurally efficient.

4.9.2 Foundations

Imposed loads as well as self weight of the bridge structure will be supported by the cables which in turn will be supported by the pylon and backstay (if required). Substantial reinforced concrete, piled foundations will be required to support the downward pylon loads and to prevent uplift of the backstay anchorage.

A pile foundation will also be constructed on John's Quay to support the bridge load and ramps/staircases. Piled foundations will ensure no additional surcharge is applied to the existing quay walls.

4.9.3 Visual Issues

The visual appearance of stayed structures can be very effective. They are frequently considered appealing or eye-catching and can be tailored to provide a substantial visual focal point, particularly when situated in areas which are undergoing regeneration or improvements with associated modern developments.

At the current position proposed for the pedestrian bridge the location of the large pylon structure on the western bank of the River Nore (Bateman Quay/Market Yard area) may conflict with prominent historical structure of St Canice's Tower located further west within the city environs and also the refurbished stone faced "Tea House" directly north along the bank. For example a tower of 15m height would be 10m above the roof level of the Tea House.

Views looking south from the linear park along the east bank (taking in Kilkenny Castle/Johns Bridge in the back ground) may also be considerable affected by a large pylon structure on either bank. The west bank is preferred from this perspective as it would maintain a clear view of the castle from the linear park.

However in mitigation of this impact the position is close to recently completed modern court house buildings, and the recently acquired Diageo site for which development has yet to be considered.

4.9.4 Cost

A cable stayed bridge is expected to be more expensive than the other options considered for the Kilkenny Pedestrian Footbridge.

As costs will be dependent on option chosen the following is a broad indication of construction costs and should be revisited once further detail is available on the type of cable stayed bridge.

Approximate Cost Estimate:

The estimated Cost/m^2 for the structure would be €3,150 to €3,800.

The total cost is estimated at €860,000 based on a 37.5m span by 3m deck width). The increase in cost is mainly due to the extended deck for a cable stayed bridge and substantial ground works associated with the Pylon and Cables.

For the purposes of this estimate the following have not been considered:

- Changes to adjacent road layout, where pylon and back stays require space within the Bateman Quay/Market Yard area on the west bank.
- Only minimum deck area of 37.5m river span x 3m wide deck considered. Depending on option chosen deck may need to be extended

4.9.5 Summary

- Provides a statement structure.
- Pylon(s) expected to extent to 12m to 15m in height.
- Height of pylon(s) on west bank may conflict with St Canice's Tower, Johns Bridge, and therefore the historic nature of Kilkenny City.
- Back stay requirement would impact on adjacent traffic lanes.
- It does not eliminate the need for structural deck, due to need to resist lateral and torsion forces. Therefore thickness of deck will be similar to other truss type bridge options, railings however could be of lighter construction.

4.10 Option 8 – Wooden Options

4.10.1 Structural Form

Typically wooden bridges would take the structural form of a truss for smaller spans and a glue lam beam for longer spans. There are a number of combinations of this that may be suitable for the span being considered for the proposed bridge.

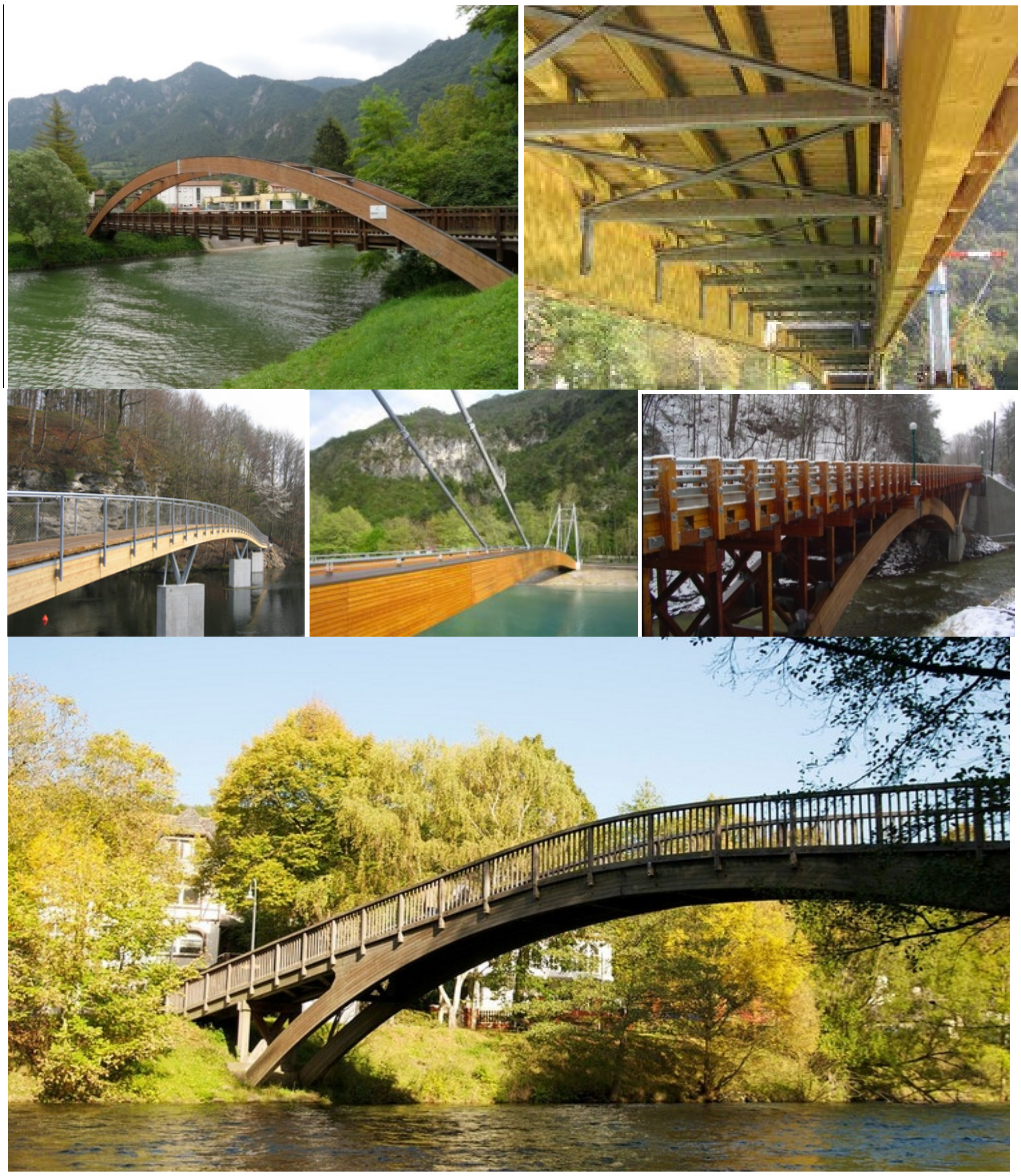

Figure T - Wooden Bridges

It is considered that a wooden truss would not be suitable for the size of span under consideration. Typically wooden trusses are used for smaller span pedestrian walkways with spans of approximately 10 to 15m. The larger span of 37.5m required for the proposed location would be expected to be beyond the capacity for suitable sized wooden sections particularly from a visual perspective.

The alternative is a glue laminated wooden beam or arch configuration. In some arrangements this involves additional steel structural bracings and fixings.

4.10.2 Cost

The estimated cost is €3,000 / m^2 for a wooden structure.

The increased depth of structure and subsequent abutment and bank works give an estimated total cost of €540,000.

4.10.3 Summary

A deep section glue laminated beam arrangement is deemed unsuitable for the proposed location due the additional height that would be added to landing positions on both banks.

The built up and medieval nature of the proposed site is not suitable for a wooden format similar to the examples above, as the site and city environs are noted for their use of limestone stone work in buildings and wall.

Some argument could be made to allow for inclusion of wooden cladding, decking or other features on a number of the previous options to improve the overall user experience and softening of some harsh features. This would be considered in due course for the option that is taken forward to detailed design.

5. CONCLUSIONS

Table 3 - Summary Table (All Options)

Ref.	Option Name	Advantages	Disadvantages	Comments
1	Simple Beam	• Straight forward construction • Lower cost • Simple foundations	• Significantly depth caused issued on landing at both banks. • Not visually pleasing (unless cladded)	• Not suitable for further consideration due mainly to visual impact and abutments.
2	Tapered Beam/Girder	• Structural form more visually pleasing than similar beam	• Complex foundations • Complex design, and construction • Higher costs	• Not suitable for further consideration due mainly to impact at abutments.
3	Lattice Truss	• Functional and practical to construct, maintain. • Fits into local environment • Lower cost • Lowest profile, hence lower height of abutment and ramps on east bank	• Detailing required to improve visual aspects of truss. • Not a statement structure, however suitable design and detailing of approaches to bridge can create suitable statement to provide dramatic new bridge crossing environment.	• Could be considered further.
4	Vierendeel Arch	• Statement Structure. • Structural form provides low profile (similar to lattice truss).	• Out of keeping with medieval city environs – St Canice's, Kilkenny Castle etc.	• Not suitable for further consideration due nature of site and historic nature of Kilkenny City.
5	Vierendeel Truss	As above for Lattice Truss, plus: • Improvement in visual impact due to use of vertical members.	As above for Lattice Truss, plus: • Higher cost due to steel & moment joints.	• Could be considered further.

Ref.	Option Name	Advantages	Disadvantages	Comments
6	Box Girder	• Can have a slender appearance.	• This option will raise the deck similar to beam option. • Likely to be more expensive due to the fabrication costs of the box girder, cantilevered deck and the requirement for moment connections.	• Not suitable for further consideration due mainly to visual impact and abutments.
7	Cable Stayed	• Reduces depth of deck beam. • Potential to provide dramatic centre piece and focal point for Kilkenny City, with view to regeneration of Diageo site and Market Yard area of the City. • Space for pylon on west bank.	• Significant depth of deck still required unless truss option chosen. • Out of keeping with medieval city environs – St Canice's, Kilkenny Castle etc. • Pylon and back stays may impact significantly on road system on west bank. • Difficult to maintain. • Higher cost. • Increased design checks due to susceptibility of vibration and oscillation.	• Could be considered father, however full "buy in" of all stakeholders required.
8	Wood – Arch/Beam	• Natural materials	• Span does not suit simple solution. • Does not match local environment. • Out of keeping with river banks and nature of city.	• Not suitable for further consideration due mainly to impact at abutments, and site environment not suiting material options.

Table 4 - Cost Summary

(i) Deck Area	Span	Width	M^2
Basic	37.5	3	112.5
Extended	42.5	3	127.5

(ii) Abutment & Bank Works			
	Height Increase:	+1m	+ 0.2 to 0.6
West Bank	€ 40,000	€ 15,000	€ 10,000
East Bank	€ 100,000	€ 45,000	€ 30,000

(iii) Cost Summary

	Options	Deck Area	H Increase	Estimated Cost/M^2	Base Cost	West Bank	East Bank	Add. Costs	Total	Comments
1	Beam	112.5	1	€ 2,400	€ 270,000	€ 55,000	€ 145,000		€ 470,000	
2	Arched Beam/Truss	112.5	1	€ 3,500	€ 393,750	€ 55,000	€ 145,000	€ 200,000	€ 793,750	Abutment works included as additional costs.
3	Lattice Truss	112.5	0	€ 2,400	€ 270,000	€ 40,000	€ 100,000		€ 410,000	
4	Vierendeel Arch	112.5	0	€ 2,700	€ 303,750	€ 40,000	€ 100,000		€ 443,750	
5	Vierendeel Truss	112.5	0	€ 3,000	€ 337,500	€ 50,000	€ 100,000		€ 487,500	
6	Box Girder	112.5	1	€ 3,000	€ 337,500	€ 55,000	€ 145,000		€ 537,500	
7	Cable Stayed	**127.5**	0.5	€ 3,800	€ 484,500	€ 50,000	€ 130,000	€ 200,000	€ 864,500	Extended deck for cable stay option. Pylon, Cables & Substantial ground works included as additional costs
8	Wood	112.5	1	€ 3,000	€ 337,500	€ 55,000	€ 145,000		€ 537,500	

5.1 Developed Options and Visualisations

From the above options the following four options were selected to be reviewed and computer generated visuals created in order to assess in more detail their overall applicability to the proposed site and the Kilkenny City environs, particularly in relation to their overall visual impact.

- Option 1 Beam
- Option 3 Lattice Truss
- Option 4 Vierendeel Arch
- Option 7 Cable Stayed

5.2 Developed Options Overall Summary (Pros & Cons)

Table 5 - Summary Table (Developed Options)

	Beam	Lattice Truss	Vierendeel Arch	Cable Stayed
Pros	• Simple construction & installation • Foundation loadings • Allows light detailing above deck • Cost effective • Allows use of cladding	• Low landing position • Visually low impact • Arch creates pleasant experience • Lowest east bank ramps • Cost effective • Simple construction & installation	• Statement structure • Dramatic structure allows light detailing of rails and guard rails • Low landing position • Vertical "windows" frame local views	• Cable stay allows flexibility for deck design • Statement structure • Create focal point for west bank
Cons	• c. 1m deep • Major visual impact • Increased ramp heights & length on east bank (+10 to 20m)	• Design to improve visual permeability • Not a statement structure	• c. 2.8m in height at apex • Major visual impact • Increased cost (steel & fabrication)	• c. 0.5m deep deck - ramp heights • Major visual impact on skyline (c.15m), conflict with historic sites • Major works for pylon foundations • Complex design • Significant cost • Impact on road/traffic on west

5.3 Emerging Preferred Option

Following review of the four developed options, and in particular review of visualisation, it is considered the **Arched Lattice Truss** should be recommended as the emerging preferred option.

In summary the following characteristics of the lattice truss have highlighted it as the most suitable structural and architectural option. This is considering the various constraints (both financial and environmental) at the proposed site:

- Low visual impact, and suitable for centre of Kilkenny City
- Cost effective
- Low impact on River Nore flood constraints
- Straight forward construction

APPENDIX A DRAWINGS

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NOTES

Revision Details	By / Check	Date	Suffix

CONSTRUCTION RISKS	MAINTENANCE / CLEANING RISK	DEMOLITION RISKS

In addition to the hazard/risks normally associated with the types of work detailed on this drawing take note of above. It is assumed that all works on this drawing will be carried out by a competent contractor working, where appropriate, to an appropriate method statement.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

Purpose of issue: FOR INFORMATION

Client:

Project Title: KILKENNY CITY PEDESTRIAN BRIDGE

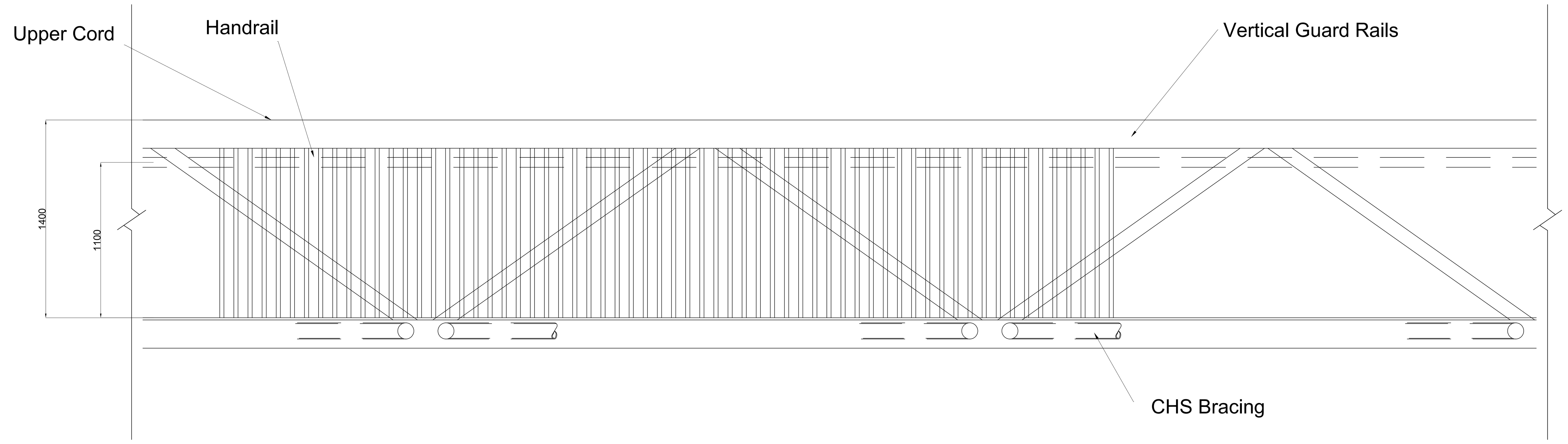
Drawing Title: SCHEME LOCATION PLAN (OS MAPPING)

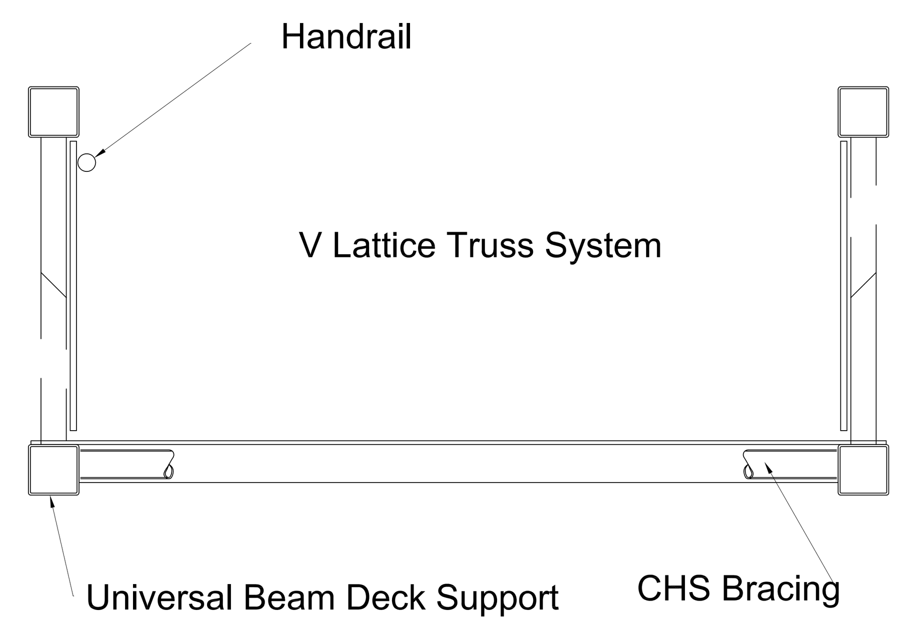
Designed	Drawn	Checked	Approved	Date
RS	RS	EG	MLR	25/10/2012

URS Internal Project No.: 47061456
Suitability:
Scale @ A1: 1:500
Zone / Mileage:

URS Infrastructure & Environment UK Limited
Iveagh Court
6-8 Harcourt Road
Dublin
01 415 5100
01 415 5101
www.ursglobal.com

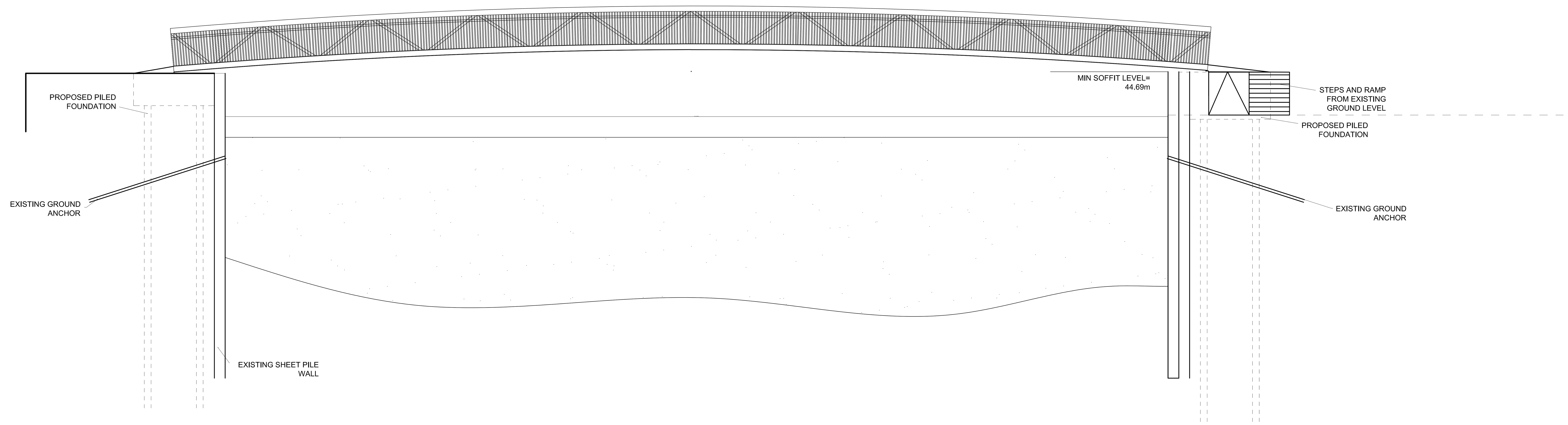
Drawing Number: 47061456/P8/100-2
Rev: P0





Partial Elevation
Scale 1:25

Section
Scale 1:25



Elevation
Scale 1:100

CONSTRUCTION RISKS	MAINTENANCE / CLEANING RISK	DEMOLITION RISKS

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SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

NOTES

This drawing is for preliminary purposes only and is subject to amendment during design development. UNDER NO CIRCUMSTANCES MUST THIS DRAWING BE USED FOR CONSTRUCTION PURPOSES

Revision Details	By / Check	Date	Suffix

Purpose of issue

FOR DRAFT

Client

Project Title

KILKENNY CITY
PEDESTRIAN BRIDGE

Drawing Title

PROPOSED FOOT BRIDGE
PRELIM STRUCTURAL SECTIONS
LATTICE TRUSS

Designed	Drawn	Checked	Approved	Date
EG	MM	EG	EG	25/10/12

URS Internal Project No.	Suitability
47061456	N/A
Scale @ A1	**Zone / Mileage**
AS SHOWN	N/A

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Drawing Number: 47061456/P8/102
Rev: P0

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APPENDIX B INITIAL VISUALS

LATTICE TRUSS (ARCHED)

CABLESTAYED

BEAM

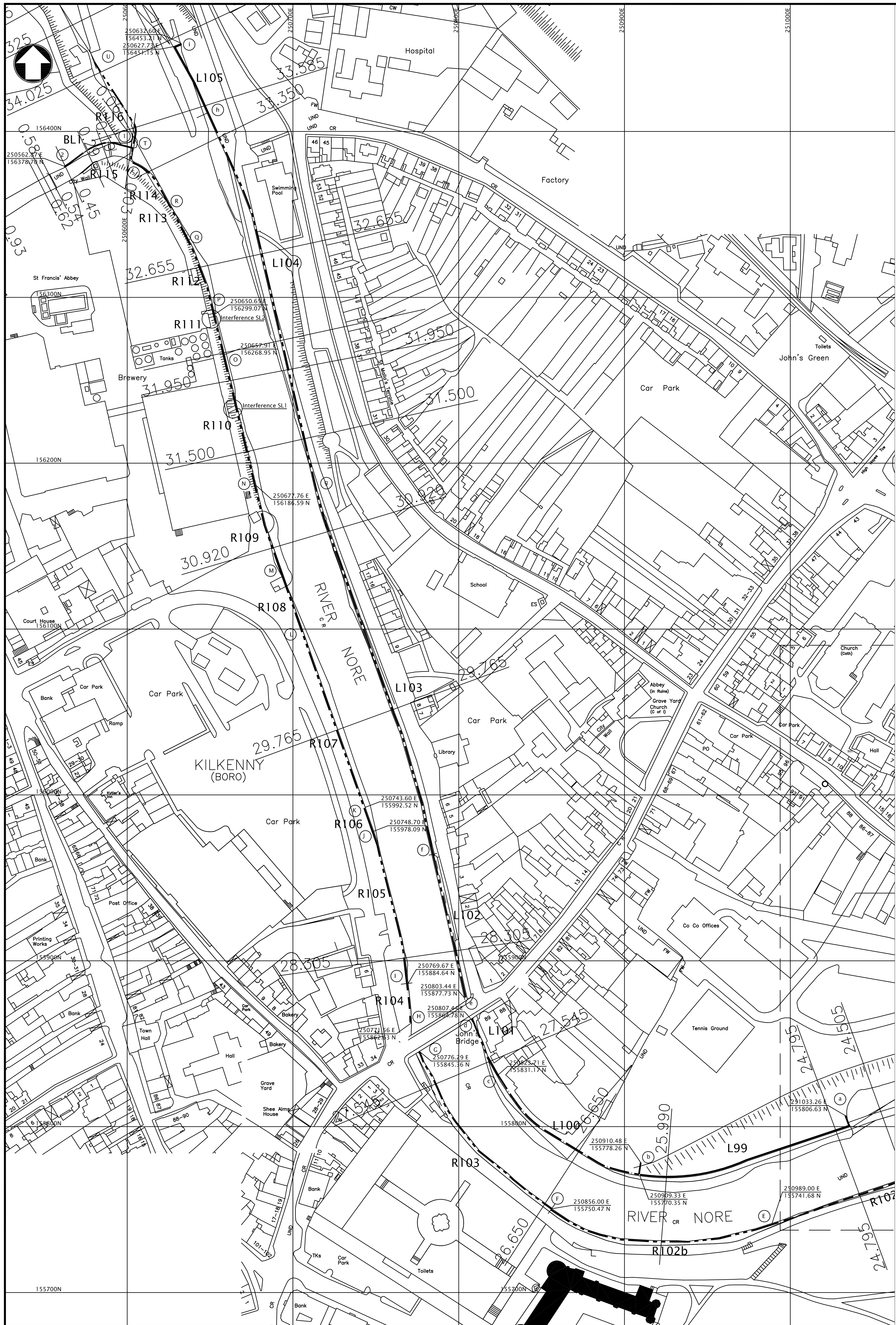
VIERENDEEL ARCH

APPENDIX C RNDS DRAWINGS

24203/MAR/041

24203/MAR/042

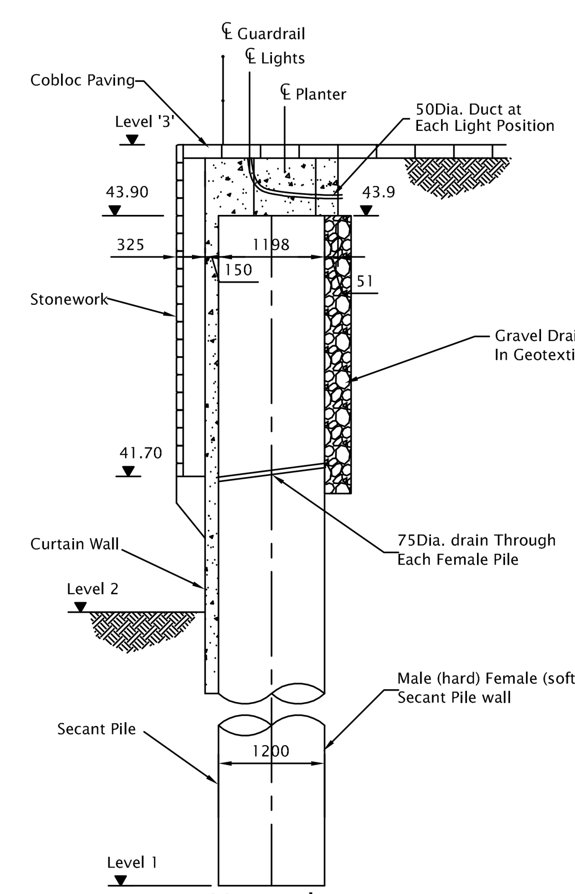
24203/MAR/043



Seacant Pile Walls								
Defence reference	Start Ref.	Finish Ref.	Significant Elevations					Capping Beam Type
			Level '1' No Rock (mAD)		Level '2' at start of structure	Level '2' at end of structure	Level '3'	
			Male	Female	(mAD)	(mAD)	(mAD)	
L100	b	c	28.2	35.3	38.3	38.3	44.625	B3
L101	c	d	28.2	35.3	38.6	38.6	42.450	B3

Anchored Sheet Pile Walls													
Defence reference	Start Ref.	Finish Ref.	Significant Elevations				Anchor Details					Capping beam type	Pile type
			Level '1' (mAD)	Level '2' Start of defence (mAD)	Level '2' End of defence (mAD)	Level '3' (mAD)	Working Load (Tw) (kN)	Inclination ∝ (deg.)	Free length 'L' (m)	Total length 'LT' (m)	Anchor Spacing (m c/c)		
L102	e	f	34.5	38.8	38.9	41.7	370.0	45.0	12.0	20	2.0	A11	Larssen LX25
L103	f	g	34.5	39.2	39.4	43.5	417.0	45.0	8.0	17.2	3.0	A12	Larssen LX25
L104	g	h	34.5	39.2	39.4	44.0	405.0	45.0	8.0	17.2	3.0	A13	Larssen LX25

Gabion Retaining Walls																
Defence reference	Start Ref.	Finish Ref.	Level '2' (mAD)	Level '3' (mAD)	Gabion Heights						Gabion Widths					
					'a' (m)	'b' (m)	'c' (m)	'd' (m)	'e' (m)	'f' (m)	'La' (m)	'Lb' (m)	'Lc' (m)	'Ld' (m)	'Le' (m)	'Lf' (m)
L105	h	i	39.4	44.0	0.5	1.0	1.0	1.0	1.0	1.0	1.5	2.0	2.5	3.0	3.5	4.0



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Seacant Pile Wall
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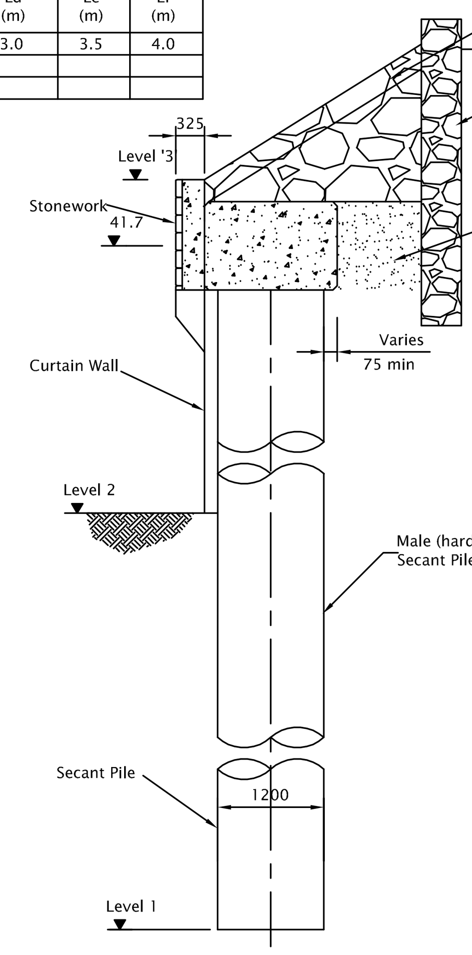
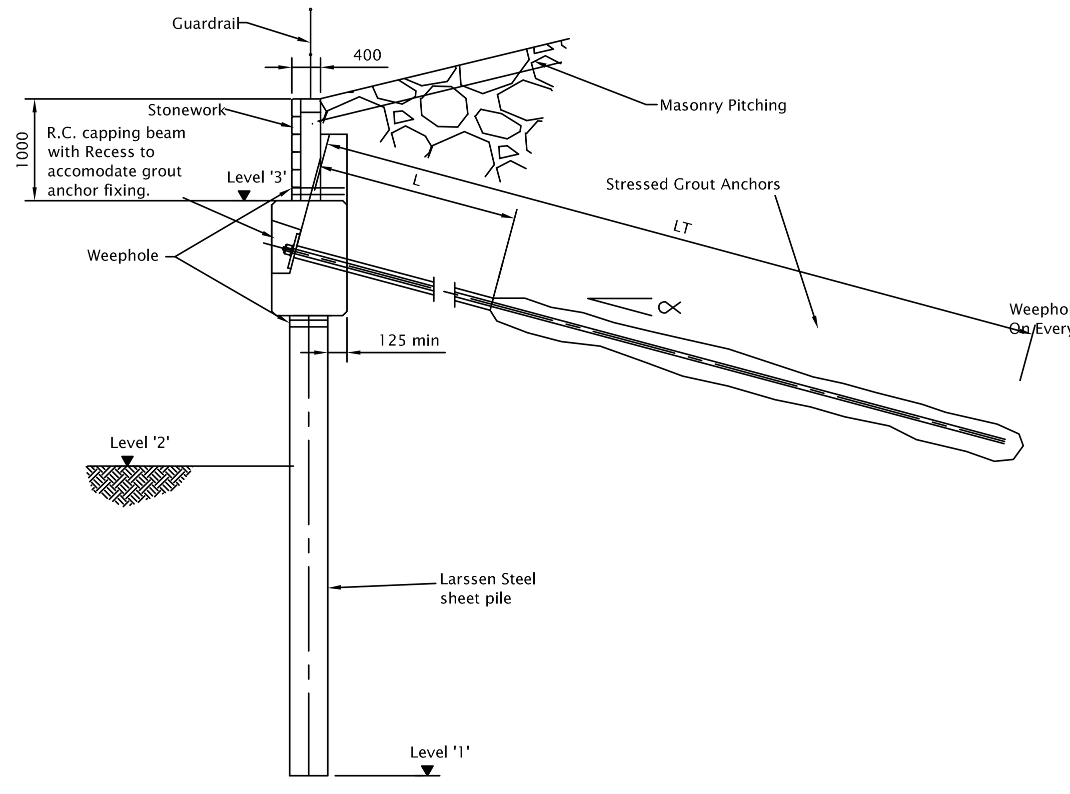
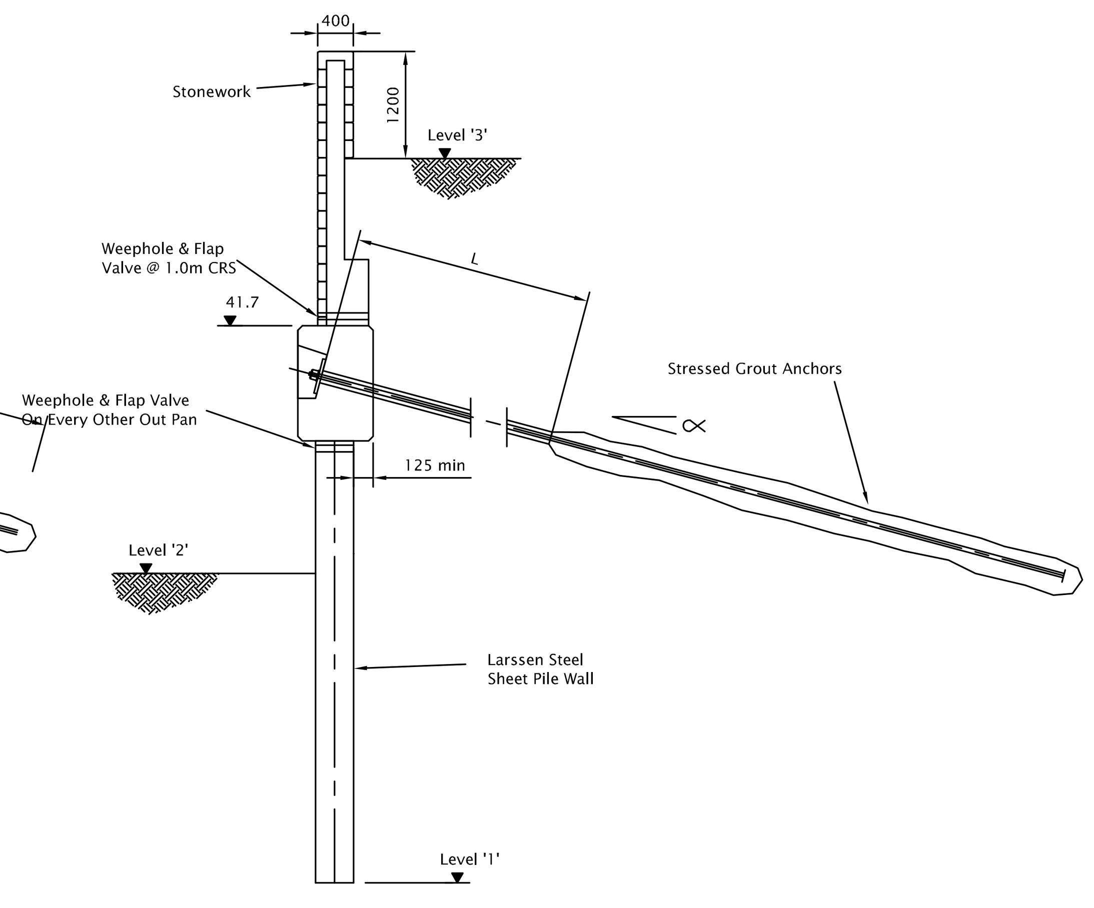


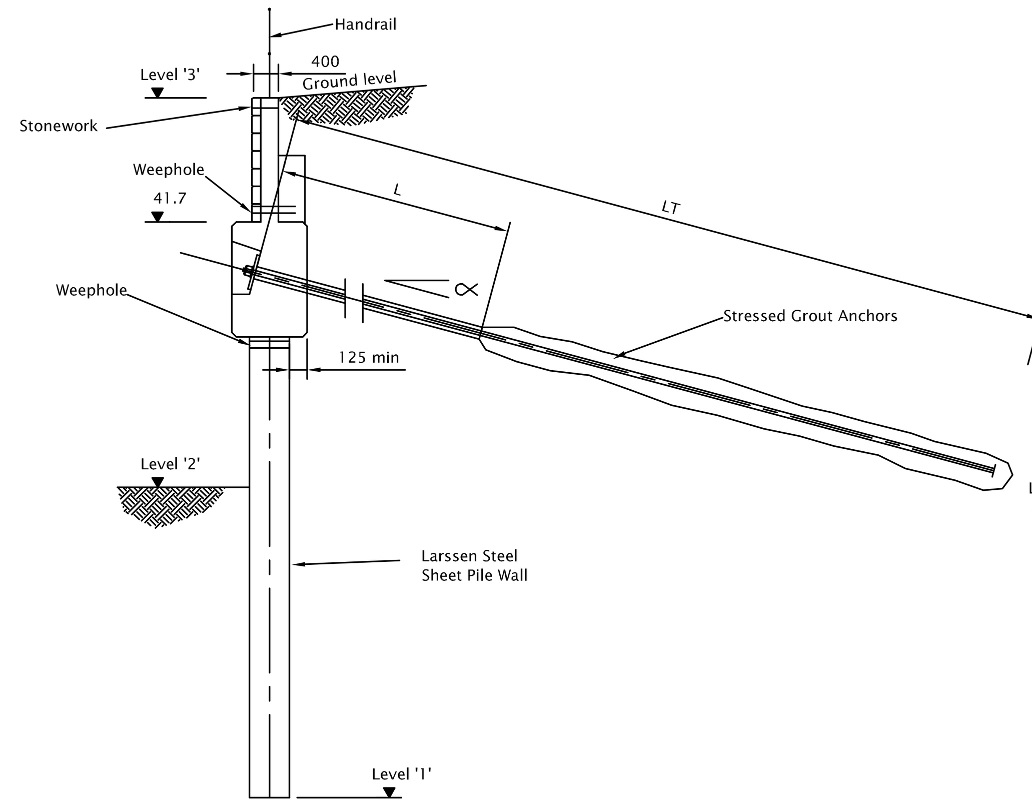
No rock
Defence Reference - L101
Seacant Pile Wall
1:50



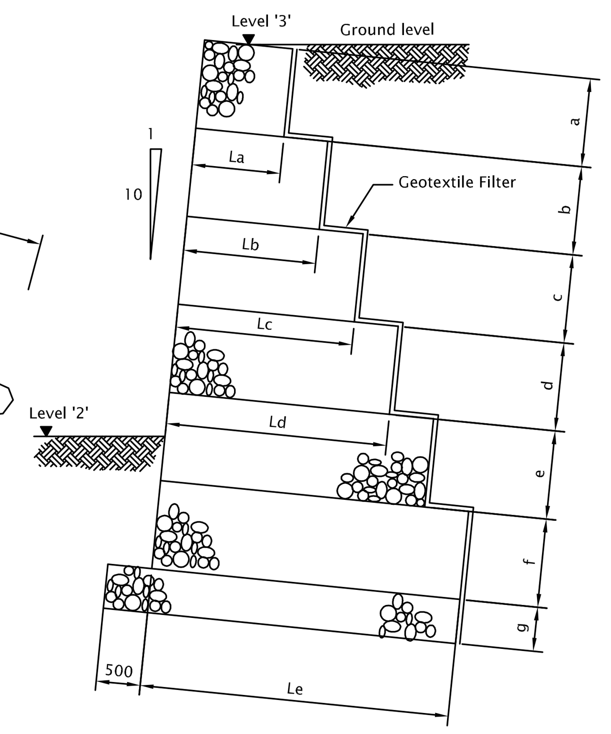
Defence Reference L102
Anchored Sheet Pile Wall - Typical Section
1:50



Defence Reference L103
Anchored Sheet Pile Wall with Concrete 'Stem' Wall
1:50



Defence Reference L104
Anchored Sheet Pile Wall with Concrete 'Stem' Wall.
1:50



Defence Reference - L105
Gabion Retaining Wall
1:50

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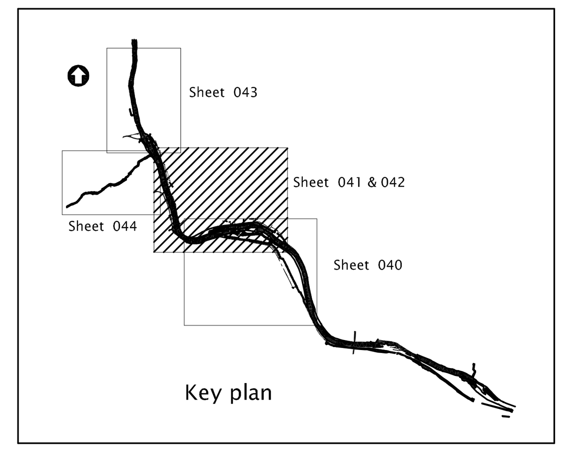
Notes

1. All dimensions are in millimetres.
2. All levels are in metres above Ordnance Datum.
3. Rock socket
   i) Rock at bed level: Provide rock socket detail (a).
   ii) No rock: Toe of pile taken to detail (b) elevation.
   iii) Rock between bed level and elevation of toe (b):
   A rock socket of length equal to that shown in detail (a) shall be installed unless this would take the toe level below that shown in detail (b) in which case socket is to be terminated at detail (b) toe level.
4. Design dredge levels: Dredge levels at start and finish of defence lengths are shown on the table. Dredged levels between these points will vary uniformly.
5. Bank elevation: Bank elevations shown on the table are the maximum level expected in the defence length.
6. Capping beam and cladding: Refer to River Wall Details on Drawing No. 045.
7. Alignment, Start and End Co-ordinates of each defence are approimate. Exact position to be confirmed on site.
8. All sheet piles shall be grade 43A.
9. For details of weepholes beneath Capping Beam to Steel Sheet Pile and Secant Pile wall see drawing No. 045.
10. For details of weepholes through 'Stem' wall see drawing No. 045.
11. For details of longitudinal drain behind 'Stem' wall on Defence L100 see drawing No. 045.
12. For Sequence of Construction of anchored sheet pile walls see notes on Drawing 24203/MAR/045.

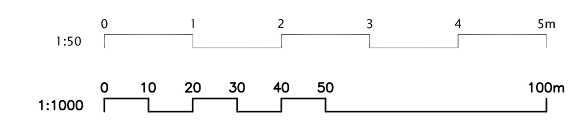
Key to symbols

- Anchored Sheet Piles
- Cantilevered Sheet Piles
- Anchored King Post Wall
- Gabion Walls
- Secant Piles

Note:
For Right Bank Defence Details See Drawing 042



Key plan



Rev	Date	Drawn	Description	Ch'k'd	App'd
AB	Jan. '06	CMcA	As Built	R.C.	G.R.

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Client
OPW Engineering Services
Design Section
Dublin.

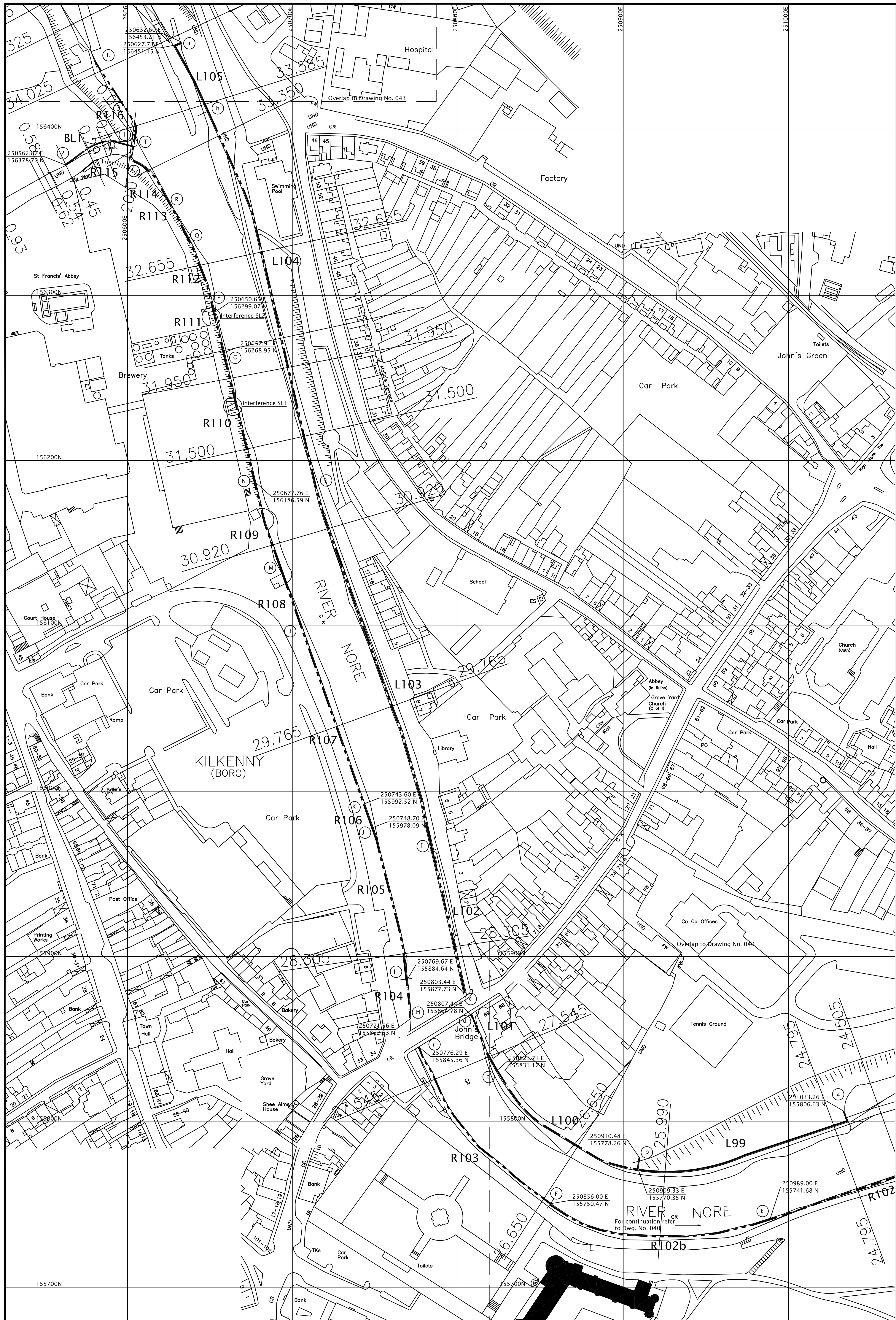
Title
RIVER NORE (KILKENNY CITY) DRAINAGE SCHEME

River Wall Details
Sheet 2

Designed	A A S	A A S	Eng.Chk.	SS	SS
Drawn	P M S	P M S	Coordination		
Dwg.Chk.	S S	S S	Approved	K W B	K W B

Scale 1:1000 | Project 24203 | CAD file 24203/DWGS/041 | Status ASB

Drawing No 24203/MAR/041 | Rev AB



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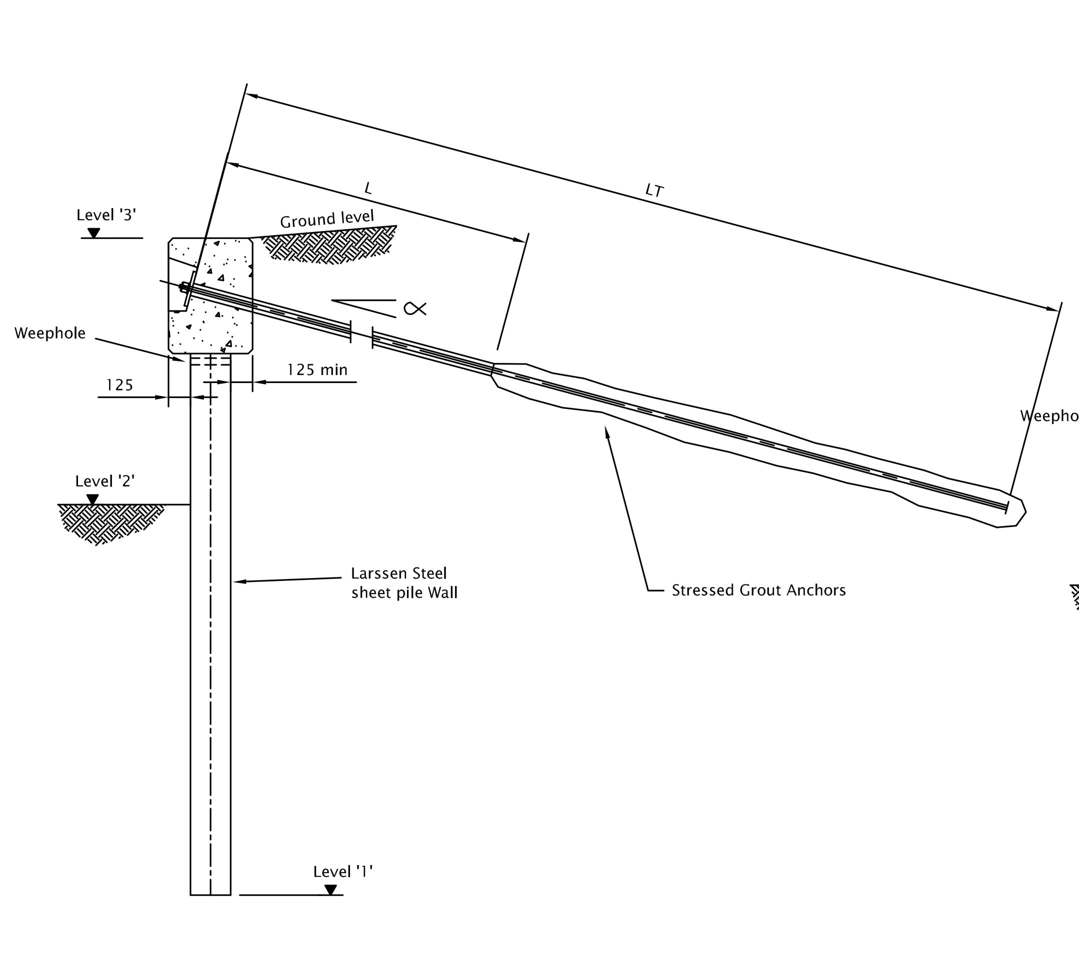
Anchored Sheet Pile Walls

Defence reference	Start Ref.	Finish Ref.	Significant Elevations: Level '1' (mAD)	Level '2' Start of defence (mAD)	Level '2' End of defence (mAD)	Level '3' (mAD)	Anchor Details: Working Load (Tw) (kN)	Inclination ∝ (deg.)	Free length 'L' (m)	Total length 'LT' (m)	Anchor Spacing (m c/c)	Capping beam type	Pile type
R102b	E	F	35.5	38.7	38.8	41.7	363.0	30.0	8.0	17.0	3.0	A3	Larssen LX20
R103	F	G	35.5	38.8	38.9	41.7	340.0	30.0	8.0	17.0	3.0	A3	Larssen LX20
R105	I	J	32.0	38.9	39.0	43.2	399.0	45.0	8.0	17.2	3.0	A13	Larssen LX25
R106	J	K	32.0	39.0	39.0	43.75	399.0	45.0	8.0	17.2	3.0	A13	Larssen LX25
R107	K	L	30.0	39.0	39.1	43.75	471.0	45.0	8.0	18.2	3.0	A13	Larssen LX20

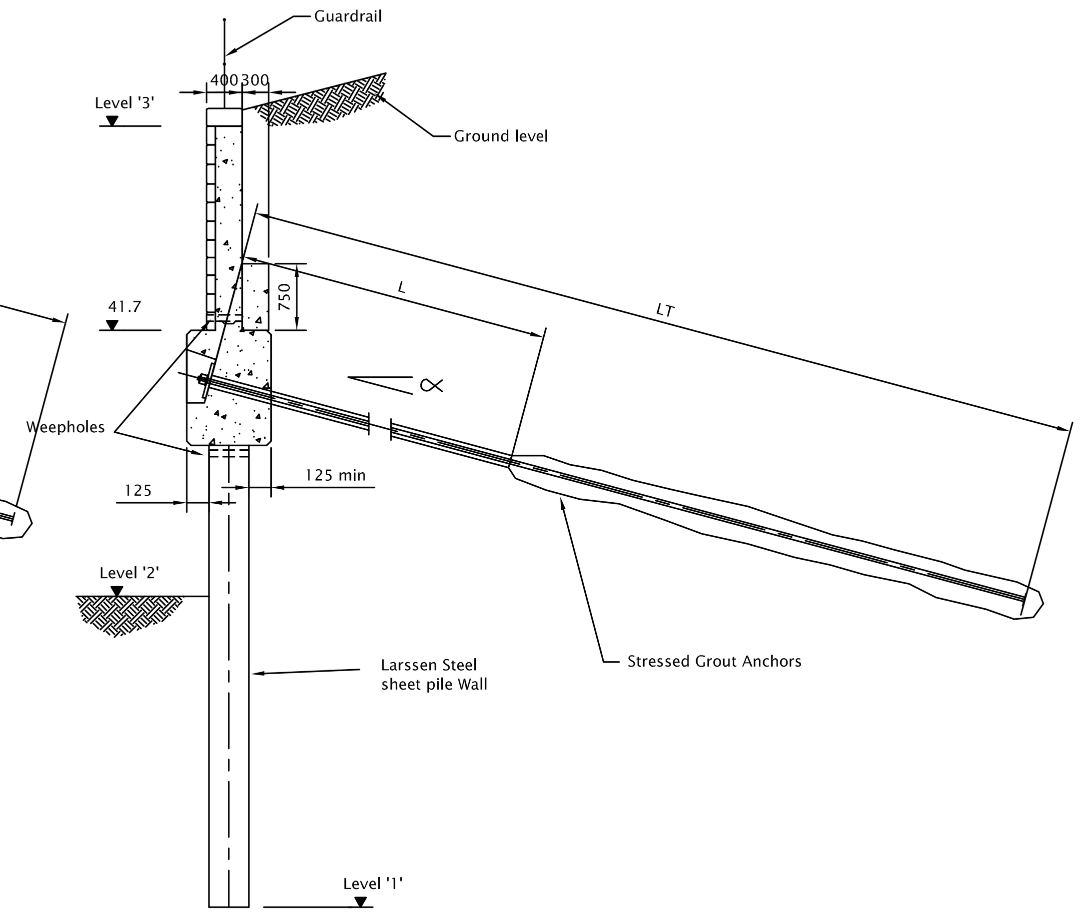
Cantilevered Sheet Pile Walls

Defence reference	Start Ref.	Finish Ref.	Significant Elevations: Level '1' (mAD)	Level '2' at start of structure (mAD)	Level '2' at end of structure (mAD)	Level '3' (mAD)	Capping Beam Type	Pile Type
R104	H	I	30.0	38.9	38.9	41.7	A8	Larssen LX25
R110	N	O	35.0	39.2	39.2	41.7	A3*	Larssen LX20
R111	O	P	35.0	39.2	39.2	41.7	A3*	Larssen LX20
R112	P	Q	35.0	39.2	39.3	41.7	A3*	Larssen LX20
R113	Q	R	35.0	39.3	39.4	41.7	A3*	Larssen LX20
R114	R	S	35.0	39.4	39.4	41.7	A3*	Larssen LX20
R115	S	T	36.0	39.8	39.8	41.7	A3a	Larssen LX20
R116	T	U	36.0	39.4	39.4	41.7	A3*	Larssen LX20

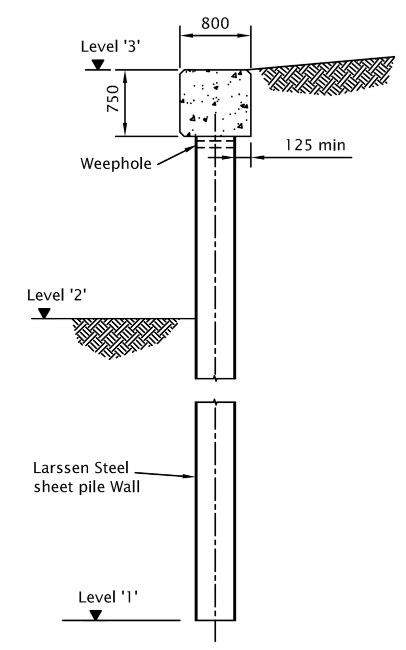
* - Anchor Holes Ommitted



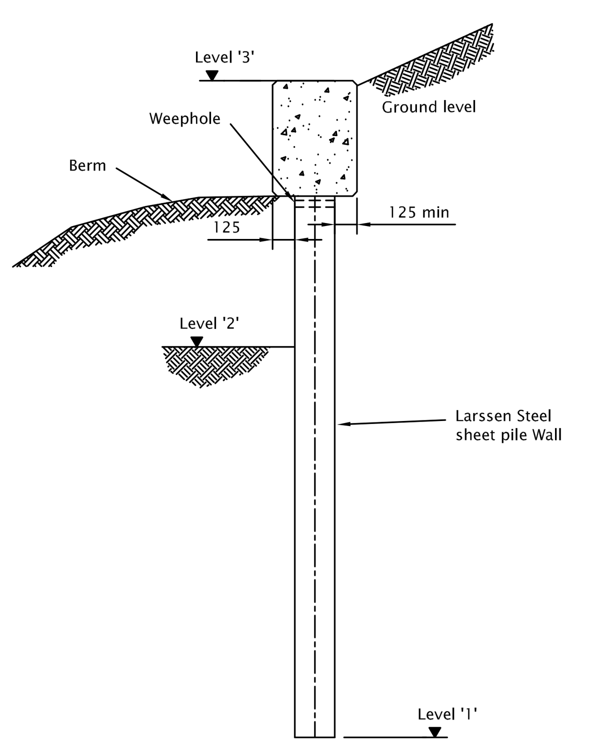
Defence Reference R102b and R103
Anchored Sheet Pile Wall
1:50



Defence Reference R105 to R107
Anchored Sheet Pile Wall with Concrete 'Stem' Wall.
1:50

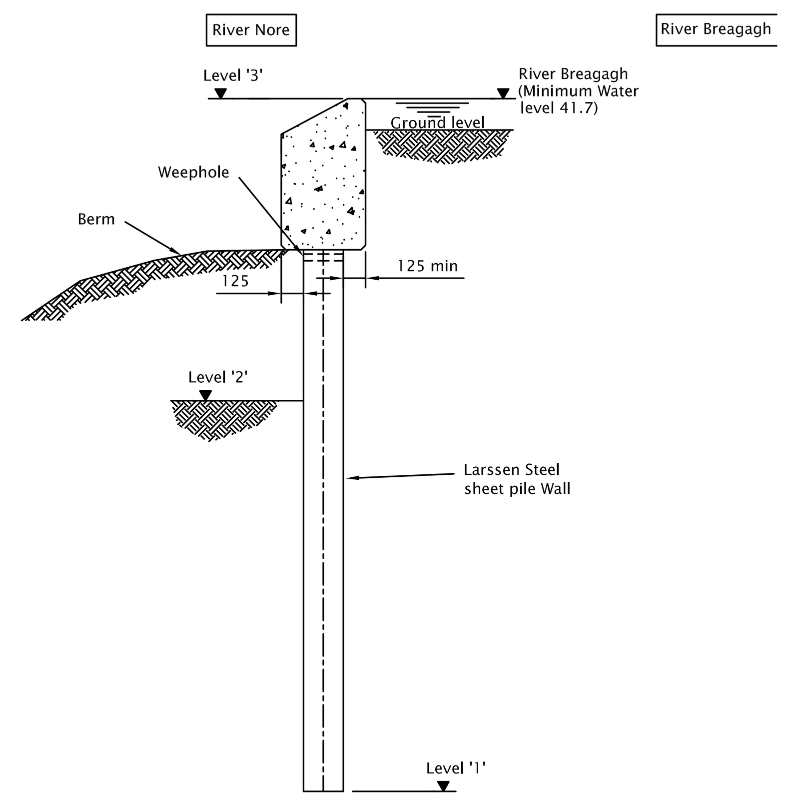


Defence Reference R104
Cantilever Sheet Pile Wall
1:50



Defence Reference R110 to R114 & R116
Cantilever Sheet Pile Wall
1:50

Refer to Drawing 124217/DUB/067 for Details of Berms infront of Sheet Pile Walls R110 to R116



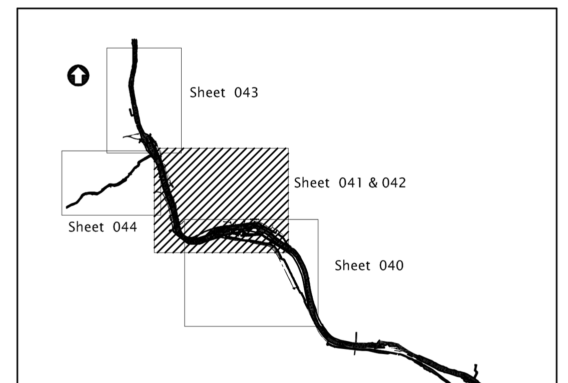
Defence Reference R115
Cantilever Sheet Pile Wall
1:50

Notes

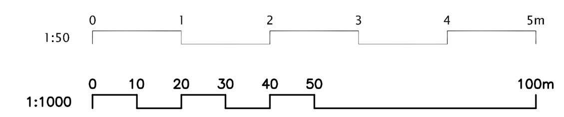
1. All dimensions are in millimetres unless noted otherwise.
2. All levels are in metres above Ordnance Datum.
3. Design dredge levels: Dredge levels at start and finish of defence lengths are shown on the table. Dredged levels between these points will vary uniformly.
4. Bank elevation: Bank elevations shown on the table are the maximum level expected in the defence length.
5. Capping beam and cladding: Refer to River Wall Details Sheet 045.
6. The installed face of masonry cladding is to be vertical.
7. All sheet piles shall be grade 43a.
8. For details of weepholes beneath Capping Beam to Steel Pile and Secant Pile Wall see Drawing No. 045.
9. For details of weepholes through 'Stem' wall see Drawing No. 045.
10. For scour protection in Defence length R115, refer to Drawing No. 24203/WEM/040 "River Breagagh Weirs".

Key to symbols

- Anchored Sheet Piles
- Cantilevered Sheet Piles
- Anchored King Post Wall
- Gabion Walls
- Secant Piles



Key plan



Rev	Date	Drawn	Description	Ch'k'd	App'd
AB	Jan. '06	CMcA	As Built	R.C.	G.R.

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Client
OPW Engineering Services
Design Section
Dublin.

Title
RIVER NORE (KILKENNY CITY) DRAINAGE SCHEME

River Wall Details
Sheet 3

Designed	A A S	A A S	Eng.Chk.	S S	S S
Drawn	MS	M S	Coordination		
Dwg.Chk.	S S	S S	Approved	K W B	K W B

Scale: As Shown	Project: 24203 / CAD file: 24203/DWGS/042	Status: ASB
Drawing No: 24203/MAR/042		Rev: AB

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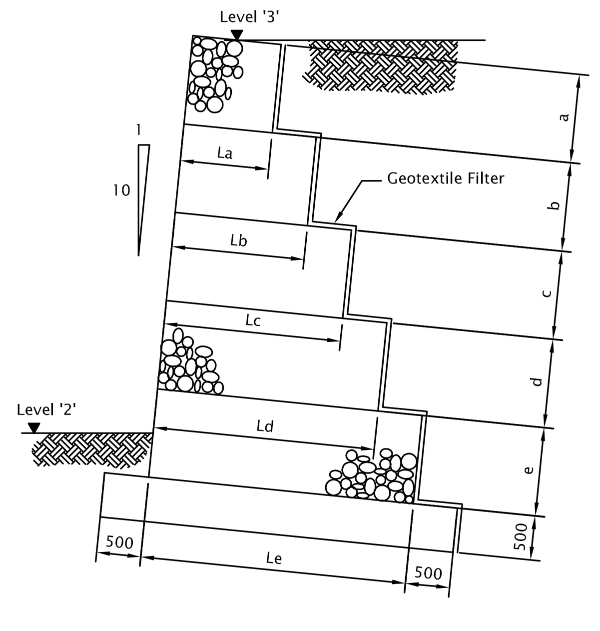
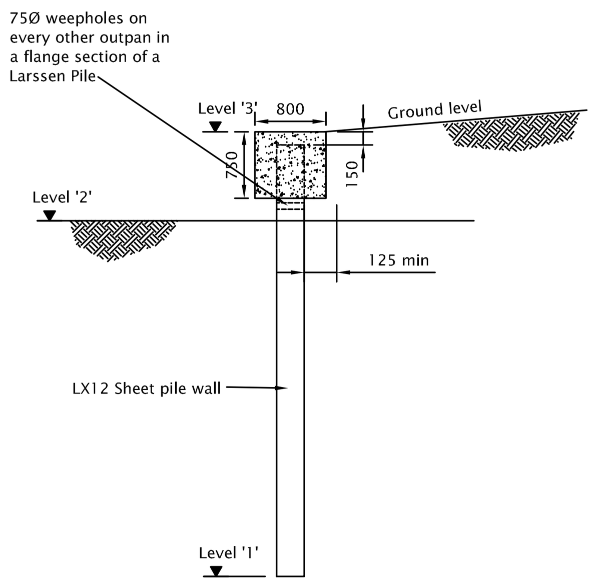
Cantilevered Sheet Pile Walls								
Defence reference	Start Ref.	Finish Ref.	Significant Elevations				Capping Beam Type	Pile Type
			Level '1' (mAD)	Level '2' at start of structure (mAD)	Level '2' at end of structure (mAD)	Level '3' (mAD)		
L106	j	k	37.2	41.0	41.0	42.0	A7	Larssen LX12

Gabion Retaining Walls														
Defence reference	Start Ref.	Finish Ref.	Level '2' (mAD)	Level '3' (mAD)	Gabion Heights					Gabion Widths				
					'a' (m)	'b' (m)	'c' (m)	'd' (m)	'e' (m)	'La' (m)	'Lb' (m)	'Lc' (m)	'Ld' (m)	'Le' (m)
L107	l	m	41.0	45.0	1.0	1.0	1.5	0.5	0.5	1.0	1.5	2.0	2.5	3.0
L108	m	n	41.0	45.0	1.0	1.0	1.5	0.5	0.5	1.0	1.5	2.0	2.5	3.0
L109	n	o	41.0	45.0	1.0	1.0	1.5	0.5	0.5	1.0	1.5	2.0	2.5	3.0
L110b	q	r	41.1	44.9	1.0	1.0	1.5	0.5	-	1.0	1.5	2.0	2.5	-
L110a	p	q	41.1	44.9	1.0	1.0	1.5	0.5	-	1.0	1.5	2.0	2.5	-



Gabion Retaining Wall Defence Reference - L107, L108, L109, L110a & L110b

1:50



Defence Reference L106

Cantilevered Sheet Pile Walls

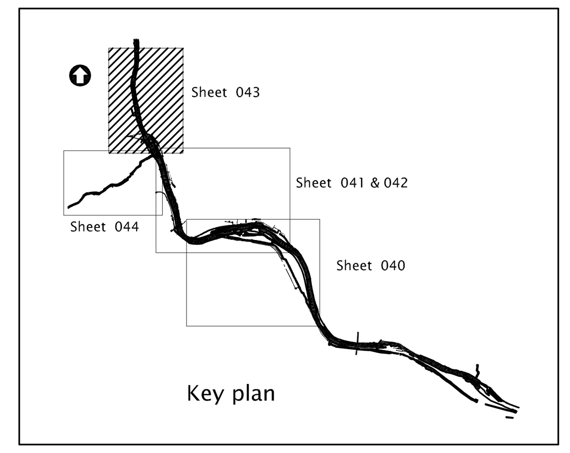
1:50

Notes

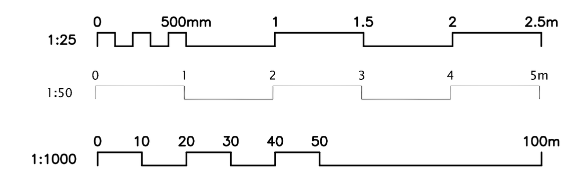
1. All dimensions are in millimetres.
2. All levels are in metres above Ordnance Datum.
3. Rock socket
   i) Rock at bed level: Provide rock socket detail (a).
   ii) No rock: Toe of pile taken to detail (b) elevation.
   iii) Rock between bed level and elevation of toe (b):
   A rock socket of length equal to that shown in detail (a) shall be installed unless this would take the toe level below that shown in detail (b) in which case socket is to be terminated at detail (b) toe level.
4. Design dredge levels: Dredge levels at start and finish of defence lengths are shown on the table. Dredged levels between these points will vary uniformly.
5. Bank elevation: Bank elevations shown on the table are the maximum level expected in the defence length.
6. Capping beam and cladding: Refer to River Wall Details Sheet 045.
7. King post piles and infill SSP steel shall be to the size specified and manufactured by Preussag or similar approved.
8. The sequence of construction of Anchored King Post Pile Wall shall be as follows unless otherwise agreed with the Engineer:
   (i) Bore hole through overburden down to rock head level, providing casing as necessary to prevent collapse of ground.
   (ii) Drill specified diameter hole through rock to the required depth.
   (iii) Position specified Peine PSp -Single Pile with Locking Bars in drilled hole accurately and concrete as required.
   (iv) Handle, pitch and drive Peine Intermediate Section PZ 612 sheet piles to key into rock, as specified.
   (v) Excavate down to formation level of capping beam.
   (vi) Cast capping beam.
   (vii) Drill and Install ground anchors and stress as specified and lock anchor at 20% working load and lock.
   (viii) Dredge river bed to specified level.
   (ix) Stress anchor to 110% working load and lock.
9. The installed face of masonry cladding is to be vertical.
10. All sheet piles shall be grade 43A.
11. For details of weepholes beneath Capping Beam to Steel Sheet Pile and Secant Pile wall see Drawing No. 24203/MAR/045.
12. For details of weepholes through 'Stem' wall see Drawing No. 045.

Key to symbols

- Anchored Sheet Piles
- Cantilevered Sheet Piles
- Anchored King Post Wall
- Gabion Walls
- Secant Piles



Key plan



Rev	Date	Drawn	Description	Ch'k'd	App'd
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Client

OPW The Office of Public Works Oifig na nOibreacha Poiblí

OPW Engineering Services
Design Section
Dublin.

Title

RIVER NORE (KILKENNY CITY) DRAINAGE SCHEME

River Wall Details
Sheet 4

Designed	A A S	A A S	Eng.Chk.	S S	S S
Drawn	MS	M S	Coordination		
Dwg.Chk.	S S	S S	Approved	K W B	K W B

Scale	Project	Status
As Shown	24203	ASB
	CAD file 24203/DWGS/043	

Drawing No 24203/MAR/043

Rev AB