ARUP

JBA consulting

KING'S ISLAND
FLOOD RELIEF SCHEME

King's Island Flood Relief Scheme
Environmental Impact Assessment Report
Volume 2 - EIAR Appendices

Final Report

December 2019

Comhairle Cathrach & Contae Luimnigh
Limerick City & County Council

OPW
Oifig na nOibreacha Poiblí
Office of Public Works

Appendices

A Outline Construction Method Statement
B Statutory Consultation Responses
C Biodiversity
D Surface and Groundwater
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A Outline Construction Method Statement

File Note

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Project title	Kings Island Flood Relief Scheme	Job number	265545-00
cc	Bernadette O'Connell Samuel McKeever	File reference	
Prepared by	Phoebe Watson Ken Leahy	Date	18 December 2019
Subject	Outline Method Statements		

1 Construction Phasing

As the nature of much of the proposed construction work is seasonal, to assess the potential construction impacts, it was considered important to consider two scenarios, one having a Spring stat date and another having an Autumn Start date. Therefore, two outline construction programmes have been developed. The first having an assumed construction start date in October 2020, resulting in a 21-month construction period, while the second, having an assumed construction start date in March 2021, having an 18-month construction period.

1.1 Key Constraints

Some of the time-sensitive construction constraints considered were as follows:

- The embankments need to be constructed as early as possible in the program to allow for reinstatement after phased construction, surcharging and settlement.
- Landscaping / re-seeding of river side embankment should be done at the beginning of summer to allow for vegetation establishment before the winter. Otherwise mitigation measures will be required to minimise silt run-off to the Shannon SAC.
- A3: pondweed needs to be moved before embankment in this area is constructed.
- A4: JK bund needs to be moved before embankment in this area is constructed.
- Works in the wetlands SAC: assume these need to be done in the summer, as the area will be regularly saturated over the winter
- A5: Pitches need to be relocated before embankment in this area is constructed. Disturbance to Star Rovers FC needs to be minimised and works carried out in off-season where possible.
- A6: Athlunkard BC works needs to be done in 2 phases to maintain vehicle access.
- A7: Minimise disruption to Absolute Hotel, although Hotel doesn't have a preferred season
- B2: Locke Bar would prefer works over the winter season

File Note

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- Jack up barge constraints of A9 and the Courthouse boardwalk at B3: limitation relating to the fisheries season here.
- Duration of works in the Potato Market in B3 will need to be minimised to reduce loss of parking and associated revenue generation.

2 General Method Statements

The following method statements outline the general construction process for a number of key aspects of the project which occur in multiple areas.

2.1 Construction of New Backing Wall to strengthen Historical Quay Walls

The following method statement will be applied to areas where a new mass concrete backing wall is required to augment an existing quay wall to provide a flood defence function (Note: a similar approach was successfully completed for the historical river wall at Verdant Place). This solution applies in parts of areas A10, B1, B2 and B3. The mass concrete backing working in conjunction with the existing key wall increases the mass and thus strengthens the existing historic quay walls to ensure that the combined structure has sufficient strength to withstand the various design load cases, including an allowance, where reasonably possible, for the future extension of the wall to accommodate increases in the design flood level due to climate change. The mass concrete will also act as a cut-off for seepage flow paths.

2.1.1 Step 1- Initial Quay Wall Stabilisation and Strengthening

- Clean vegetation from the face of the existing quay wall and remove loose mortar.
- Point the existing wall with mortar and replace any missing stone.
- Grout the wall by drilling small diameter vertical grout holes through the wall at 2m centres typically and allowing the grout to flow through the wall under gravity. (The location and centres of grout holes will be finalised following detailed localised SI and detailed design to ensure that the majority of the wall is grouted without risking grouting of the existing backfill behind the wall.)

The above works will give the existing quay wall additional strength and stability ahead of the subsequent stages of work. It will also decrease the porosity of the wall, reducing the risk of seepage through the wall during a flood event.

2.1.2 Step 2 - Mass concrete backing wall

- Excavate behind the now grouted quay wall in a supported excavation e.g. using a trench box or similar appropriately designed temporary works, to limit the extent of excavation. Full archaeological supervision of the works will be provided.
- During the excavation, the existing quay wall will also be supported where deemed necessary. (again with appropriately design temporary works(e.g. propping)
- The above will be undertaken in short discrete lengths (typically 3 to 6 metres at a time) to reduce the risk of destabilising the overall quay wall. This also assists in undertaking the excavation and backfill by working around the tide.
- Tide and river levels will be monitored during the works. Works can be halted and the excavation backfilled if there is deemed to be a risk to wall stability due to rising river levels. The works may need to be done over a number of tidal cycles.

- Mass concrete will be poured in approx. 1m lifts to limit the pressure on the existing wall from wet concrete and the risk of leakage.

2.1.3 Step 3 – Pressure grout Quay Wall

Following completion of the backing wall, if deemed necessary, further grouting of the existing quay wall can take place, using similar drilling techniques to the gravity grouting but by pumping the grout at higher pressures. A decision on the need for this will be made based on the quantities of grout used in the gravity grouting exercise and an examination of the back of the existing quay wall when the excavation for the backing wall is taking place.

2.2 Embankment construction

- Monitor weather and tides for periods of neap tides and high pressure when river levels are lowest.
- During a suitable window and in short lengths, remove the existing footpath, concrete stub wall and sand bags.
- Strip topsoil under the footprint of the embankment. Top soil stripping to be carried out under license with archaeological monitoring
- Construct the clay embankment in one of two ways:

Option A:

- In the first season, construct the lower portion of the proposed clay embankment to a level no lower than the current embankment crest level, and allow it to achieve initial consolidation by gravity over several months between seasons. In this case, the contractor will be obliged to manage flood risk, and may choose to use the existing sandbags as a temporary measure atop of the partially constructed embankment.
- Complete construction of the remainder of the embankment to flood defence level in the second season.

Option B

- Construct the embankment in one season to above final flood defence level, by placing additional fill above the design flood defence level and allow it to consolidate by monitoring, topping up the embankment if necessary where actual consolidation is greater than estimated.

- Place additional landscaping fill and topsoil to create an embankment with softened side slopes. A biodegradable erosion protection matting may be used on the river side of the embankment to aid establishment of the grass root system.
- Construct a new asphalt footpath on compacted hardcore on top of the embankment, as well as along access paths in specified locations.
- Install ducting for future cctv and lighting along the footpath, ensuring that no preferential flow path for water is created.
- Install lighting
- Top up topsoil and grass seed.

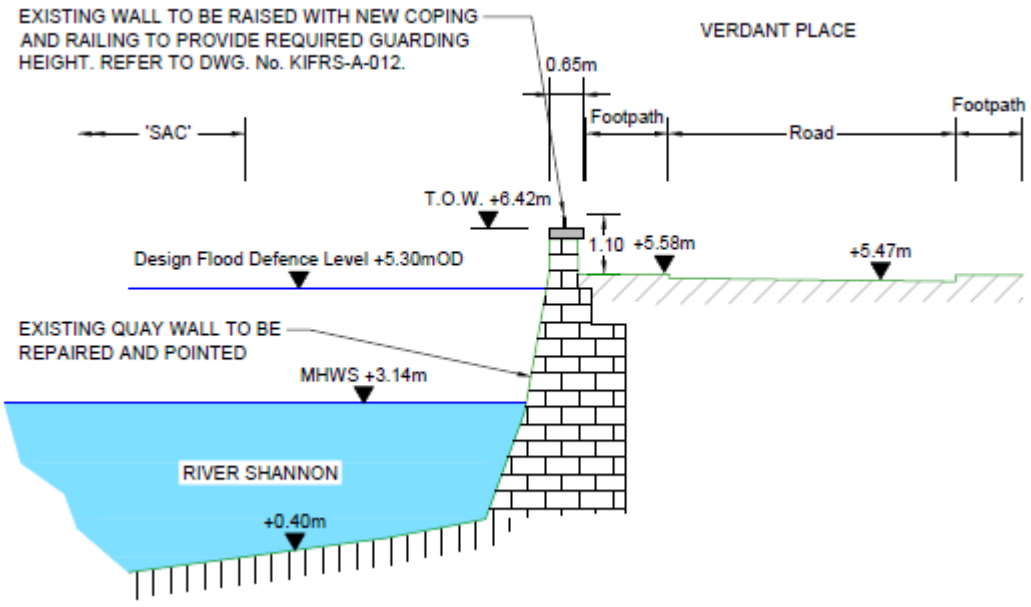
- Install land drainage at the dry-side toe of the embankment

3 Method Statement for each Area

3.1 Area A1 Thomond Bridge / Verdant Place

1. Clean vegetation from the face of the existing wall and remove loose mortar
2. Point the existing wall with mortar and replace any missing stone.
3. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
4. Remove the existing railing over an approx. length of 40m between Thomond Bridge and the new flood defence wall at Verdant Place
5. Install a concrete coping on top of the existing wall over the same length.
6. Paint both the wet and dry sides of the coping over the full length of Verdant Place. Work to be carried out from the dry side using a mobile platform as necessary.
7. Install a safety railing on top of the 40m length of new coping to meet the 1.1m pedestrian guarding height required for the scheme.

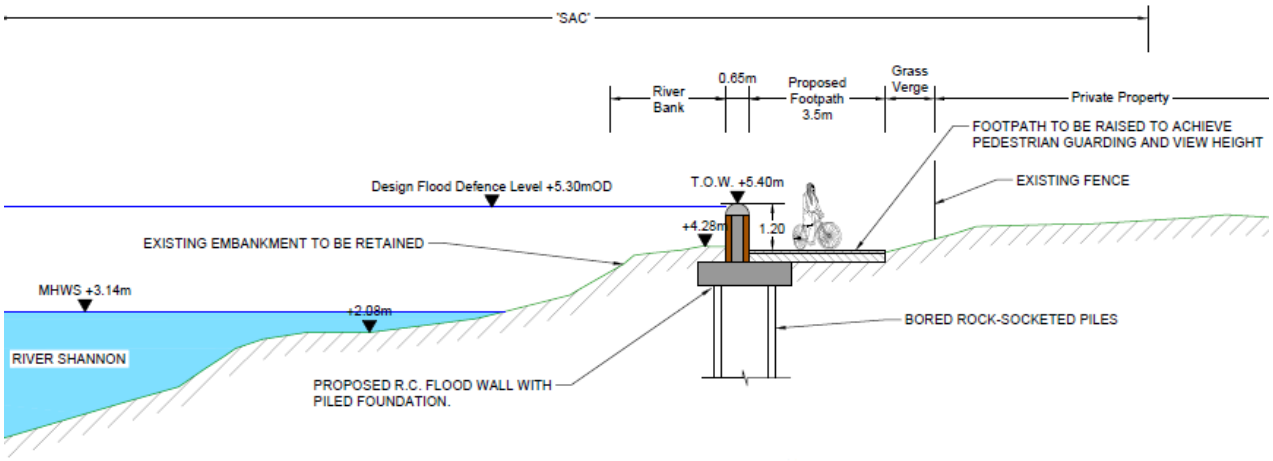
Figure 1: Area A1 Thomond Bridge / Verdant Place



3.2 Area A2 Verdant Place / Creche

1. Remove the existing footpath, sandbags, concrete stub wall, temporary barriers and shallow obstructions
2. Construct a piling platform at the northern end of this section to allow for piling at the embankment tie-in section. Temporary sheet piles may be required. The piling platform will consist of a layer of granular material which will be reinforced with geotextiles if necessary.
3. Install two rows of bored, rock-socketed concrete piles along the full length of the wall. The piles will be constructed of in-situ reinforced concrete.
4. Cut down the top of the piles (where necessary) and cast an in-situ reinforced concrete capping beam and flood defence wall.
5. Remove all suitable excavated material to a stockpile for reuse as general fill where possible.
6. Clad the wall with stone as per relevant pattern identified on the relevant drawings.
7. Install drainage and lighting as required.
8. Install a new bitmac footpath to a level 1.2m below the top of the new flood defence wall.

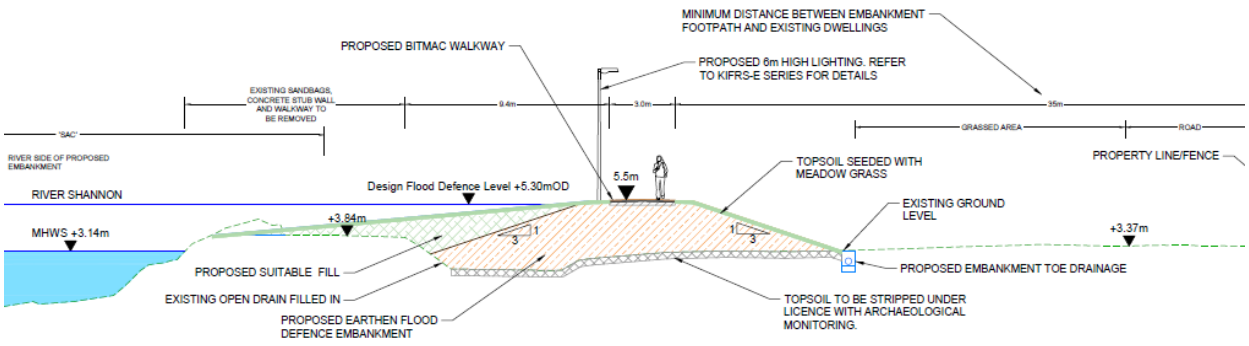
Figure 2: Area A2 Verdant Place / Creche



3.3 Area A3 North Western Embankment

1. Excavate a new open drain for the relocation of pondweed, to be lined with >1m of clay if necessary.
2. Relocate pondweed in accordance with NPWS requirements.
3. Remove the existing footpath, concrete stub wall and sand bags.
4. Strip the topsoil under the embankment footprint under archaeological supervision
5. Construct the embankment core in shallow layers (typically 150mm to 300mm thick), compacting each layer.
6. Place additional landscaping to generate design profile of sinuous embankment
7. Construct a new bitmac footpath on top of the embankment, as well as access paths in specified locations.
8. Install ducting and lighting along the footpath.
9. Place topsoil and grass seed.
10. Install drainage at the dry-side toe of the embankment where no swale is present.

Figure 3: Area A3 North Western Embankment



3.4 Area A4 North Eastern Embankment

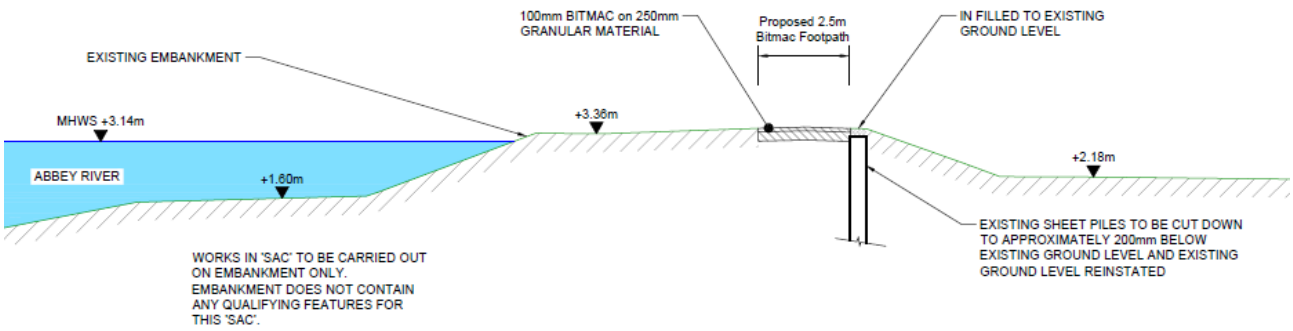
Where the proposed embankment is adjacent to the boundary of the SAC, in Area A4, the construction site boundary will be located a minimum of 1m from the SAC, outside the location of the toe of the embankment, on the SAC side of the embankment.

The embankment construction will typically be similar to the process described for Area A3.

3.4.1 Emergency sheet pile cutting-down works

1. Excavate material from either side of existing sheet piles to maximum width of 500mm, to depth of 300mm below existing ground level.
2. Cut sheet piles to 200mm below ground level.
3. Backfill above sheet piles.
4. Install bitmac footpath on compacted hardcore, 2.4m wide.
5. Carry out minor landscaping works to recreate a smooth surface over the sheet piles, at both ends of the sheet piled area, and remove any significant difference in levels between the two sides of the sheet piles.
6. Remove the current fence and gate to reopen access to the public.
7. LCCC to monitor and maintain on a regular basis

Figure 4: Emergency sheet pile cutting-down works



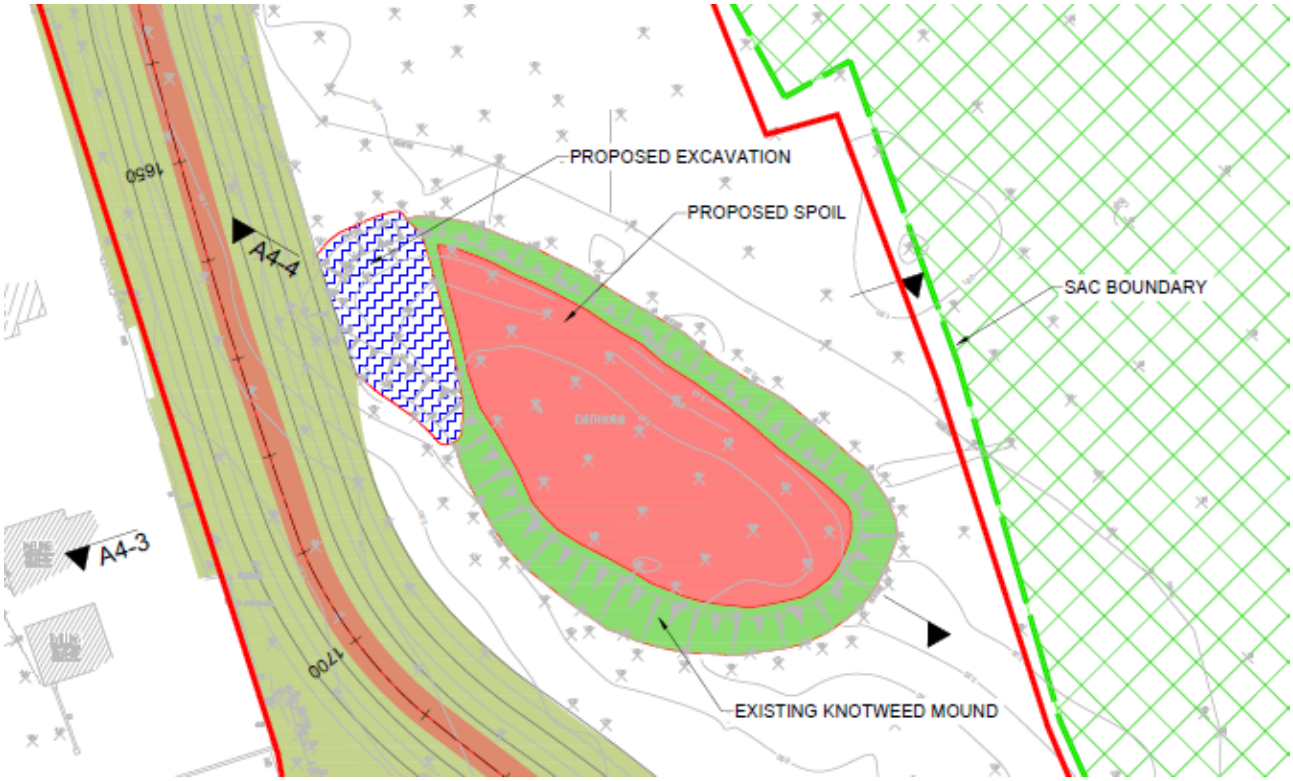
3.4.2 Japanese Knotweed bund

Appropriate environmental measures for working in an area of Japanese Knotweed to be implemented for this section of the works, such as vehicle washing, exclusion zones etc. Such works to be monitored by a site ecologist.

1. Any visible growth of knotweed to be sprayed or injected in advance of the works.
2. Excavate the north-western section of the bund to required depth determined by specialist (could be up to 4m below ground level.)

3. Place root barrier membrane over the excavated section of knotweed bund. Replace any root barrier membrane damaged by the works.
4. Relocate contaminated material by spreading on top of existing bund, allowing a 1m ledge between existing slope and new slope for spraying access. The maximum height of new material to be 1m above existing bund level.

Figure 5: Japanese Knotweed bund Option A

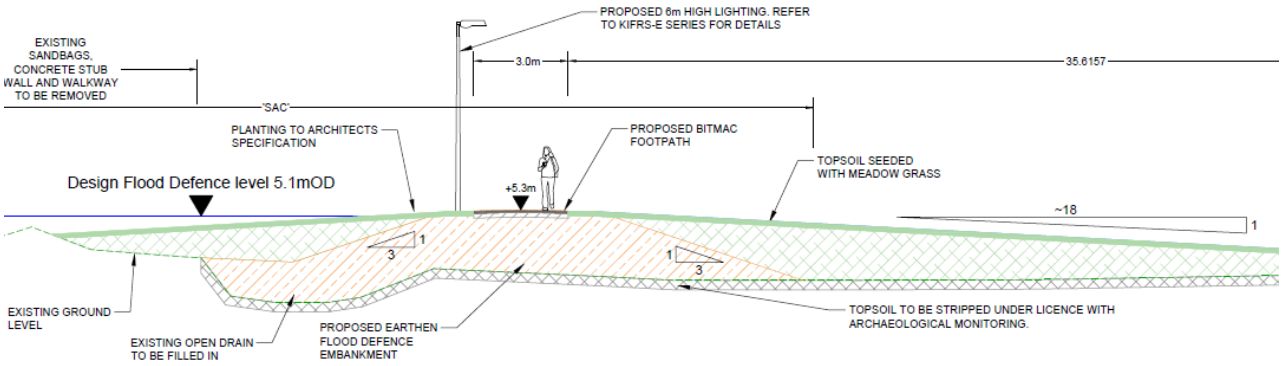


3.5 Area A5 Star Rovers FC

Where the proposed embankment is adjacent to the boundary of the SAC, in Area A5, the construction site boundary will be located a minimum of 1m from the SAC outside the location of the toe of the embankment, on the SAC side of the embankment.

1. Relocate pitches and AstroTurf as per the agreement with Star Rovers FC.
2. Remove the existing footpath, sandbags, concrete stub wall and shallow obstructions over the width of the proposed embankment.
3. Fill in the existing drain east of the Star Rovers pitch with embankment fill
4. Construct the embankment similar to other areas.

Figure 6: Area A5 Star Rovers FC



3.6 Area A6 Athlunkard Boat Club

3.6.1 Northern section – Phase 1

1. Secure site boundary and relocate site access as per the agreement with Athlunkard Boat Club.
2. Demolish the boundary wall of Athlunkard boat club to the north of the existing access (allowing access to remain to the boat club facilities through existing access)
3. Remove the existing footpath, sandbags, concrete wall and topsoil over the width of the proposed works.
4. Install two rows of bored, rock-socketed concrete piles along the full length of the flood defence wall and the proposed retaining wall. The piles will be constructed of in-situ reinforced concrete.
5. Cast an in-situ reinforced concrete capping beam and flood defence wall / retaining wall.
6. Construct the embankment
7. Install lighting along the access route / footpath
8. Construct a new vehicle access route / footpath on top of the embankment.
9. Build up the wall to 2.75m above ground level in fair-faced masonry.
10. Clad the western face of the wall in stone as per the relevant drawings

3.6.2 Southern section – Phase 2

1. Once the new northern access route is established, secure the southern portion of the site as per the agreement with Athlunkard Boat Club.
2. Demolish the remainder of the existing boundary wall of Athlunkard boat club.
3. Remove the existing footpath and topsoil over the width of the proposed works.
4. Install two rows of bored, rock-socketed concrete piles along the full length of the wall. The piles will be constructed of in-situ reinforced concrete.
5. Cast an in-situ reinforced concrete capping beam and flood wall to the required level.
6. Build up the flood wall to 2.75m above ground level in fair-faced masonry.
7. Clad the outer face of the flood defence wall as per the architect’s requirements.
8. Construct a new bitmac footpath / vehicle access route and any required drainage.
9. Install lighting along the footpath.

3.7 Area A7 Sir Harry's Mall

1. Locally excavate the road surface and footpath to the rear of the existing flood defence wall to provide space for the proposed in-situ reinforced concrete shear key.
2. Install an in-situ reinforced concrete shear key to strengthen the existing wall, connected by dowels to the existing wall foundation.
3. Install horizontal strengthening dowels on the river side, using a mobile platform from the land-side.
4. Drill vertical dowels into the top of the existing wall.
5. Cast an additional layer of in-situ reinforced concrete, approximately 300mm high, on top of the existing wall
6. Clad the top and dry side of the wall in stone as per the relevant drawings
7. At the southern end, construct the new raised footpath and access ramp using in-situ mass concrete.
8. Install lighting along the footpath
9. Reinstate the existing road.

3.8 Area A8 Absolute Hotel

1. Remove the paved footpath surface on the access ramp at both sides of the boardwalk.
2. Carry out minor local re-grading of the ground to meet the required flood defence level.
3. Relay the footpath paving.

3.9 Area A9 South of Absolute Hotel

It is proposed to use a land-transportable jack-up barge for this section of construction.

1. Prepare the proposed slipway for boat access during construction.
2. Assemble the jack-up barge at the proposed location and launch. Machinery to be transferred to and from the barge at the same location.
3. Secure jack up barge in working position in the channel.
4. Clean vegetation from the face of the existing wall and remove loose mortar.
5. Demolish the existing masonry parapet to approx. 800mm below footpath level
6. Point the existing quay wall with mortar and replace any missing stone.
7. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity.
8. Install two rows of mini piles behind the existing quay wall.
9. Cast the in-situ reinforced pile cap and R.C. wall atop of the old quay wall, set back from its face to allow for the thickness of the cladding and minor differentiate in the external alignment to distinguish between the old quay wall and the new parapet.
10. Clad both sides of the wall with stone laid to course as per the relevant drawings.
11. Install or reinstate lighting.
12. Reinstate the footpath behind the wall.

3.10 Area A10 Abbey Bridge to Baal's Bridge

3.10.1 Section of new parapet wall

1. Remove the existing trees.
2. Clean vegetation from the face of the existing wall and remove loose mortar.
3. Point the existing wall with mortar and replace any missing stone.
4. Demolish the existing masonry parapet to approx. 800mm below footpath level.
5. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity.
6. Excavate at the back of the wall and cast the in-situ reinforced concrete backing wall
7. Clad both sides of the wall in stone as per the relevant drawings
8. Install or reinstate lighting.
9. Plant new trees in lined root boxes.
10. Reinstate the footpath behind the wall.

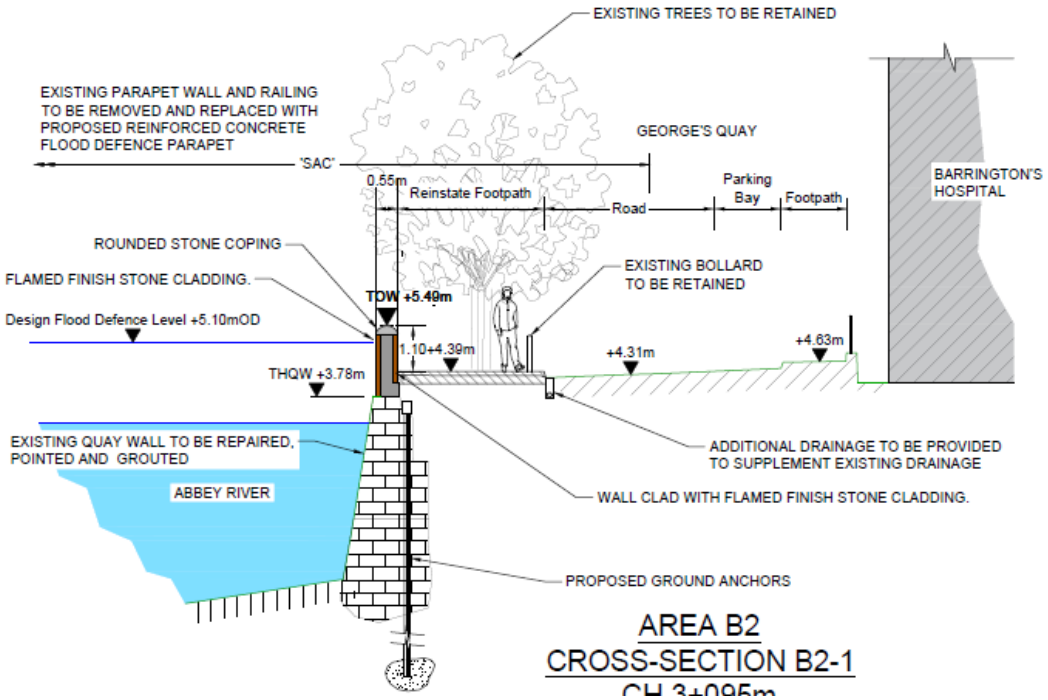
3.11 Area B1 &B2 George's Quay

There are typically 3 different types of defence solutions along George's Quay. Each type is described below.

3.11.1 Ground anchor system

1. Prune trees as per the arborist recommendations, to allow sufficient head room for construction.
2. Clean vegetation from the face of the existing wall and remove loose mortar.
3. Point the existing wall with mortar and replace any missing stone.
4. Remove the existing parapet to the level of the historic quay wall (approx. 600mm)
5. Excavate behind the wall at discrete locations to expose the back of the wall, approx. 1 – 1.5m, using hand-digging to avoid damage to tree roots.
6. Drill through the existing wall to install ground anchors. These anchors are expected to be circa 40mm in diameter.
7. Install steel ground anchors to approx. 5m below the toe level of the existing wall.
8. Grout the ground anchors in place.
9. Pressure grout the existing quay wall.
10. Construct an in-situ concrete parapet
11. Clad both sides of the wall in stone as per the relevant drawings
12. Reinstate the paved footpath behind the wall.

Figure 7: Proposed ground anchor system



3.11.2 Glass Flood Defence Panels

1. Remove or prune trees as required, in compliance with arborist's recommendations.
2. Clean vegetation from the face of the existing wall and remove loose mortar
3. Point the existing wall with mortar and replace any missing stone.
4. Remove the existing parapet wall to approximately 800mm below ground level.
5. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
6. Construct the mass concrete backing wall
7. Cast the in-situ reinforced concrete wall base and upstand for the base of the glass flood defence panels.
8. Fix the glass panels as per the manufacturer's instructions.
9. Finalise stone cladding elements.
10. Install lighting and drainage as required.
11. Install new trees in root boxes if required.
12. Reinstate the footpath.

3.11.3 Pontoon access area

1. Clean vegetation from the face of the existing wall and remove loose mortar.
2. Point the existing wall with mortar and replace any missing stone.
3. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
4. Construct the mass concrete backing wall and reinforced concrete flood wall.
5. Clad both sides of the wall in stone as per the relevant drawings
6. Install access steps
7. Install lighting and drainage as required.
8. Reinstate the footpath.

3.1 Area B3 Courthouse and Civic Buildings

All work works in this area are to be carried out under archaeological supervision.

3.1.1 Potato Market Viewing Platform

Note: there will be low head room in this working area.

1. Clean vegetation from the face of the existing quay wall and remove loose mortar.
2. Point the existing quay wall with mortar and replace any missing stones.
3. Grout the quay wall by drilling vertical grout holes through the rear of the quay wall and allowing the grout to flow through the wall under gravity.
4. Remove the existing cantilever viewing platform and railing.
5. Excavate behind the wall and construct mass concrete backing wall.
6. Construct reinforced concrete foundation and upstand for the connection of the glass flood defence panels.
7. Fix the glass flood defence panels as per the manufacturer's instructions.
8. Complete local stone cladding to upstand.
9. Install bollards to prevent damage to the glass panels by parking cars.
10. Reinstate the footpath / car park surface.

3.1.2 Access Ramp and Steps at Sylvester O'Halloran Bridge

1. Following archaeological test trenching, excavate existing car park surface to a shallow depth (circa 500mm) and construct a raft concrete foundation under the entire footprint of the proposed ramped and stepped access to Sylvester O'Halloran Bridge
2. Construct the remaining RC structures for the stepped access and a ramp.
3. Install stone cladding and coping to walls of ramped access
4. Install handrails.
5. Reinstate the footpath/car park surface surrounding the ramp.

3.1.3 Potato Market existing walls

3.1.3.1 Section to be retained

1. Clean vegetation from the face of the existing wall and remove loose mortar.
2. Point the existing wall with mortar and replace any missing stones.
3. Grout the quay wall by drilling grout holes through the rear of the quay wall and allowing the grout to flow through the wall under gravity.

3.1.4 Defence Wall adjoining Curragower Boat Club

1. Clean vegetation from the face of the existing boundary wall and remove loose mortar.
2. Point the existing wall with mortar and replace any missing stones.
3. Excavate for wall foundation under archaeological monitoring, founding at a suitable level on firm subbase.

   (It is possible that an old quay wall could be encountered during excavation. If this arises, the foundation will be omitted locally with the vertical element of the flood wall spanning horizontally between sections of foundation either side of any historic feature.)
4. Construct the in-situ reinforced concrete flood wall against the existing wall, but debonded using a separation membrane. To avoid excessive temporary loads on the existing wall, the new wall will be poured in lifts of 1m or less.
5. Construct a stone coping and clad the wall with stone as per the drawings.
6. Locally reinstate the carpark surface

3.1.5 Automatic Flood Gate adjoining Curragower Boat Club

1. Once the receiving piers at either end are completed as part of the relevant permanent flood defence wall, works can commence on construction of the flood gate as follows:
2. Excavate to shallow depth (circa 1m) to construct foundation pit for automatic flood gate.
3. Install the automatic flood gate and manual back-up as per the manufacturer’s instructions
4. Re-grade the existing road to create a table-top ramp around the flood gate.

3.1.6 Stone Clad Wall between Automatic Flood Gate and Courthouse

1. Clean vegetation from the face of the existing quay wall and remove loose mortar.
2. Point the existing quay wall with mortar and replace any missing stone.
3. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
4. Remove the existing railing

5. Excavate behind the existing quay wall and construct the mass concrete backing wall.
6. Construct the in-situ reinforced concrete flood defence wall
7. Fit Stone Coping and clad both sides of the wall with stone as per the relevant drawings.
8. Install lighting and drainage as required.
9. Reinstate the footpath.

3.1.7 Glass panels south of Courthouse

1. Clean vegetation from the face of the existing quay wall and remove loose mortar.
2. Point the existing quay wall with mortar and replace any missing stone.
3. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
4. Remove the existing railing.
5. Excavate and construct the mass concrete backing wall.
6. Construct the in-situ reinforced concrete wall base and upstand for the connection to the glass panels (This will be set back behind the existing top quay stone which will be exposed.)
7. Clad both sides of the upstand with stone as per the relevant drawings
8. Fix the glass flood defence panels as per the manufacturer's instructions.
9. Install lighting and drainage as required.
10. Reinstate the footpath.

3.1.8 Courthouse boardwalk

It is proposed that a road-transportable jack-up barge will be used to construct this section of the works due to the lack of working space around the courthouse.

1. Create a ramp access into the river for the jack-up barge at the proposed location.
2. Assemble the jack-up barge and launch.
3. Set up barge at construction location.
4. Demolish the existing boardwalk.
5. Clean vegetation from the face of the existing quay wall and remove loose mortar.
6. Point the existing quay wall with mortar and replace any missing stone.
7. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
8. Construct a line of bored concrete piles at circa 4m centres (intermittent with anchors previously installed for current boardwalk.
9. Construct the new cantilever base and upstand. (The underside of the new cantilever will be at the same level as existing to avoid any further removal of the historic quays.

10. Fix the glass flood defence panels as per the manufacturer's specification.
11. Clad both sides of the concrete upstand as per the relevant drawings.
12. Erect the railing separating the courthouse access from the public walkway
13. Reinstate the paving on both walkways.

3.1.9 Glass flood defence panels adjacent to Civic Buildings

1. Remove or prune existing trees as required.
2. Clean vegetation from the face of the existing quay wall and remove loose mortar.
3. Point the existing quay wall with mortar and replace any missing stone.
4. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
5. Excavate and construct the mass concrete backing wall
6. Construct the in-situ reinforced concrete wall base and upstand for the connection to the glass flood defence panels. (This will be set back behind the existing top quay stone which will be exposed.)
7. Clad both sides of the upstand with Stone as per the relevant drawings.
8. Fix the glass flood defence panels as per the manufacturer's instructions.
9. Install lighting and drainage as required.
10. Reinstate the footpath.

3.1.10 Area in Vicinity of old Mill and access bridge structure

1. To the northwest of the Civil offices, an historic Bridge links the old city wall (which is a National monument) to an historic Mill structure, the remains of which can just be seen protruding from the historic quay wall. An historic tunnel structure is also located in this area. All work in this area will be undertaken under supervision of a licensed archaeologist under ministerial consent.
2. Archaeological test trenching will be undertaken to define the plan extents and depths of any historic archaeological features. These features will all be recorded.
3. Once the features are clearly defined, a grillage of bored piles will be installed, which avoid the various features and provide a means to transfer the loads from the proposed flood walls to the lock level rock, without apply new loads to the historic features or without impacting such features.
4. A shallow reinforced concrete foundation will be constructed on the piles. A compressible filler material will be placed above the historical features to ensure that the reinforced slab is suspended between the piled supports above the features and does not transfer load directly to the features.
5. A new RC flood defence wall will be constructed from the shallow foundation.
6. The wall will be clad in stone as per the relevant drawings.
7. The existing quay wall will also be pointed and grouted where possible.

8. Where possible, in some locations, there will be localised short sections of glass flood defence barriers in lieu of the stone clad wall.
9. Install lighting and drainage as required.
10. A new paved area will be constructed to reduce the relative height of the flood defence parapet to 1100mm to maintain river views. The colour and texture of the paving material will be chosen to highlight the position of the underlying historic features.
11. Interpretation signage will be constructed to provide information on the historic features.

3.1.11 Glass flood defence panels adjacent to Civic Buildings

(Applies north of the area of the historic mill and bridge, and stops short of the existing Castle wall.)

1. Clean vegetation from the face of the existing quay wall and remove loose mortar.
2. Point the existing quay wall with mortar and replace any missing stone.
3. Grout the wall by drilling vertical grout holes through the wall and allowing the grout to flow through the wall under gravity
4. Excavate and construct the mass concrete backing wall
5. Construct the in-situ reinforced concrete wall base and upstand for the connection to the glass flood defence panels. (This will be set back behind the existing top quay stone which will be exposed.)
6. Clad both sides of the upstand with stone as per the relevant drawings.
7. Fix the glass flood defence panels as per the manufacturer's instructions.
8. Install lighting and drainage as required.
9. Reinstate the footpath.

File Note

265545-00 18 December 2019

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Phoebe Watson	Marie Murphy	Ken Leahy
Signature			

B Statutory Consultation Responses

Mr Ross Macklin,
Triturus Environmental
Services,
42 Norwood Court,
Rochestown,
Cork.
T12 ECF3

Iascach Intíre Éireann
Inland Fisheries Ireland

5 January, 2018

Re: Kings Island Flood Relief Scheme.

Dear Ross,

IFI has no objection in principle to providing flood protection for land and properties around Kings Island and Limerick city generally. Please note that we consider that we have not received all of the details of the proposed works or details in respect of land drainage and of the aquatic habitats in the drainage channels contained on Kings Island. A significant portion of the island is designated as an SAC. At this time our observations are based on the documents that we have received and which will be indicated in the submission below.

The Shannon in this area is considered a fishery. It is an important zone of passage for many fish species some of which are protected under national and EU Legislation. In particular this part of the Shannon is frequented by: adult salmon, salmon smolt, brown trout, potentially some sea trout, smelt, european eel, sea and river lamprey, pike, dabs, other small coarse fish or intertidal species. Some of the area will be important feeding grounds for some of these species moving up and down with the tide. The six-inch ordnance survey suggests that the top of the tidal influence is to the north of Kings Island. However, studies carried out for the construction of the Shannon tunnel suggest that the Shannon backs up in front of the tide and that there may be no significant salt water intrusion in this part of the Shannon. This suggests, notwithstanding the tidal influence, that the River Shannon around Kings Island (and the watercourses on the island) may be considered to be predominantly freshwater habitat.

The River Shannon in this area is an important amenity. Local anglers fish from: the riverbank, bridges and by wading into the River Shannon itself. Other water users will include: swimmers and kayakers rowing/sculling boats other pleasure craft and emergency services. IFI suggest that there are safety implications especially in regard people entering and using the River for angling or recreation purposes. Ardnacrusha power station is required to be on standby at all times and therefore may release water through the turbines at any time. This gives rise to a very rapid rise in water levels especially if there is an incoming tide at the same time. Anglers and other users who use the river must have safe access and egress but in particular must be able to get out of the river quickly and safely if there is a sudden rise in water levels.

IFI suggest that the above should be taken into account in the design of the embankment. Some consideration should also be given to providing an access ramp and ensuring that existing stairways to the river are maintained and are accessible. It should be noted that there are existing bathing areas along the west side of Kings Island. The new embankment must accommodate access to these bathing areas. In the past high levels of pathogenic bacteria inhibited the use of these bathing areas. However, with improvements in sewage treatment it is likely that these bathing areas will again become popular.
It is important to preserve the amenity value of the river and the works should provide opportunities for improved amenity access to the river.

IFI has the following observations and recommendations to make in respect of the outline proposals set out in the documents that we have received.

Embankment Alignments West Embankment Option 2 (offset from sandbags).

This appears to be a general plan giving an outline indication of the proposed works around Kings Island.

1. It is not clear how near to the water's edge (Ordinary summer levels) the actual new embankment will be. If the embankment is in close proximity to the river, IFI suggests that the toe of the embankment is armoured with large heavy limestone or sandstone. At least two or more layers of large rock (not less than one ton in weight) with the first layer embedded at least 450 mm below river bed level. This is to provide anti-scour and erosion protection.

2. If it is intended to construct the embankment away from the water's edge (except for tidal or high flood flows) it is likely that there will be little or no impact on the aquatic habitats except in the areas which have been specifically identified.

3. In the event that an encroachment onto the existing riverbed is likely to take place then particular attention must be given to juvenile lamprey ammocoetes which may be present in the sediments along the water's edge. An assessment of the presence or absence of juvenile lamprey and/or other fish may be required depending on the final design. As mentioned above the area is a zone of passage for fish and particularly salmon which will rest in this area and downstream above and below the Curragower falls.

4. These works have the potential to give rise to significant pollution especially in respect of silt and other surface water run-off from the proposed new road development over the river. Even where there is no direct contact with the water's edge methodologies to minimise silt run-off from embankment construction works especially after precipitation will need to be developed and agreed with the relevant authorities including IFI.

5. As sections of embankment are completed IFI strongly recommends that any exposed raw earth should be seeded with an appropriate grass seed as soon as possible. This will help to minimising silt run-off from the embankment works either to the Shannon or to the adjacent small watercourses on the island itself.

6. Generally, contractors should liaise with: the Local Authority, IFI and NPWS in respect of all methodologies for this development.

7. This plan provides some basic detail regarding the existing drainage from the island itself. On the eastern side there appears to be at least five straight drains and a ring drain all around the outer boundary of the island. A lot of the island is a designated SAC and the area to the east shows wetlands and drainage contiguous to the SAC. The importance of these wetlands or the drainage channels and their condition needs to be assessed. There is no clear indication of how the surface water discharges to the River Shannon. The location of discharge points and the type and condition of outlet valve if any that may be present needs to be determined. It is important to assess the fishery status in these channels as this could have implications for the type of discharge that would be permitted particularly in the context of the SAC and protected species such as lamprey.
   Given that the Limerick area is also known to have some unusual plant species IFI considers that a flora survey of these watercourses and wetlands must be undertaken as part of the Environmental Impact Assessment. It would be important to liaise with NPWS in this matter.

8. This plan also shows that it is proposed to use the redundant fishing weir, known as Thomond weir, to support a new road from Kings Island to the right bank of the river. This is likely to entail some instream works and IFI should be consulted in relation to any instream proposals.

9. IFI would have some concerns regarding the lighting of the footpath and roadway. Illumination should be "cowled" or designed to ensure that the pool of light falls only on the footpath and carriageways and not on the water on either side of the bridge. This is important as this is part of a resting area for salmon and the light impinging on the water will attract fish and may cause them to delay passing through the area and increase the illegal fishing opportunities. IFI request that it should be consulted more particularly about the design of the bridge so as to ensure that the design will minimise the impact on the fishery and fish movement.

10. IFI would also like to see further information in respect of the surface water drainage from the bridge and the roadway. In particular IFI recommends that silt and hydrocarbon removal facilities should be incorporated into the design of the crossing.

11. IFI considers that the stability of the embankment is of paramount importance. Hence IFI's suggestion for rock armour at the toe of the embankment. But IFI also considers that it may be necessary to remove some trees and to have a maintenance plan to ensure that no significant large trees are permitted to grow on the embankment. Significant tree root development in some situations can cause the bank to become more porous allowing ingress of water which can weaken the bank structure.

12. IFI Biosecurity protocols should be applied in respect of all works undertaken in this area and must be an integral part of the project. Care should also be taken to ensure that alien species on site are appropriately dealt with. Similarly every effort should be undertaken to ensure that alien species are not imported to the site in fill material used in the construction of the embankment.

Instream Works, Kings Island.

In regards to the above IFI has received an aerial photograph and a sketch which both indicate the proposed locations of instream works and the type of instream works envisaged at this time.

1. The photograph shows that it is proposed to construct two "Instream working platforms" in two areas to facilitate anti-scour works. The larger area is in the vicinity of the Limerick City and County Council offices and the courthouse upstream of the Abbey River confluence. The second area is in the Abbey River on the right bank at the "Absolute Hotel". At this location the Abbey River is turning to the right (west) and the mouth of the navigation canal is on the left bank.

2. IFI considers that the proposed "instream working platforms" will give rise to considerable environmental disruption, pollution and adversely affect lamprey and fish habitat including resting areas for salmon in the River Shannon. There may also be a negative impact on angling efforts in the river.

3. IFI considers that an alternative methodology needs to be developed and suggest that coffer dams using sheet piles might provide a better alternative. If sheet piles can be used and are properly sealed that this should considerably reduce pollution potential as all the work will be contained within the coffer dam area. In particular there will be an opportunity to remove juvenile lamprey (ammocoetes) and other fish from the works area.

4. For any instream works a fisheries assessment will be required and there is a strong possibility that a fish removal operation will be required. The removal of lamprey in particular is tedious and takes time. It will be important that a contractor is identified at an early stage so that an application can be made to the Department of Communications Climate Action and Environment for a section 14 licence permitting electro-fishing to take place.
5. In addition for this type of instream work and any other instream work associated with the project if the work is taking place in the close season then derogation will be required under The Local Authority Works Act 1949.

6. IFI request that there is early contact with the contractors for this development so as to ensure that method statements can be agreed in a timely fashion which will minimise the impact of the works on the aquatic habitats and species.

Photograph Adjacent to the Community Centre (KI-0016)

This is photograph is apparently taking close to the community centre.

1. It seems likely that the embankment will take in at least the footpath and perhaps part of the wall and railing. IFI would have no objection to the use of a retaining wall (perhaps a reinforced earth wall) on the landward side to limit the extent of the embankment if this is deemed necessary and feasible.

2. At this time IFI has no other observations on this photograph.

Photograph taken adjacent to the running track (KI-040).

As described above this photograph is taken near the northern end of the running track and notes that it is in the SAC.

1. As noted on the plan "**Embankment Alignments West Embankment Option 2 (offset from sandbags)"** the proposed embankment is going to impinge on the running track. To the right of the footpath there appears to be a watercourse and this is in keeping with the details can be observed in the above plan. To impinge on the running track it would appear that the open watercourse is likely to be lost. The loss of the watercourse, in IFI's opinion, would be contrary to the objectives and criteria set out in the Water Framework Directive. To culvert or remove the watercourse will cause deterioration in the status of this watercourse and the ECJ has already indicated that at this may not be allowed. (Please find attached a copy of report on the ECJ decision.)

2. As alluded to above the aquatic habitats i.e. wetlands and watercourses on the island must be assessed in terms of their fisheries importance especially for lamprey and/or any other fish species. An assessment must also be carried out in respect of the flora that may be contained in the wetlands, watercourses or in the adjacent riparian zones. IFI is aware that in the past there was a very rich avian diversity on the island and at one time a lot of illegal bird trapping took place adjacent to these watercourses. There may be important interaction between the aquatic and terrestrial habitats.

3. To preserve the existing aquatic habitat it may be necessary to design a section of the bank to facilitate the preservation of the watercourse and the running track whilst still providing a robust embankment in this particular area.

Kings Island (extract from Bing maps)

This map shows a general outline of Kings Island the Western side of which is of fisheries importance.

1. The map shows that there is an existing pathway around the island. It is assumed that this pathway will be relocated to be on top of the new embankment that is proposed to be constructed. Provided that the embankment is constructed in an environmentally sustainable manner and complies with EU directives and water pollution legislation there should be no difficulty. Key to this will be good liaison to develop the appropriate methodologies to minimise any negative impact on the fisheries and aquatic habitats.
2. The photograph also clearly highlights the juxtaposition of Thomond weir which was utilised by the ESB for commercial fishing primarily for salmon. It is important that when the road is being constructed using the pillars of the old weir that any refurbishment works are carried out in the open season for instream works or in accordance with an appropriate derogation under the Local Authority Works Act 1949.

3. To improve the amenity of the river and facilitate passage of boats, including kayaks angling cots, sculling boats et cetera it may be desirable to remove one or two of the piers and developing a clear span structure in this space. This will provide better access for small boats and other craft but also may be important in terms of health and safety.

This concludes IFI's observations and recommendations at this time. Should you require clarification on any matter please do not hesitate to contact this office

Yours Sincerely

Michael Fitzsimons

Senior Fisheries Environment Officer
IFI, Shannon IRBD.

Emily Rick

From: Barry <barry@nfgws.ie>
Sent: 07 January 2019 13:01
To: Emily Rick; Bernadette OConnell
Cc: sean@nfgws.ie; 'Joe Gallagher'
Subject: RE: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Hello Emily and Bernadette,

We appreciate the opportunity to consult on the proposed project. The project itself is unlikely to impact on our group water schemes members, however, we will have a look at the scoping report and revert back if we have any comments, observations or concerns.

Kind Regards

Barry Deane,
National Federation of Group Water Schemes,
087 6866099

www.nfgws.ie

From: Emily Rick <Emily.Rick@jbaconsulting.ie>
Sent: 21 December 2018 17:45
To: barry@nfgws.ie; sean@nfgws.ie
Cc: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Mr. Barry Deane and Mr. Sean Clerkin,

JBA Consulting Ltd. acts on behalf of our client the Limerick City and County Council in this matter.

Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

The Scoping Report will also be published on the King's Island Flood Relief Scheme website (http://www.kingsislandfrs.ie/) in the coming weeks.

The EIAR will be a systematic evaluation of the likely significant impacts of the proposed Flood Relief Scheme on the environment. It will identify, describe and evaluate the likely significant effects on the environment of the proposed scheme and reasonable alternatives taking into account the objectives and geographical scope of the proposed works.

We request that any comments, observations or submissions in relation to the scope and level of information to be included in the Environmental Report be made within a period of 4-6 weeks from the date of receipt of this email (before Friday 01st February 2019).

Forward all submissions to Bernadette O'Connell at JBA Consulting, 24 Grove Island, Corbally, Limerick or bernadette.oconnell@jbaconsulting.ie

If you have any queries or require additional copies, please do not hesitate to contact the undersigned.

Sincerely,

Bernadette O'Connell

Principal Environmental Scientist

bernadette.oconnell@jbaconsulting.ie

Emily Rick

From: planning applications <planning.applications@failteireland.ie>
Sent: 09 January 2019 15:06
To: Bernadette OConnell
Subject: FW: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City
Attachments: 2015s3353-Kings Island - EIAR Scoping Report V3.0.pdf; EIS &Tourism Guidelines.pdf

Dear Bernadette,

Thank you for your recent e-mail regarding **the proposal to construct a Flood Relief Scheme for King's Island in Limerick City.**
Please see attached a copy of Fáilte Ireland's Guidelines for the treatment of tourism in an EIS, which we recommend should be taken into account in preparing the EIAR.

Regards,

Yvonne

Yvonne Jackson
Product Development-Environmental & Planning Support | Fáilte Ireland
Áras Fáilte, 88/95 Amiens Street, Dublin 1. D01WR86
T +353 (0)1 884 7224 | **www.failteireland.ie**

Fáilte Ireland
National Tourism Development Authority

From: Emily Rick <Emily.Rick@jbaconsulting.ie>
Sent: 21 December 2018 17:06
To: Eoin McDonnell <Eoin.McDonnell@failteireland.ie>
Cc: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Mr. Eoin Mcdonnell,

JBA Consulting Ltd. acts on behalf of our client the Limerick City and County Council in this matter.

Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

The Scoping Report will also be published on the King's Island Flood Relief Scheme website (http://www.kingsislandfrs.ie/) in the coming weeks.

The EIAR will be a systematic evaluation of the likely significant impacts of the proposed Flood Relief Scheme on the environment. It will identify, describe and evaluate the likely significant effects on the environment of the proposed scheme and reasonable alternatives taking into account the objectives and geographical scope of the proposed works.

We request that any comments, observations or submissions in relation to the scope and level of information to be included in the Environmental Report be made within a period of 4-6 weeks from the date of receipt of this email (before Friday 01st February 2019).

Forward all submissions to Bernadette O'Connell at JBA Consulting, 24 Grove Island, Corbally, Limerick or bernadette.oconnell@jbaconsulting.ie

If you have any queries or require additional copies, please do not hesitate to contact the undersigned.

Sincerely,

Bernadette O'Connell

Principal Environmental Scientist

bernadette.oconnell@jbaconsulting.ie

Emily Rick

From: Emily Rick
Sent: 10 January 2019 10:25
To: 'bernard.burke@coillte.ie'
Cc: Bernadette OConnell
Subject: RE: Reply - Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Hello Bernard,

Thank you for your response. It is much appreciated.

Kind regards,

Emily Rick

From: Bernard Burke <bernard.burke@coillte.ie>
Sent: Thursday, January 10, 2019 9:53 a.m.
To: Bernadette OConnell
Cc: Bernard Burke
Subject: Reply - Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Hi Bernadette,

I had a look at the submission for the Kings Island Flood Relief Scheme. The proposed development does not appears to interfere or infringe on any Coillte lands, so at the moment we have no reason for concern in relation to the development.

Best Regards,

Bernard Burke

BAU Leader, Coillte Forest | Coillte
Back Of The Forge, Lower Main Street, Castleisland, Co Kerry, Ireland

E Bernard.Burke@coillte.ie
T +353667163374
M +353(86)6020096

www.coillte.ie

Emily Rick

Subject: FW: EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

From: Environmental Co-ordination (Inbox) <Environmental_Co-ordination@agriculture.gov.ie>
Sent: 11 January 2019 11:49
To: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Good morning,

I refer to your recent correspondence concerning the above and wish to state that at this time the Department of Agriculture, Food and the Marine has no submissions or observations in regards to same.

Yours sincerely,

Breeda Hennebry

Breeda Hennebry | *Clerical Officer,* ***An tAonad um Chomhordú Timpeallachta, An Rannóg um Athrú Aeráide agus Beartas Bithfhuinnimh,***
Environmental Co-ordination Unit |Climate Change & Bioenergy Policy Division | environmentalco-ordination@agriculture.gov.ie
An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine
Lárionad Gnó Grattan, Bóthar Bhaile Átha Cliath, Port Laoise, Co Laoise, R32 K857
Grattan Business Centre, Dublin Road, Portlaoise, Co. Laoise, R32 K857
T +353 (0)57 868 9914
www.agriculture.gov.ie

Emily Rick

Subject: FW: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

From: INFO <INFO@tii.ie>
Sent: 23 January 2019 14:59
To: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: RE: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Ms. O'Connell,

Thank you for your EIAR scoping report in respect of the above proposed project. TII's position is outlined as follows.

The issuing of this correspondence is provided as best practice guidance only and does not prejudice TII's statutory right to make any observations, requests for further information, objections or appeals following the examination of any valid application referred.

The approach to be adopted by TII in making such submissions or comments will seek to uphold official policy and guidance as outlined in the Spatial Planning and National Roads Guidelines for Planning Authorities (2012). Regard should also be had to other relevant guidance available at www.TII.ie.

In this instance, the project for which EIAR is to be prepared is the Flood Relief Scheme (FRS) for King's Island in Limerick City stated to be designed to provide protection to properties within the study area for the 1 in 200 year tidal flood event (0.5% AEP event). Figure 1.1 providing an indication of the study area extents is enclosed.

With respect to EIAR Scoping issues, the recommendations indicated below provide only general guidance for the preparation of EIAR, which may affect the National Roads Network. The developer should have regard, *inter alia*, to the following;

1. As set out in the DoECLG Spatial Planning and National Roads Guidelines (2012), it is in the public interest that, in so far as is reasonably practicable, the national road network continues to serve its intended strategic purpose. The EIAR should identify the methods/techniques proposed for any works traversing/in proximity to the national road network in order to demonstrate that the development can proceed complementary to safeguarding the capacity, safety and operational efficiency of that network.
2. Consultations should be had with the relevant Local Authority/National Roads Design Office with regard to locations of existing and future national road schemes.
3. Clearly identify haul routes proposed and fully assess the network to be traversed. Separate structure approvals/permits and other licences may be required in connection with the proposed haul route and all structures on the haul route should be checked by the applicant/developer to confirm their capacity to accommodate any abnormal load proposed.
4. Where appropriate, subject to meeting the appropriate thresholds and criteria and having regard to best practice, a Traffic and Transport Assessment be carried out in accordance with relevant guidelines, noting traffic volumes attending the site and traffic routes to/from the site with reference to impacts on the national road network and junctions of lower category roads with national roads. TII's Traffic and Transport Assessment Guidelines (2014) should be referred to in relation to proposed development with potential impacts on the national road network. The scheme promoter is also advised to have regard to Section 2.2 of the TII TTA Guidelines which addresses requirements for sub-threshold TTA.
5. TII Standards should be consulted to determine the requirement for Road Safety Audit (RSA) and Road Safety Impact Assessment (RSIA).

6. Assessments and design and construction and maintenance standards and guidance are available at TII Publications that replaced the NRA Design Manual for Roads and Bridges (DMRB) and the NRA Manual of Contract Documents for Road Works (MCDRW).

7. The developer, in conducting Environmental Impact Assessment, should have regard to TII Environment Guidelines that deal with assessment and mitigation measures for varied environmental factors and occurrences. In particular, evidenced assessment of the protection of the strategic function of the national road in relation to the following matters is required;

    a. TII's Environmental Assessment and Construction Guidelines, including the *Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes* (National Roads Authority, 2006),

    b. The EIAR should consider the Environmental Noise Regulations 2006 (SI 140 of 2006) and, in particular, how the development will affect future action plans by the relevant competent authority. The developer may need to consider the incorporation of noise barriers to reduce noise impacts (see *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (1st Rev., National Roads Authority, 2004)).

The developer is advised that any additional works/structures required as a result of the Assessment should be funded by the developer.

I trust that the above comments are of assistance in your EIAR preparation.

Yours sincerely,

Michael McCormack
Senior Land Use Planner

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

From: Emily Rick <Emily.Rick@jbaconsulting.ie>
Sent: Friday 21 December 2018 17:12
To: INFO <INFO@tii.ie>
Cc: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Sir/Madam,

JBA Consulting Ltd. acts on behalf of our client the Limerick City and County Council in this matter.

Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

The Scoping Report will also be published on the King's Island Flood Relief Scheme website (http://www.kingsislandfrs.ie/) in the coming weeks.

The EIAR will be a systematic evaluation of the likely significant impacts of the proposed Flood Relief Scheme on the environment. It will identify, describe and evaluate the likely significant effects on the environment of the proposed scheme and reasonable alternatives taking into account the objectives and geographical scope of the proposed works.

We request that any comments, observations or submissions in relation to the scope and level of information to be included in the Environmental Report be made within a period of 4-6 weeks from the date of receipt of this email (before Friday 01st February 2019).

Forward all submissions to Bernadette O'Connell at JBA Consulting, 24 Grove Island, Corbally, Limerick or bernadette.oconnell@jbaconsulting.ie

If you have any queries or require additional copies, please do not hesitate to contact the undersigned.

Sincerely,

Bernadette O'Connell

Principal Environmental Scientist

bernadette.oconnell@jbaconsulting.ie

Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

JBA Consulting,
Unit 24,
Grove Island,
Corbally,
Limerick
V94 312N

14 January, 2019.

Re: EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City.

Your Ref: 2015s3353-King's_Island_Constraints
Our Ref: 18/171

A chara,

With reference to your email received on 21 December, 2018, concerning the EIAR Scoping Report for the King's Island Flood Relief Scheme, Geological Survey Ireland (a division of Department of Communications, Climate Action and Environment) would like to make the following comments.

Geological Survey Ireland provides information on all aspects of the geology of Ireland on our Map Viewer available on the GSI website www.gsi.ie. There are multiple layers of data available including Geology, Groundwater, Quaternary, Landslides, and Geological Heritage. Our newest map is the Physiographic Units map and this is especially designed to give information on land use. We would encourage the use of our Map Viewer when during the planning process.

Geoheritage

County Geological Sites (CGS) are now routinely included in County Development Plans and in the GIS of planning departments, to ensure the recognition and appropriate protection of geological heritage within the planning system. County Geological Sites in audited and unaudited counties can now be viewed online under the Geological Heritage tab on the Geological Survey Public Data Online Viewer at: Geological Survey's Online Viewer or via a direct link at: Geoheritage Online Viewer.

Our records show that there are no CGSs located within the vicinity of King's Island. With the current plans, there is no envisaged impact on the integrity of County Geological Sites by the proposed developments. However, if the proposed development plan is altered, please contact Siobhán Power at Siobhan.Power@gsi.ie for further information and possible mitigation measures if applicable.

Groundwater

It should be noted that according to the Groundwater layer on our Map Viewer, parts of King's Island have areas of High Groundwater Vulnerability. This should be taken into account when engaging in planning.

Other Comments

Geological Survey Ireland is the national earth science agency and has datasets on Bedrock Geology, Quaternary Geology, Geological Heritage Sites, Mineral deposits, Groundwater Resources and the Irish Seabed. These comprise maps, reports and extensive databases that include mineral occurrences, bedrock/mineral exploration groundwater/site investigation boreholes, karst features, wells and springs. Please see our website for data availability.

I hope that these comments are of assistance, and if we can be of any further help, please do not hesitate to contact me, or one of my colleagues in the Geoheritage Programme (Sarah Gatley at Sarah.Gatley@gsi.ie or Siobhán Power at Siobhan.Power@gsi.ie).

Le meas,

Dylan Potter
Contract Geologist
Geoheritage Programme
Geological Survey Ireland

Emily Rick

From: GCU <GeneralCo-OrdinationUnit@dttas.gov.ie>
Sent: 26 February 2019 13:33
To: Emily Rick
Cc: Bernadette OConnell
Subject: RE: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Good afternoon Emily,

Apologies for late response to your request below.

The Department of Transport Tourism and Sport would like the following observation from our Public Transport Regulation and Sustainability Division be considered .

'We would hope that all urban street development would go through the Design Manual for Urban Roads and Streets (DMURS) process or perhaps be run by the NTA to ensure that no opportunity to supply a more sustainable built environment is lost (including any opportunity to build a cycle lane where space allows).

Regards
Jacqui

Jacqui Traynor
Corporate Support and Communications Division

An Roinn Iompair, Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

Lána Líosain, Baile Átha Cliath, D02 TR60
Leeson Lane, Dublin, D02 TR60

T +353 (0)1 604 1177
Jacquitraynor@dttas.gov.ie www.dttas.gov.ie

From: Emily Rick [mailto:Emily.Rick@jbaconsulting.ie]
Sent: 21 December 2018 16:57
To: GCU
Cc: Bernadette OConnell
Subject: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Sir/Madam,

JBA Consulting Ltd. acts on behalf of our client the Limerick City and County Council in this matter.

Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

The Scoping Report will also be published on the King's Island Flood Relief Scheme website (http://www.kingsislandfrs.ie/) in the coming weeks.

The EIAR will be a systematic evaluation of the likely significant impacts of the proposed Flood Relief Scheme on the environment. It will identify, describe and evaluate the likely significant effects on the environment of the proposed scheme and reasonable alternatives taking into account the objectives and geographical scope of the proposed works.

We request that any comments, observations or submissions in relation to the scope and level of information to be included in the Environmental Report be made within a period of 4-6 weeks from the date of receipt of this email (before Friday 01st February 2019).

Forward all submissions to Bernadette O'Connell at JBA Consulting, 24 Grove Island, Corbally, Limerick or bernadette.oconnell@jbaconsulting.ie

If you have any queries or require additional copies, please do not hesitate to contact the undersigned.

Sincerely,

Bernadette O'Connell

Principal Environmental Scientist

bernadette.oconnell@jbaconsulting.ie

****

****

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Your Ref: 2015s3353
Our Ref: G Pre00001/2019 *(Please quote in all related correspondence)*

06 February 2019

JBA Consulting
24 Grove Island
Corbally
Limerick
Ireland
V94 312N

Via email to: emily.rick@jbaconsulting.ie, bernadette.oconnell@jbaconsulting.ie

Re: Notification to the Minister for Culture, Heritage and the Gaeltacht under the Planning and Development Act, 2000, as amended.

Proposed Development: Pre Planning - Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

A chara

On behalf of the Department of Culture, Heritage and the Gaeltacht, I refer to correspondence received in connection with the above.

Outlined below are heritage-related observations/recommendations of the Department under the stated heading(s).

Archaeology
All proposed development and strategies should be in compliance with the National Monuments Acts 1930 to 2004 and with the national policy on protection of archaeological heritage – 'Framework and Principles for the Protection of the Archaeological Heritage' published in 1999 by the Department of Arts, Heritage, Gaeltacht and the Islands.

General Guidance

1) All areas of archaeological heritage should be addressed, including;
   a) Immovable cultural heritage e.g., monuments and ancient field boundaries.
   b) Underwater cultural heritage.
   c) Movable cultural heritage e.g., loose carved stones, sculptures, architectural fragments etc.

2) All proposed development within proximity to archaeological monuments should be subject to appropriate consultation, at the earliest possible stage, with the Department of Arts, Heritage and the Gaeltacht.

3) All impacts which may impinge on the archaeological heritage should be assessed by a suitably qualified archaeologist.

4) Where appropriate, specialists in the field of archaeological heritage should be consulted throughout the process, from design through to implementation.

5) All surveys pertaining to archaeological heritage must be of a high standard in order to allow informed decisions to be taken.

6) All impacts must be assessed, to include ground disturbance, impacts on the setting of the monuments and visual impacts. These should include direct, indirect, temporary and cumulative impacts.

7) Mitigation of impacts, identified through consultation, should be taken into account within the development at the earliest possible stages. Various approaches should be considered, such as avoidance, design modification and relocation where appropriate.

8) Where there are no archaeological monuments present but the development is large in scale, e.g., over 0.5 hectares in area and over 1 kilometre in length, it is recommended that an archaeological assessment should be undertaken, unless there are substantial grounds to show that it is not necessary. Refer to Framework and Principles for the Protection of the Archaeological Heritage 1999, in particular section 3.6.6 in regard to EIA.

Further information and relevant publications can be obtained on www.archaeology.ie.

You are requested to send further communications to this Department's Development Applications Unit (DAU) at **manager.dau@ahg.gov.ie** (team monitored); if this is not possible, correspondence may alternatively be sent to:

The Manager
Development Applications Unit (DAU)
Department of Culture, Heritage and the Gaeltacht
Newtown Road
Wexford
Y35 AP90

Is mise, le meas

Diarmuid Buttimer
Development Applications Unit

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Your Ref: 2015s3353
Our Ref: G Pre00001/2019 *(Please quote in all related correspondence)*

22 March 2019

JBA Consulting
24 Grove Island
Corbally
Limerick
Ireland
V94 312N

Via email to: emily.rick@jbaconsulting.ie, bernadette.oconnell@jbaconsulting.ie

Re: Notification to the Minister for Culture, Heritage and the Gaeltacht under the Planning and Development Act, 2000, as amended.

Proposed Development: Pre Planning - Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

A chara

On behalf of the Department of Culture, Heritage and the Gaeltacht, I refer to correspondence received in connection with the above.

Outlined below are heritage-related observations/recommendations of the Department under the stated heading(s).

Nature Conservation

The following is advised concerning impact assessment on the Lower River Shannon candidate Special Aea of Conservation (cSAC) (2165) and on wildlife. Note that this advice is not comprehensive, and is without prejudice to any future observations or submission which may be made to the planning authority.

- Area A3 (Northwest Embankment): A Section 21 (Wildlife Act) licence will be necessary for the translocation of the opposite-leaved pondweed, and should be applied for to the Licensing Unit, National Parks & Wildlife Service (NPWS).
- Area A7 (Sir Harry's Mall): See below concerning the alluvial trees and summer snowflake (Leucojum aestivum) occurring in this area.
- Area A9 (Hotel to Abbey Bridge) & Courthouse: A survey for juvenile lamprey in the working area of the jack-up rig is recommended, and impacts on juvenile lamprey habitat assessed.
- All areas involving riparian works: A pre-application and pre-construction otter survey following NRA guidance is recommended (see https://www.tii.ie/tii-library/environment/construction-guidelines/Guidelines-for-the-Treatment-of-Otters-prior-to-the-Construction-of-National-Road-Schemes.pdf).

Sir Harry's Mall

From the Section drawings on p.1 of the Technical Note (previously received, dated 23 March 2018), a cantilevered boardwalk is proposed to extend for 2.0m. As the existing wall is 0.8m, this means that 1.2m of the cSAC will be overshadowed but not completely covered or excavated due to its cantilevered nature. This overhang design is particularly favourable, as it allows maximum tide debris (see Photo 1 in the Technical Note) to still accumulate under the walkway rather than further downslope in the vegetated habitat area if a wall was constructed.

The habitat present is alluvial tree-line in an estuary environment with characteristic species such as white willow (Salix alba), crack willow (Salix fragilis) and summer snowflake (Leucojum aestivum). It forms part of the Estuary habitat type, as well as being important for the connectivity of alluvial woodland habitat on the opposite bank to the south-east. However, the upper 1.5m near the existing wall is not of particular conservation value compared to the area downslope from this. From Photo 1 in the Technical Note, it can be seen (second tree) that crack willow will readily grow horizontally outwards. It is recommended that the 3-5 trees removed or coppiced, are replaced by planting, or by facilitating regeneration, outside the boardwalk, so that the tree-line / estuary ecotone is maintained.

The above assumes that the footprint of the works does not need to extend further out beyond the 2.0m of the proposed boardwalk. Any snowflake plants in this zone should be translocated. In the event that the footprint will need to be extended, please contact the NPWS for further consultation.

You are requested to send further communications to this Department's Development Applications Unit (DAU) at **manager.dau@ahg.gov.ie** (team monitored); if this is not possible, correspondence may alternatively be sent to:

The Manager
Development Applications Unit (DAU)
Department of Culture, Heritage and the Gaeltacht
Newtown Road
Wexford
Y35 AP90

Is mise, le meas

Diarmuid Buttimer
Development Applications Unit

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Your Ref: 2015s3353 12 June 2019
Our Ref: **G Pre00001/2019**
(Please quote in all related correspondence)

JBA Consulting
24 Grove Island
Corbally
Limerick
Ireland
V94 312N
Via email: Emily.Rick@jbaconsulting.ie cc: bernadette.oconnell@jbaconsulting.ie

Re: Pre-planning consultation regarding the proposal by Limerick City and County Council to construct a Flood Relief Scheme for King's Island.

A chara

On behalf of the Department of Culture, Heritage and the Gaeltacht, I refer to correspondence received in connection with the above.

Outlined below are heritage-related observations/recommendations of the Department under the stated headings.

Underwater Archaeology

The Department welcomes being consulted in regard to the proposed Environmental Impact Assessment Report (EIAR) for King's Island Flood Relief Scheme.

The Department notes in the Scoping Document that there is an intention to address the Underwater Cultural Heritage, which is welcome. As part of assessing the Underwater Cultural Heritage and potential impacts to same, results from all previous underwater archaeological impact assessments should be considered, as should any monitoring of dredging programmes that have taken place as part of previous associated works (e.g. at Verdant Place, etc.). The proposed desktop study should contain a detailed overview of the maritime cultural heritage of King's Island and associated areas, including Athlunkard, the Abbey River, etc. as conduits and sites of particular maritime importance over time. The results from the Limerick Main Drainage scheme, particularly from within the Abbey River, attest to the high potential for Underwater Cultural Heritage to exist within and adjacent to the main river courses into and around Limerick City.

King's Island would have been the central focus of maritime activity during the heyday of medieval settlement on the island, from the Viking period through to 17th century events and later. There is therefore a high potential that previously unrecorded cultural heritage, and particularly that associated with maritime activity (e.g. the remains of logboats, larger vessels, early quays, jetties, fish traps, maritime-context artefactual material, etc.) could be

encountered during proposed works to streams, along the river's edge, in what could be reclaimed ground etc.

The EIAR Cultural Heritage section should assess the potential for this, which should include archaeologically assessing any in-stream or river bank/intra-riverine impacts. The services of suitably qualified archaeological personnel with underwater archaeological experience should be engaged to carry this out. The EIAR should also put forward recommendations to archaeologically mitigate in advance of any in-water works, to ensure there are no delays to works going forward should substantial Underwater Cultural Heritage be encountered.

The EIAR Cultural Heritage Section should also address the potential for identification of water-logged material and make provision for a defined finds retrieval strategy and post-excavation strategy to be included in all proposed works from the beginning.

Nature Conservation

The Department refers to your application (dated 20 March 2019) for a Wildlife Act Section 21 derogation licence to translocate the protected plant opposite-leaved pondweed, and to your e-mails to the National Parks & Wildlife Service (NPWS) Regional Ecologist (dated 17 May 2019 and 20 May 2019) concerning the candidate Special Area of Conservation (cSAC) boundary and juvenile lamprey.

Translocation of opposite-leaved pondweed

With regard to the proposed translocation of opposite-leaved pondweed, it would be the Department's preference that the existing drain, where the plant occurs, is retained. The reason for this preference is the low success of translocation projects for this species in the past. The implications of this would be construction of the embankment inside the existing drain, or possibly increasing the interior slope angle of the embankment. The Department is available to discuss this in more detail, if you wish.

Marshland at cSAC boundary

Three pieces of information are required for the Department to advise fully on this question:

- It needs to be calculated how much marsh habitat *within* the cSAC will be lost to the embankment.
- The type of marsh vegetation proposed to be lost within the cSAC needs to be described.
- The extent to which the marsh vegetation is dependent on poor drainage (perched water), as opposed to water due to groundwater backup due to river flooding, needs to be established.

Translocation of juvenile lamprey

The Department accepts the advice of fish experts concerning the preference against an invasive survey as part of the Natura Impact Statement (NIS), and proceeding with the

assumption of their presence. Nevertheless, the Department recommends that the following information should be included in the Natura Impact Statement:

- A statement of the efficiency of the removal of the juvenile lamprey (i.e. how many are likely to be left behind);
- A statement of where the juvenile lamprey will be translocated to, and their likelihood of survival;
- A clear description of how the jack-up barge will be operated and supported, and whether rock infill will be required, and if so, how this will be removed post-construction;
- A prediction of how quickly un-compacted silt habitat will naturally regenerate, and how soon the area will be fully recolonized to baseline condition.

The above observations/recommendations are based on the papers submitted to this Department on a pre-planning basis and are made without prejudice to any observations that the Minister may make in the context of any consultation arising on foot of any development application referred to the Minister, by the planning authority, in her role as statutory consultee under the Planning and Development Act, 2000, as amended.

You are requested to send further communications to this Department's Development Applications Unit (DAU) at **manager.dau@chg.gov.ie** (team monitored); if this is not possible, correspondence may alternatively be sent to:

The Manager
Development Applications Unit (DAU)
Department of Culture, Heritage and the Gaeltacht
Newtown Road
Wexford
Y35 AP90

Is mise, le meas

Sinéad O' Brien

Sinéad O' Brien
Development Applications Unit

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Your Ref: **2015s3353**
Our Ref: **G Pre00001/2019** *(Please quote in all related correspondence)*

13 August 2019

JBA Consulting
24 Grove Island
Corbally
Limerick
Ireland
V94 312N
Via email: Emily.Rick@jbaconsulting.ie cc: bernadette.oconnell@jbaconsulting.ie

Proposed Development: Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

A chara

On behalf of the Department of Culture, Heritage and the Gaeltacht, I refer to correspondence received in relation to the above.

Outlined below are heritage-related observations/recommendations of the Department under the stated heading(s).

Underwater Archaeology

The Department notes the response to previous recommendations as received in the attached application. The Department also notes the statement that there is to be no in-river works, however, one of the maps submitted infers that in-river works may be necessary. It is also noted the applicants' details on the use of the jack-up barge and while in itself this may be minimal, if used over a wide area then the cumulative impact can be large on submerged cultural heritage, including artefactual heritage.

The Department therefore reiterates our previous requirements that the EIAR Cultural Heritage section should assess the potential impacts of all works, including cumulative impacts on submerged archaeology either by barge operations, excavation for flood

defence walls in areas that may be reclaimed, etc. as well as archaeologically assessing any in-stream or river bank impacts. The services of suitably qualified archaeological personnel with underwater archaeological experience should be engaged to undertake the UAIA. The EIAR should also put forward recommendations to archaeologically mitigate in advance any in-water works, to ensure there are no delays to works going forward should substantial underwater cultural heritage be encountered.

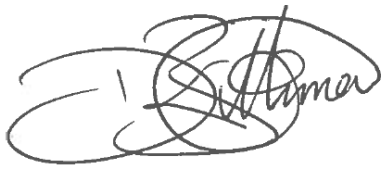
The EIAR Cultural Heritage Section should also address the potential for identification of water-logged material and make provision for a defined finds retrieval strategy and post-excavation strategy to be included in all proposed works from the beginning.

The Underwater Archaeology Unit will be available to meet on site should it be thought advantageous to progress and to discuss the overall scheme.

You are requested to send further communications to this Department's Development Applications Unit (DAU) via ***eReferral***, where used, or to **manager.dau@chg.gov.ie**; if emailing is not possible, correspondence may alternatively be sent to:

The Manager
Development Applications Unit (DAU)
Department of Culture, Heritage and the Gaeltacht
Newtown Road
Wexford
Y35 AP90

Is mise, le meas



Diarmuid Buttimer
Development Applications Unit

Emily Rick

Subject: FW: Scoping Response for Kings Island.

Sensitivity: Private

From: O'Neill, Thomas <thomas.oneill@limerick.ie>
Sent: 04 January 2019 14:20
To: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Cc: O'Donoghue, Donogh <donogh.odonoghue@limerick.ie>; Burke, Karen <karen.burke@limerick.ie>
Subject: Scoping Response for Kings Island.
Sensitivity: Private

Bernadette,

Here's some suggested topics for consideration following receipt of your scoping request.

1 The emphasis on the importance of monuments around the "water's edge" (S5.6.1) is welcomed Our archaeologist Sarah McCutcheon would be able to help further in this regard. This type of monument has been a frequent topic in submissions made by DAHG in land use plans being prepared by the Local Authority.

2 It would be useful in the EIAR to cross reference, where necessary, with the NIS. This could include topics such as treatment of Annex Habitats (S5.7.1 pp. 29-30). Treatment of the Triangular Club Rush and Opposite Leaved Pond Weed and associated mitigation measures such as relocation could also be cross referenced. Discussions with other local authorities have indicated that lack of cross referencing between EIARs and NISs have led to third party submissions which cite poor procedure and inadequate coverage of topics. It would be best to try and avoid this by corssrefe4enceing between the EIAR and NIS where appropriate.

3 New guidance on EIAR mentions both climate change and the probability of accidents. Climate change has been mentioned in the scoping document but perhaps this would be tied in with the necessity of flood defences to prevent future flood events and associated potential for accidents.

4 The mention of a comprehensive Invasive Species Management Plan is welcomed (5.7.1.4).

5 I would agree with the Assessment Methodology in 5.7.3.1. When available which should be June the year round bird survey commissioned for the SIFP could provide valuable background information.

6 The proposed assessment of the effects of lighting on both residents and ecology is useful. This is another aspect that would be common to the EIAR and NIS.

7 One aspect that might be considered in Hydrogeology is the possibility contaminant flow into nearby water courses or though ground water. This is most likely during eth construction phase as the Scoping document points out. Water dependant ecology (p.35) could be a common topic in both EIAR and the NIS.

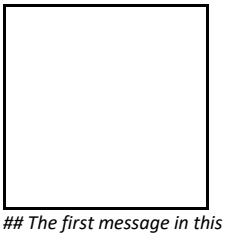
8 LCCC has produced a new Noise action plan 2018 -2023. The old one mentioned on page 36 is out of date.

I hope the above is useful. If you have any questions do get in touch.

All the best,

Tom O Neill.

Limerick ....One of the 'TOP 10 PLACES TO INVEST IN EUROPE'- 6th Global Best to Invest Report, Site Selection Magazine Limerick City & County Council Disclaimer: This electronic message contains information (and may contain files), which may be privileged or confidential. The information is intended to be for the sole use of the individual(s) or entity named above. If you are not the intended recipient be aware that any disclosure, copying, distribution or use of the contents of this information and or files is prohibited. If you have received this electronic message in error, please notify the sender immediately. This is also to certify that this mail has been scanned for viruses. Tá eolas sa teachtaireacht leictreonach seo (agus b'fhéidir sa chomhaid ceangailte leis) a d'fhéadfadh bheith príobháideach nó faoi rún. Is le h-aghaidh an duine/na ndaoine nó le h-aghaidh an aonáin atá ainmnithe thuas agus le haghaidh an duine/na ndaoine sin amháin atá an t-eolas. Murab ionann tusa agus an té a bhfuil an teachtaireacht ceaptha dó bíodh a fhios agat nach gceadaítear nochtadh, cóipeáil, scaipeadh nó úsáid an eolais agus/nó an chomhaid seo. Más trí earráid a fuair tú an teachtaireacht leictreonach seo cuir, más é do thoil é, an té ar sheol an teachtaireacht ar an eolas láithreach. Deimhnítear leis seo freisin nár aimseodh víreas sa phost seo tar éis a scanadh.



The first message in this conversation was sent internally from within the JBA organisation.

Emily Rick

From: McCutcheon, Sarah <sarah.mccutcheon@limerick.ie>
Sent: 01 February 2019 12:22
To: Emily Rick
Cc: Bernadette OConnell
Subject: RE: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Bernadette
While the scoping report for the EIAR you attached contains the basic template for such reports, given the lamentable mitigation afforded to archaeology in the recent works in Verdant Place, I expect to see some robust measures included in any forthcoming reports to avoid a reoccurrence. Limerick City & County Council has a good record of caring for its heritage and the recent works at Verdant Place created a blot on our reputation.
Sarah

From: Emily Rick [mailto:Emily.Rick@jbaconsulting.ie]
Sent: 21 December 2018 18:26
To: McCutcheon, Sarah <sarah.mccutcheon@limerick.ie>
Cc: Bernadette OConnell <Bernadette.OConnell@jbaconsulting.ie>
Subject: 2015s3353 Request for Consultation - EIAR Scoping Report for the King's Island Flood Relief Scheme (FRS), Limerick City

Dear Ms. Sarah McCutcheon,

JBA Consulting Ltd. acts on behalf of our client the Limerick City and County Council in this matter.

Limerick City and County Council propose to construct a Flood Relief Scheme for King's Island. In accordance with the Aarhus Convention and the 2014 EU Directive on Environmental Impact Assessment, we attach the Scoping Report for the Environmental Impact Assessment Report (EIAR). The purpose of the Scoping Report is to scope the contents of the chapters in the EIAR. We are issuing the Scoping Report to statutory and non-statutory bodies, interested parties and the public for comment.

The Scoping Report will also be published on the King's Island Flood Relief Scheme website (http://www.kingsislandfrs.ie/) in the coming weeks.

The EIAR will be a systematic evaluation of the likely significant impacts of the proposed Flood Relief Scheme on the environment. It will identify, describe and evaluate the likely significant effects on the environment of the proposed scheme and reasonable alternatives taking into account the objectives and geographical scope of the proposed works.

We request that any comments, observations or submissions in relation to the scope and level of information to be included in the Environmental Report be made within a period of 4-6 weeks from the date of receipt of this email (before Friday 01st February 2019).

Forward all submissions to Bernadette O'Connell at JBA Consulting, 24 Grove Island, Corbally, Limerick or bernadette.oconnell@jbaconsulting.ie

If you have any queries or require additional copies, please do not hesitate to contact the undersigned.

Sincerely,

Bernadette O'Connell

Principal Environmental Scientist

bernadette.oconnell@jbaconsulting.ie

C Biodiversity

C1 Ecological Plates

C2 Supporting Bird Species Desktop and Survey Data

C3 Summary of Opposite-leaved pondweed Groelandia densa Data for NPWS

C4 Correspondence from DAU ref G Pre00001/2019

C5 Licence for Opposite Pond-weed removal

C6 Licence for Electrofishing

C7 Licence for Badger sett destruction

Appendix C1 - Ecology plates

Plate 8-1: Tidal rivers - where Shannon and Abbey Rivers divide

Plate 8-2: Riparian woodland/ Alluvial Forests *[91E0]

Plate 8-3: Summer Snowflake

Plate 8-4: Ditch at north of King's Island

Plate 8-5: Drainage channel across marsh habitat- looking west

Plate 8-6: Drainage ditch at south east of site in flood

Plate 8-7: Marsh in dry conditions

Plate 8-8: Marsh under flood conditions (March 2019)

Plate 8-9: Wet grassland near north west ditch

Plate 8-10: Willow treeline between north west ditch and embankment


Plate 8-11: Poached grassland to east of St Mary's estate.

Plate 8-12: Amenity grassland


Plate 8-13: Sheet piling and earthen pathway

Plate 8-14: Opposite-leaved pondweed (Denyer, 2017)1

Plate 8-15: Mammal hole

[1] Denyer, J. (2017) King's Island *Groenlandia densa Survey, June 2017. Unpublished report*

Plate 8-16: Mammal hole- adjacent to flood water


Plate 8-17: Badger recorded on camera beside mammal holes (2019)

Plate 8-18: Entrance holes to mining bee nests in sandbags

Plate 8-19: Early growth of Giant Hogweed beside path

Plate 8-20: Area A9 to be electro-fished (bank beside walkway)

Appendix C2 Supporting Bird Species Desktop and Survey Data

National Biodiversity Data Centre Bird Data

Table C-1: Protected and Notable Bird Species within gird square R55Y, R55Z, R55T and 55U. (Data from National Biodiversity Data Centre, 2019)

Grid square	Scientific name	Common name	Record	Designation
R55Y	*Anas platyrhynchos*	Mallard	2013	Wildlife Acts, EU Birds Directive
R55Y	*Asio flammeus*	Short-eared Owl	2011	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55Y	*Cygnus olor*	Mute Swan	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Delichon urbicum*	House Martin	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Fulica atra*	Common Coot	2013	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55Y	*Hirundo rustica*	Barn Swallow	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Larus canus*	Mew Gull	2013	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Larus ridibundus*	Black-headed Gull	2013	Wildlife Acts, Birds of Conservation Concern - Red List
R55Y	*Phalacrocorax carbo*	Great Cormorant	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Riparia riparia*	Sand Martin	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Sturnus vulgaris*	Common Starling	2014	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Tachybaptus ruficollis*	Little Grebe	2013	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Y	*Tyto alba*	Barn Owl	2013	Wildlife Acts, Birds of Conservation Concern - Red List
R55Z	*Larus fuscus*	Lesser Black-backed Gull	2011	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Z	*Larus ridibundus*	Black-headed Gull	2015	Wildlife Acts, Birds of Conservation Concern - Red List
R55Z	*Mergus merganser*	Goosander	2011	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55Z	*Phalacrocorax carbo*	Great Cormorant	2011	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Z	*Sturnus vulgaris*	Common Starling	2015	Wildlife Acts, Birds of Conservation Concern - Amber List
R55Z	*Alcedo atthis*	Common Kingfisher	2011	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55Z	*Tachybaptus ruficollis*	Little Grebe	2011	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Anas crecca*	Teal	2017	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55T	*Mergus merganser*	Goosander	2011	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Amber List
R55T	*Anas clypeata*	Northern Shoveler	2011	Wildlife Acts, EU Birds Directive, Birds of Conservation Concern - Red List
R55T	*Passer domesticus*	House Sparrow	2011	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Phalacrocorax carbo*	Great Cormorant	2013	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Rallus aquaticus*	Water Rail	2011	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Riparia riparia*	Sand Martin	2014	Wildlife Acts, Birds of Conservation Concern - Amber List

R55T	*Sturnus vulgaris*	Common Starling	2012	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Tachybaptus ruficollis*	Little Grebe	2012	Wildlife Acts, Birds of Conservation Concern - Amber List
R55T	*Tringa totanus*	Common Redshank	2011	Wildlife Acts, Birds of Conservation Concern - Red List
R55U	*Alcedo atthis*	Common Kingfisher	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Columba livia*	Rock Pigeon	23/08/2013	Wildlife Acts, EU Birds Directive
R55U	*Anas platyrhynchos*	Mallard	31/12/2011	Wildlife Acts, EU Birds Directive
R55U	*Anas crecca*	Eurasian Teal	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List, EU Birds Directive
R55U	*Anser anser*	Greylag Goose	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List, EU Birds Directive
R55U	*Aythya fuligula*	Tufted Duck	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List, EU Birds Directive
R55U	*Mergus merganser*	Goosander	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List, EU Birds Directive
R55U	*Cygnus olor*	Mute Swan	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Haematopus ostralegus*	Eurasian Oystercatcher	26/02/2013	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Larus fuscus*	Lesser Black-backed Gull	23/08/2013	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Phalacrocorax carbo*	Great Cormorant	09/04/2016	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Sturnus vulgaris*	Common Starling	23/08/2013	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Tachybaptus ruficollis*	Little Grebe	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List
R55U	*Larus ridibundus*	Black-headed Gull	23/08/2013	Wildlife Acts Birds of Conservation Concern - Red List
R55U	*Alcedo atthis*	Common Kingfisher	31/12/2011	Wildlife Acts Birds of Conservation Concern - Amber List

Full Breeding Bird Survey Data

Table C-2: Bird species recorded within the survey area.

Common Name	Latin name	Conservation Status			Breeding status	Comments	Habitat
		EU Annex Species	Conservation Listed Species	Riparian Action Plan Species			
Kingfisher	*Alcedo atthis*	Annex I	Amber	✓	Possible	Kingfisher observed flying along Shannon further north of Kings Island. No nesting banks found on within FRS	Likely to nest on opposite bank of Shannon and Abbey Rivers. Historically noted on Shannon further north
Little Egret	*Egretta garzetta*	Annex I	Green	✓	Possible	Observed foraging south of Kings Island at Clancy's Strand. No nesting within FRS	No evidence of nesting in marsh or woodland of Kings Island. Urbanised location may make it unsuitable.
Grey Wagtail	*Motacilla cinerea*	-	Red	✓	Confirmed	Observed in suitable habitat, nest in wall at Thomond Weir at Brown's Quay. No nesting found within FRS	Foraging for food and nest in between crevices in wall.
Mute Swan	*Cygnus olor*	-	Amber	✓	Confirmed	Female on nest on river marsh on north edge of Kings Island beyond embankment	Marsh Habitat
Cormorant	*Phalacrocorax carbo*	-	Amber	✓	Unlikely	Group of 5 No nesting within FRS they may be part of the nesting colonies at Bunlicky further south.	5 Observed on gravelly area below Parteen Railway
Coot	*Fulica atra*		Amber	✓	Possible	One male calling from river edge reeds on Abbey River No nesting within FRS	Alluvial Woodland
Swift	*Apus apus*		Amber		Not breeding	Flyover only	
Black-headed Gull	*Chroicocephalus ridibundus*	-	Red		Not breeding	Roosting on playing pitches	
Blackbird	*Turdus merula*	-	Green		Probable	At least 5 pairs observed in suitable habitat feeding young and alarm calling on Kings Island	Riparian woodland and vegetation along the ditches
Blackcap	*Sylvia atricapilla*	-	Green		Probable	1 male and female Observed in suitable habitat on Kings Island	Riparian woodland
Blue Tit	*Cyanistes caeruleus*	-	Green		Possible	At least 4 pairs observed in suitable habitat	Riparian woodland and scrub

						on Kings Island; males singing	along ditches
Bullfinch	*Pyrrhula pyrrhula*	-	Green		Possible	One male observed in suitable habitat on Kings Island	Scrub along ditch
Carrion Crow	*Corvus corone*	-	Green		Possible	2 pairs Observed in suitable habitat on Kings Island	Alluvial Woodland and individual trees along ditches
Chaffinch	*Fringilla coelebs*	-	Green		Probable	Female and males observed alarm calling. Observed carrying food material for young on Kings Island	Alluvial Woodland and scrub habitat of ditches
Chiffchaff	*Phylloscopus collybita*	-	Green		Possible	Observed carrying food material for young on Kings Island	Alluvial Woodland and scrub habitat of ditches
Coal Tit	*Periparus ater*	-	Green		Confirmed	Group of 9 observed moving along woodland on Kings Island	Riparian woodland
Dunnock	*Prunella modularis*	-	Green		Possible	At least 2 pairs observed in suitable habitat; males singing on Kings Island	Alluvial Woodland and scrub habitat of ditches
Goldfinch	*Carduelis carduelis*	-	Green		Probable	At least 3 pairs observed in suitable habitat on Kings Island	Scrub habitat of ditches
Great Tit	*Parus major*	-	Green		Possible	One male singing observed in suitable habitat on Kings Island	Scrub habitat of ditches
Grey Heron	*Ardea cinerea*	-	Green		Possible	No nesting on Kings Island. Observed hunting along river at Verdant Plc	May be nesting beyond Kings Island
Hooded Crow	*Corvus cornix*	-	Green		Possible	Nesting in one tree along path of Kings Island	Trees
Mallard	*Anas platyrhynchos*	-	Green		Possible	1 female with young observed in suitable habitat Riparian Woodland on Kings Island along Abbey River	Alluvial Woodland and River
Magpie	*Pica pica*	-	Green		Confirmed	Observed alarm calling and carrying food material for young on Kings Island	Alluvial woodland
Pied Wagtail	*Motacilla alba*	-	Green		Confirmed	Observed flying into nest under house gutter at St. Marys Park on Kings Island	Amenity grassland and houses
Robin	*Erithacus*	-	Green		Confirmed	2 pairs - one pair	Alluvial

	rubecula					in Alluvial Woodland Alarm calling and young fledglings in bush along ditch on Kings Island	Woodland and scrub habitat of ditches
Rook	*Corvus frugilegus*	-	Green		Possible	Colony Observed in suitable habitat on Kings Island	Beyond Kings Island at Parteen
Song Thrush	*Turdus philomelos*	-	Green		Possible	One pair observed on foraging football pitch on Kings Island	Amenity grassland and scrub along ditches
Swallow	*Hirundo rustica*	-	Amber		Possible	Observed feeding over wet grassland of SAC on Kings Island	Near sheds and buildings
Woodpigeon	*Columba palumbus*	-	Green		Possible	1 Observed in suitable habitat; male singing	Alluvial Woodland
Wren	*Troglodytes troglodytes*	-	Green		Confirmed	3 pairs observed along ditches of Kings Island.	Scrub along ditches

Appendix C3 Summary of Opposite-leaved pondweed Groelandia densa Data for NPWS

This section contains all references to Opposite-leaved Pondweed *G. densa* in the EIAR as requested by NPWS. This is for the purpose of ease of access to the information for this and future translocation projects for this species.

Chapter 4 Description of Proposed Development

Area A3 - North West Embankment (Ch 0+365 to 1+250)

A3 Existing Condition

There is currently an existing embankment encircling the north of the island and an associated footpath. Approximately 520m of the existing embankment is located within the SAC. The crest of the embankment is formed by large sandbags which were installed as temporary flood defence measures during previous high flood events, however many of these sandbags are damaged and no longer provide adequate defence. There is an open drain on the eastern side of the existing embankment which currently contains a protected species, pondweed (Groenlandia densa).

A3 Design Proposal

A new embankment is proposed along 920m of the northwest perimeter of the island, set back on the inside of the existing embankments. The top of the embankments will be at the FDL height of 5.3m, constructed of impermeable clay, with a top width of 3m. The clay will slope down at a 1 to 3 slope on both sides. They will be graded and surfaced with landscape fill and topsoil respectively, at a 30-degree slope on the side of St. Mary's Park, and sloped downward so that the end meets the top of the existing embankment. Overall, with the total width will range from 60 to 70m but will vary at different locations and is designed to blend into St. Mary's Park. The surface would be seeded with meadow grassland. A new bitmac footpath (3m wide) is proposed along the top of the embankment, with breakout areas to allow street furniture in the future. Additional connecting paths are proposed to connect the embankment to the St. Mary's Park housing estate to the east and south. Street lighting (columns 6m high) is proposed along the outside of the walkway, which would be directed inward and away from the SAC.

The proposed embankment would envelop the existing drainage ditch to the west and the open drain to the east which currently contains the protected pondweed, and as such filter drains are proposed on the inside of the embankments. A new swale is also proposed along the northwest corner of the island on the inside of the proposed embankment. The swale would allow pondweed (Groenlandia densa) to be translocated under licence from the existing ditch.

A3 Drainage Design

There is an existing outfall to the River Shannon from an existing open drain on the inside of the existing flood embankment, outfall location towards the north-west corner of the island. As part of the Kings Island Flood Scheme works, this outfall will be decommissioned, and a new outfall will be constructed. The new outfall location will be at the southern end of a new open drain on the inside of the new flood embankment which is required to translocate the opposite leaved pondweed in the existing open drain. A filter drain at the toe of the new flood embankment will run from the filter drain to the north of St. Mary's Crèche towards the new open drain. A second open drain to the north of the island will capture runoff from the embankment from the west of the handball alley to the proposed open drain. Refer drawing no. 2015s3218-003 to 2015s3218-004.

Chapter 5 Consultation

Consultation Responses

Table 5-1 Summary of statutory consultation responses

Consultee	Response	Response Date
Department of Culture, Heritage and the Gaeltacht (DAU) including National Parks and Wildlife Services (NPWS)	Email ref. G Pre00001/ 2019 requesting that the archaeological assessment be completed under certain guidelines as outlined Letter dated 22 March 2019 included points regarding ecological impacts for works proposed in Areas A3, A7 and A9. Letter dated 12 June 2019 included recommendations for the treatment of underwater archaeology and the proposed translocation of Opposite-leaved pondweed and juvenile lamprey.	06/02/2019 22/03/2019 12/06/2019

Responses are further summarized and addressed in the following table according to their relevance to the appropriate section of the EIAR.

Summary of Issues Raised through Statutory Consultation

Consultee	Summary of Additional Issues Raised	How the issue is addressed in this EIAR
4. Description of Scheme		
DAU (NPWS	It would be the Department's preference that the existing drain, where opposite-leaved pondweed is found, is retained. The reason for this preference is the low success of translocation projects for this species in the past.	A response was submitted to NPWS at the design stage, which was followed by a meeting which took place between NPWS, LCCC, Arup, and JBA, on the 2nd of July to discuss these matters. This is summarized below.
	Three pieces of information are required for the Department to advise fully on the question of marshland at the cSAC boundary: 1. It needs to be calculated how much marsh habitat within the cSAC will be lost to the embankment. 2. The type of marsh vegetation proposed to be lost within the cSAC needs to be described. 3. The extent to which the marsh vegetation is dependent on poor drainage (perched water), as opposed to water due to groundwater backup due to river flooding, needs to be established.	
8. Biodiversity		
LCCC	Thomas O'Neill (Heritage Officer) requested that the EIAR should cross reference, where necessary, with the NIS. This could include topics such as treatment of Annex Habitats, treatment of the Triangular Club Rush and Opposite Leaved Pond Weed and associated mitigation measures such as relocation	Chapter 8 -Biodiversity addresses the impact of the scheme on protected species and habitats and will cross reference the contents of the NIS and associated mitigation measures.
DAU (NPWS)	Area A3 (Northwest Embankment): A Section 21 (Wildlife Act) licence will be necessary for the translocation of the opposite-leaved pondweed, and should be applied for to the Licensing Unit, National Parks & Wildlife Service (NPWS).	This point is discussed further below in Section 5.3.3

Consultation with NPWS

A letter dated 12 June 2019 (ref G Pre00001/2019, Appendix C4) was sent to JBA regarding the pre-planning consultation, following the application for a derogation license to translocate the protected plant *Groenlandia densa*. The letter raised the following points:

Translocation of Opposite-leaved Pondweed

- It would be the Department's preference that the existing drain, where Opposite-leaved Pondweed is found, is retained. The reason for this preference is the low success of translocation projects for this species in the past.
- A response was submitted by JBA, which was followed by a meeting to discuss the points raised. The response made the following points:

Translocation of opposite-leaved pondweed

- Retaining the open drain will create engineering, public health and associated risks which together with Project Supervisor Design Process (PSDP) review we are required to design out such risk where possible, namely:
- 1. Relocating the new embankment on the inside of the existing open drain will cut off the flow path for overland flows, which currently recharge the open drain
- 2. A new embankment on the inside of the existing open drain will create a dumping ground within the existing open drain, as it will be hidden between the existing and new embankments
- 3. Should any person(s) get into trouble within the open drain, they will not be visible from St Marys, therefore, an increased risk of drowning
- 4. Locating the proposed embankment inside of the existing open drain will be such that the said drain will be exposed to the tidal element of the River Shannon more regularly and will eventually be lost as the existing embankment is eroded and/or fails in due course.

A meeting which took place on 2nd July 2019 between LCCC, NPWS, JBA and Arup discussed the following points:

- Construction methodology of embankment regarding translocation of Opposite-leaved pondweed *Groenlandia densa*
- Methodology will include sequencing of construction allowing the excavation of new ditch and drainage connection to the Shannon River prior to that of the embankment.
- Pondweed must stay in original ditch as long as possible but may go into suitable storage for a period prior to translocation. It must not be moved to new ditch before suitable hydrological and water chemistry conditions are in place.
- The Section 21 licence for the translocation of the pondweed will be contingent on final method statement approved by NPWS.

Enhancement plan for Opposite-leaved Pondweed in environs of Limerick.

- The enhancement of other sites where pondweed occurs in Limerick was a preferred option by NPWS.
- Further liaising with NPWS is required to proceed with this type of project.

Chapter 8 Biodiversity

Habitat and Protected Flora Surveys

Ecological Survey methods were in general accordance with those outlined in the following documents:

Ecological Survey methods were in general accordance with those outlined in the following documents:

- Heritage Council (2011) 2. Best Practice Guidance for Habitat Survey and Mapping.
- Phase 1 Habitat Survey methodology (Joint Nature Conservation Committee (JNCC), 1990, revised 2003) 3
- Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes (NRA, 2009)4

Plant names follow Stace (2010)5. Flora of particular ecological interest, including non-native invasive species such as Japanese Knotweed (*Reynoutria japonica*), Giant Hogweed (*Heracleum mantegazzianum*), and Himalayan Balsam (*Impatiens glandulifera*), and/or protected species such as Opposite-leaved Pondweed (*Groenlandia densa)* were recorded and mapped when observed during all surveys.

Desktop Study

A desk-based assessment was carried out to collate information regarding protected/notable species and statutorily designated nature conservation sites in, or within close proximity to, the study area. A data search for protected and notable species was conducted using the National Biodiversity Data Centre Mapping System (National Biodiversity Data Centre, 2019).

Protected Flora

Kings Island spans across four 2km national grids on the National Biodiversity Data Centre's map viewer, R55U, R55T, R55Y and R55Z. The following protected plant species have been noted in the 2km Squares:

- Opposite-leaved Pondweed (*Groenlandia densa*) in the Limerick Canal to the south east of the site and in a small area to the south by O'Callaghans Strand;

1.1 Methodology

An ecological walkover survey of the area was conducted by JBA Consulting ecologists on 09/09/2015 (resurveyed 2019) to record the habitats and flora of the scheme as part of the EIAR Constraints Study. The purpose of this survey was also to detect the presence or likely presence of protected species that may be impacted by the scheme and identify the need for further surveys, if necessary. The survey was chiefly concerned with recording habitats suitable for protected habitats and species; and notes were also made on other flora and fauna. The more detailed ecological surveys and species-specific surveys were carried out during 2016, 2017, 2018 and 2019 (re-surveying) for the proposed scheme, by a team of specialist ecologists and other technical specialists as seen in Table 8-1.

Habitat and Protected Flora Surveys

Summary of Ecological Surveys

Table 8-1 Details of specialised ecological surveys conducted in 2015 - 2019

Name	Company	Role	Ecological Receptor	Dates
Dr. Joanne Denyer & Tanya Slattery	Denyer Ecology and JBA Consulting	Aquatic plant specialist and Botanist	Opposite-leaved Pondweed *Groenlandia densa*	April 2017

[2] Heritage Council (2011). *Best Practice Guidance for Habitat Survey and Mapping.* The Heritage Council
[3] JNCC (Joint Nature Conservation Committee) (2010*). Handbook for Phase 1 habitat survey: A Technique for Environmental Audit.* Peterborough: JNCC
[4] NRA (2009). *Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes*. National Roads Authority. Available at: https://www.tii.ie/technical-services/environment/planning/Ecological-Surveying-Techniques-for-Protected-Flora-and-Fauna-during-the-Planning-of-National-Road-Schemes.pdf [Accessed 29 May 2019]
[5] Stace C. (2010). *New Flora of the British Isles*. 3rd Ed. Cambridge University Press, Cambridge.

Name	Company	Role	Ecological Receptor	Dates
Tanya Slattery	JBA Consulting	Ecologist and Botanist	Detailed habitat survey of Sir Harry's Mall Habitat	8 March 2018

Habitat and Flora Field Survey Results

(FW4) Drainage ditches

There are a number of ditches on the island. The main drainage ditches run along the inside of the embankment on King's Island and are mainly for land drainage purposes. The drainage ditch on the west (Plate 1-4) has two ouflows into the Shannon River, though one is blocked at present. The drainage ditch on the east of the island has one outflow to the Abbey River.

Vegetation within and on the banks of the drainage ditch on the west included Reed Sweet-grass (*Glyceria maxima*), Yellow Iris (*Iris pseudacorus*), Water Horsetail (*Equisetum fluviatile*) and Bulrush (Typha latifolia). A section of this drainage ditch contains the protected species Opposite-leaved pondweed (*Groenlandia densa*) and so was surveyed and characterised further by an aquatic specialist.

Nearby borehole and trial pit investigations have shown that the ditch is located in an area of relatively impermeable clay, underlain by sands and gravels. The existing ditch is fed both by surface water run-off from surrounding lands and groundwater through the lower sand/ gravels layer (Denyer, 2019)[6].

The ditch section with *Groenlandia densa* had relatively clearwater with low overall algal cover at the time of survey. Aquatic macrophytes were abundant in the channel and the ditch had shallow eastern bank, grading into wet grassland to the east. There was no shading by scrub or tall vegetation and the ditch was in mid-successional stage with small amounts of open water and a mixture of submerged, floating and emergent vegetation. Water sampling shows that the ditch has a pH between 7.5 and 8 (highly calcareous) and is neither brackish nor highly polluted (Denyer, 2017)7.

Six shallow drainage channels run across marsh habitat to the east of the site (Plate 1-5). The drainage ditch at the south east of the site flow north into the flood plain (Plate 1-6).

Protected Flora

Opposite-leaved Pondweed

Opposite-leaved Pondweed was observed in the ditch to the north west of the site during the walkover survey on the 17/01/2017 by botanist Tanya Slattery (JBA) (Plate 1-14, Appendix C1). As this plant is protected under the Flora Protection Order, confirmation of the species identification, based on photographs taken during the survey, was obtained by Aquatic Macrophyte specialist Joanne Denyer. Joanne Denyer proceeded to obtain a derogation license from the NPWS, in order to confirm the extent of its range within this area and develop possible translocation or alternative habitat development plans in consultation with the NPWS.

Opposite-leaved Pondweed is normally found in calcareous waters of rivers, streams, canals, ditches and ponds. In Ireland, this species is typically associated with areas that are periodically disturbed, including canals, drains and tidal stretches of rivers. It is one of the subtypes of one of the qualifying features of the Lower River Shannon SAC (NPWS 2012a)8 and can tolerate a

[6] Denyer J. (2019) Section 21 Application *Groenlandia densa* Methods Statement.
[7] Denyer, J. (2017) King's Island *Groenlandia densa* Survey, June 2017. Unpublished report
[8] NPWS (2012a). Lower River Shannon SAC (site code 2165). Conservation objectives supporting document- Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (habitat code 3260) [Available at: https://www.npws.ie/sites/default/files/publications/pdf/002165_Lower%20River%20Shannon%20SAC%20Water%20Courses%20Supporting%20Doc_V1.pdf [accessed 18 April 2019]

certain level of disturbance. It had not previously been identified on King's Island or within the said drainage ditch.

Figure 8-6 in EIAR Volume 3 shows the main areas of Opposite-leaved Pondweed plants observed in a section of the ditch approximately 200m in length (mapped using GPS. In the southern section of the ditch (where the transect was located), Opposite-leaved Pondweed was present throughout the channel and only particularly dense populations have been mapped. The plants appeared healthy at the time of survey and had been present in the ditch during January, suggesting they had overwintered in the ditch.

To the north and south of the section with Opposite-leaved Pondweed the ditch is infilling and overgrown suggesting that no ditch clearance had been undertaken recently. To the north the channel is shaded by scrub and dense patches of Duckweed (Lemna spp.) and litter dominate the water surface. To the south, the ditch channel is dominated by Bulrush (Typha latifolia), Reed Sweet-grass (Glyceria maxima) and Bur-reed (Sparganium spp.) Opposite-leaved Pondweed was not recorded from these overgrown ditch sections.

Macrophytes growing with Opposite-leaved Pondweed at the time of surveys included Common Stonewort (Chara vulgaris), Thread-leaved Water-crowfoot (Ranunculus cf trichophyllus) (not flowering), Blue-fruited Water-starwort (Callitriche cf obtusangula) (not flowering or fruiting), Reed Sweet-grass (Glyceria maxima), Bur-reed (Sparganium spp.) (not flowering), Least Duckweed (Lemna minuta) Common Duckweed (Lemna minor), Water Horsetail (Equisetum fluviatile), filamentous algae, Brooklime (Veronica beccabunga), Pink Water-speedwell (Veronica catenata) and Yellow Flag (Iris pseudacorus).

The area to the north-west of the Island was examined for the presence of the protected species, Triangular Club-rush, however none were identified during the ecological surveys. Access was restricted to certain areas of the site and due to the time of year that the survey was conducted, this species may not have been observable and may still be present. However potential Triangular Club-rush was recorded during the fisheries surveys between Thormond Bridge and Curragower falls on the west of King's Island.

Opposite-leaved Pondweed is protected by Section 21 of the Wildlife Act (1976) and is listed on the Flora (Protection) Order (2015)9. It is listed as 'Near Threatened' on the Irish Vascular Plant Red List (Wyse Jackson et al., 2016)10; and is identified as one of the three high conservation elements (sub-types) of the Feature of Interest of the Annex I habitat Water courses of plain to montane levels with the Ranunculion fluitanis and Callitricho-Batrachion vegetation [3260] within the Lower River Shannon Special Area of Conservation (SAC) (NPWS, 2012b11).

Opposite-leaved Pondweed was not visibly apparent in the ditch or recorded by JBA ecologists during the re-surveying of habitats on King's Island in spring/summer of 2019. This is not to say that the pondweed does not still exist there. Surveyors did not enter the close environs of the ditch in 2019 as this would require a licence by an aquatic botanical specialist.

Fisheries

Riparian habitat

Opposite-leaved Pondweed was not observed between Thomond Bridge and Sarsfield Bridge but is highly likely to occur in the slack water areas of the Abbey River. It is however known to thrive in the adjoining Park Canal, east of Baal's Bridge (Reynolds et al., 2006). Littoral

[9] S.I. No. 356/2015 - Flora (Protection) Order, 2015.[Available at: http://www.irishstatutebook.ie/eli/2015/si/356/made/en/print] [Accessed 28 may 2019]

[10] Wyse Jackson, M., FitzPatrick, Ú., Cole, E., Jebb, M., McFerran, D., Sheehy Skeffington, M. & Wright, M. (2016) Ireland Red List No. 10: Vascular Plants. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Dublin, Ireland [Available at: https://www.npws.ie/sites/default/files/publications/pdf/RL10%20VascularPlants.pdf] [accessed 28 May 2019]

[11] NPWS (2012b) Lower River Shannon SAC 002165 Conservation Objectives [online] https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002165.pdf . [Accessed 5 April 2019]

macrophytes included brooklime, Water mint, Cuckoo flower (*Cardamine pratensis*) and Fool's watercress (*Apium nodiflorum*) which were locally common upstream of Curragower Falls.

Invasive Non-native Species

The location of Giant Hogweed was contained to the outer fringe of the island, among the riparian woodland and wet grassland areas in 2017. However, by 2019 it was recorded on either side of the pathway on the western embankment, on the embankment itself and in the ditch that contains Opposite-leaved Pondweed.

Construction Impacts 2: Species loss (Protected flora)

Opposite-leaved Pondweed Groenlandia densa

Proposed activity and its duration, biophysical change and relevance to the feature in terms of ecosystem structure and function

The permanent infilling of the ditch at the base of the western embankment to enable the construction of the new embankment inside the old one, will result in the loss of the only population of the protected species Opposite-leaved Pondweed on King's Island. The species requires particular conditions in which to survive which are not available in the other ditches and watercourses on King's Island (Denyer, 2017)[12].

Characterisation of unmitigated impact on the feature

Infilling of the ditch will result in the complete loss of the population of Opposite-leaved pondweed on King's Island.

Rationale for prediction of effect

Opposite-leaved Pondweed is a protected species and only occurs in one section of ditch on King's Island. It is known to occur in Limerick Canal to the south east of the site and in a small area to the south of the King's Island by O'Callaghan's Strand (NBDC). As this is the only population of Opposite-leaved Pondweed on the island, the infilling of the ditch will result in the loss of this species in the area.

Effects without mitigation

The permanent infilling of the ditch and subsequent loss of this species on King's island will result in a significance impact at local and national level.

Operation impacts 2: Species loss (Protected flora)

Opposite-leaved Pondweed

Proposed activity and its duration, biophysical change and relevance to the feature in terms of ecosystem structure and function

Opposite-leaved Pondweed Groenlandia densa

Proposed activity and its duration, biophysical change and relevance to the feature in terms of ecosystem structure and function

The permanent infilling of the ditch at the base of the western embankment to enable the construction of the new embankment inside the old one, will result in the loss of the only population of the protected species Opposite-leaved Pondweed on King's Island. The species requires particular conditions in which to survive which are not available in the other ditches and watercourses on King's Island (Denyer, 2017)[13]

Characterisation of unmitigated impact on the feature

[12] Denyer (n 36)
[13] Denyer, J. (2017) King's Island *Groenlandia densa Survey, June 2017. Unpublished report*

Infilling of the ditch will result in the complete loss of the population of Opposite-leaved Pondweed on King's Island.

Rationale for prediction of effect

Opposite-leaved Pondweed is a protected species and only occurs in one section of ditch on King's Island. It was known to occur in Limerick's Park Canal to the south east of the site, though it has not been recorded there since 2006, in a small area to the south of the King's Island by O'Callaghan's Strand (NBDC) and in other areas of Limerick (Reynolds, 2013)[14]. As this is the only population of Opposite-leaved Pondweed on the island, the infilling of the ditch will result in the loss of this species in the area.

Effects without mitigation

The permanent infilling of the ditch and subsequent loss of this species on King's island will result in a significance impact at local and national level.

Operation impacts 4: Water quality

Proposed activity and its duration, biophysical change and relevance to the feature in terms of ecosystem structure and function

Periodic maintenance of embankments or drainage scheme (i.e. clearing of build-up of silt) will contribute additional particulate matter to sensitive water courses.

Characterisation of unmitigated impact on the feature

Once embankments and open areas are revegetated there is less opportunity for silt runoff. However, over time, vegetation debris or silt may block drains and outflows. Maintenance work may result in silt being released to the Shannon or Abbey Rivers.

Rationale for prediction of effect

Drainage and maintenance requirements for the new embankments connect these areas to sensitive water courses within the SAC. Any silt/polluted runoff will end up in the local drains or channels within King's Island and will eventually reach the rivers via the filter drains and outfalls.

Effects without mitigation

Without mitigation there could be long term impact from runoff to sensitive water courses within King's Island (channel with Opposite-leaved Pondweed) and within the SAC (Shannon and Abbey rivers). These are assessed as a significant impact at local and national level and at International level respectively.

Specific design mitigation

Opposite-leaved Pondweed

Conservation of Opposite-leaved Pondweed *Groenlandia densa* on King's Island has been discussed with NPWS (see Appendix C3-2). A licence for the translocation of the pondweed has been applied for (Appendix C3-3) and approved (Appendix C3-4) and the following mitigation applies:

- To conserve the population of Opposite-leaved Pondweed *G. densa* design mitigation includes the relocation of plant specimens to suitable watercourse habitats. This involves removal of pondweed plants from ditch habitat to a holding area and then translocation into a newly excavated channel and two other locations. Mitigation will follow the Methods statement in the Section 21 Licence Application (Floral Protection Order) for *G. densa* (Denyer, 2019)[15] (Appendix C3-3) and any additional agreements with NPWS. A licence has been granted by NPWS (see Appendix C4).

[14] Reynolds, S. (2013) *Flora of County Limerick*. National Botanic Gardens
[15] Denyer J. (2019) Section 21 Application *Groenlandia densa* Methods Statement.

- All conservation work connected with *G. densa* and its habitat to follow and implement the strategies, methods and actions described in the report "Section 21 Application. *G. densa* Methods Statement. March 2019. Unpublished report to NPWS, in support of Section 21 Licence application prepared by Denyer Ecology"[81], its two appendices A&B and the finalised detailed translocation plan (see below) and any subsequent modifications to these as may be proposed and agreed with the NPWS.
- The detailed translocation plan noted in sections 2.3.1 and 2.3.3 of the above report to be finalised in agreement with NPWS and incorporated with a finalised Methods Statement report into a Conservation Management Plan for the species at the site, in advance of commencement of any of the works – this plan to include finalised details of actions to be undertaken and the order and timeline for these.
- Translocation of *G. densa* with storage should remain the prime method; although direct translocation should also be attempted if feasible.
- Translocation/enhancement of two other sites in or as near to King's Island as possible, as per NPWS instructions under licence. The option of using the upper parts of the drains on the east side of Kings Island will be considered for habitat translocation of some plants, if suitable habitat can be created there, as a first choice in habitat enhancement, rather than sites distant from King's Island. Sites outside of King's Island will have to be owned by LC&CC. Sites where Opposite-leaved Pondweed occur in Limerick are outlined in Reynolds (2013), *Flora of Limerick.* Five potential sites have been chosen by licence holder Jo Denyer. These are described below in Table 8-14 with their ranking (1 being the highest) and are also seen in Figure 8-14. There are two sites with a ranking of 1, Rossbrien ditch/ Ballynaclogh River and Ballynaclough River, east of Dooradoyle, which are the most likely sites for enhancement. If, after surveying, none of the five sites listed in Table 8-14 are feasible NPWS will be contacted for further advice on other suitable sites.

  The enhancement of two chosen sites for *G. densa* will be developed and monitored over three years. This will be carried out as a research project for scientific and educational purposes, and a report will be published after completion.

Table 8-14: Potential *G. densa* enhancement sites and ranking (1 being highest)

Site name	Limerick CC ownership	Grid reference	Date last recorded*	Notes	Rank
Rossbrien ditch/ Ballynaclogh River	Part of site	R571546	2010	In situ populations recovered after dredging (under licence) in 2009, but subsequently declined due to lack of ditch management. Current condition unknown.	1
Ballynaclough River, east of Dooradoyle	Part of site	R566546	2009	In situ populations recovered after dredging (under licence) in 2009, but subsequently declined due to lack of ditch management. Current condition unknown.	1
Abbey River	Possibly, depending on exact location	R581574	1998	Unknown if Groenlandia densa has been recorded recently or if suitable habitat still present within LCC owned lands.	2
Near Sarsfield Bridge	Yes	R5757	1993	Unknown if Groenlandia densa has been recorded recently or if suitable habitat still present within LCC owned lands.	3
Loughmore Canal	Part of site	R5453	2006 (NPWS), possibly more recent records	Translocation plan created for proposed dredging but this may not have yet been undertaken. Not clear if Groenlandia densa is present in LCC owned part of the canal.	4

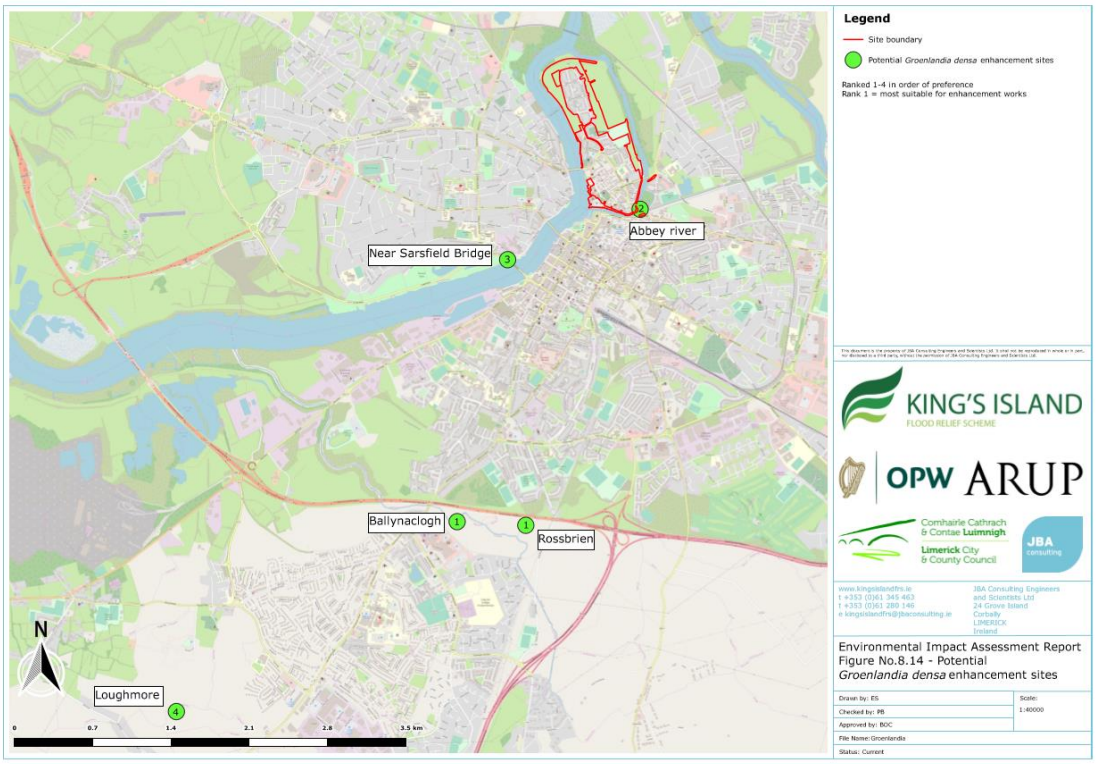


Figure 8-14: Potential *G. densa* enhancement sites

Construction Phase Mitigation

Construction Mitigation 3: Management measures for Surface Water

- No excavation shall take place below the water-table on the Application Site except for excavation of channel for Opposite-leaved Pondweed

Operation Phase Mitigation

Protected flora

To ensure the successful translocation of Opposite-leaved Pondweed to the new channel monitoring of Opposite-leaved Pondweed in the new channel on King's Island will take place according to Section 21 Licence application for *Groenlandia densa* (Denyer, 2019)[16], conditions outlined in Licence No. FL08/2019 (Licence to take Protected Flora, alter or otherwise interfere with the habitat or environment of a species of Protected Flora) seen in Appendices C3 and C4, and advice from NPWS.

The enhancement of two additional sites for *G. densa* will be developed and monitored over three years. This will be carried out as a research project for scientific and educational purposes, and a report will be published after completion.

Residual Impact

Table 8-15 summarises in tabular form the conclusions and identifies what the residual impact of the proposed King's Island FRS will be on ecological receptors.

16 Denyer J. (2019) Section 21 Application *Groenlandia densa* Methods Statement

Table 8-15: Summary of impacts of proposed King's Island FRS on ecological receptors (relevant rows re *G. densa* extracted)

Impacts	Characterisation of unmitigated impact on the feature	Effect without mitigation	Mitigation	Significance of effects of residual impacts after mitigation
Construction impacts				
Habitat loss/disturbance	Ditch and wet grassland Construction of embankments will result in direct loss of ditches and wet grassland	The loss of north west ditch is assessed as significant at a national level due to presence of protected species Opposite-leaved Pondweed.	Relocation of ditch and reinstate with similar hydrology and sediment features to original; adequate sloping of ground to allow revegetation and succession of wet grassland	Not significant
(Protected Flora) Species loss	Infilling of ditch will result in loss of population of Opposite-leaved Pondweed	Without mitigation population of Opposite-Leaved Pondweed will be lost to King's Island, leading to significant impact at a National and local level.	Removal of pondweed plants from ditch habitat to a holding area and then translocation into a newly excavated channel. Mitigation will follow the Methods statement in the Section 21 Licence Application (Floral Protection Order) for Groenlandia densa (Denyer, 2019)) and any subsequent modifications to these as may be proposed and agreed with the NPWS. . NPWS have requested enhancement of two further sites where Opposite-Leaved Pondweed is located in the environs of Limerick city. These are seen in Figure 8.14.	Not significant
Operational Impacts				
(Protected) Species loss	Opposite-leaved Pondweed A new channel with translocated population of Opposite-leaved Pondweed may not lead to successful reestablishment of this species.	Without monitoring and a management plan population may not succeed, leading to significant impact at a National and local level.	Management of channel vegetation, Monitoring of Opposite-leaved Pondweed according to Section 21 Licence application for Groenlandia densa (Denyer, 2019) and any subsequent modifications to these as may be proposed and agreed with the NPWS. Monitoring of two further enhancement sites as agreed with NPWS.	Not significant
Reduction in	Periodic maintenance	Silt runoff into ditch with	Regular review of	Not

water quality	works such as clearing filter drains and outfalls will contribute silt or pollutants to water courses	Opposite-leaved Pondweed, and Shannon and Abbey Rivers will lead to significant impact at local and national level and at an International level respectively.	maintenance requirements	significant

Monitoring

Opposite-leaved pondweed

Post-construction Monitoring for Opposite-leaved Pondweed within King's Island and at two other sites will take place under the licensing agreement for relocation of this species.

Consultant Surveys, Licence Applications and Licences for G. densa

King's Island *Groelandia densa* Survey June 2017 by Denyer Ecology is seen in Appendix C3-1. Licence application for translocation of *G. densa* is seen in Appendix C3-3 and NPWS licence approval in Appendix C4.

KING'S ISLAND *GROENLANDIA DENSA* SURVEY

June 2017

Report produced by Denyer Ecology for:
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Report information

Report title:	King's Island *Groenlandia densa* survey	
Client:	JBA Consulting	
Document reference:	DE2041 R01b	
Project number:	DE2041	
Author(s):	Dr Joanne Denyer	**Date:** Jun 2017
Checked and authorised:	Dr Joanne Denyer	**Date:** Jun 2017

CONTENTS

1 INTRODUCTION

Denyer Ecology was commissioned to undertake an initial survey and assessment of translocation options for a population of *Groenlandia densa* present in a drainage ditch at King's Island, Limerick City. *Groenlandia densa* is protected under the Flora (Protection) Order, 2015; is listed as 'Near Threatened' on the Irish Vascular Plant Red List (Wyse Jackson et al., 2016); and is identified as one of the three high conservation elements (sub-types) of the Feature of Interest of the Annex I habitat Water courses of plain to montane levels with the *Ranunculion fluitanis* and *Callitricho-Batrachion* vegetation [3260] within the Lower River Shannon Special Area of Conservation (SAC).

The aims of the survey and assessment were to:

- Consult with relevant organisations and individuals in relation to *Groenlandia densa* records in the local area and translocation methods for this species.
- Review relevant *Groenlandia densa* ecology and distribution data in Ireland.
- Undertake an Initial survey and assessment of the drainage ditch on King's Island where over-wintering *Groenlandia densa* was recently recorded by JBA (January, 2017). Included application for a National Parks and Wildlife Service (NPWS) Section 21 licence application to survey *Groenlandia densa* at the site.
- Review *Groenlandia densa* translocation options at the site.
- Advise on potential impacts to the Conservation Objectives for the Lower River Shannon SAC from translocation of *Groenlandia densa.*

1.1 Project

Flora surveys are being undertaken as part of the Ecological Impact Assessment (EcIA) of the King's Island Flood Relief Scheme, Limerick City. JBA Consulting are undertaking the EcIA and Denyer Ecology has been sub-contracted to undertake an aquatic plant survey, focussing on *Groenlandia densa.*

King's Island is susceptible to both coastal and fluvial flood risk and very significant flooding occurred in spring 2014 when existing defences failed locally, both overtopping the through breaching. An element of the proposed flood relief scheme at King's Island proposes to construct an embankment on the western side of King's Island. The proposed embankment will be constructed on the landward side of the existing sandbags/hedgerow that separates the riparian habitat of the River Shannon and the amenity grassland area adjacent to St. Oliver Plunkett Street. An existing ditch, where *Groenlandia densa* has recently been recorded, falls within the footprint of the proposed embankment. The construction of the embankment will result in the ditch being filled in and permanently lost. The project design team are currently conducting the multi-criteria assessment for the selection of the preferred option of the flood relief scheme. All options under consideration involve the construction of an embankment along the western side of King's Island and thus the resultant loss of the existing ditch.

1.2 Survey area

The ditch where *Groenlandia densa* has been recorded is located on the north-eastern side of King's Island (Figure 1, Appendix A. In addition, the remaining length of ditch on the east and western side of King's Island was surveyed (Figure 1.1).

2 METHODOLOGY

2.1 Survey area

2.2 Desktop data

The following resources were consulted:

- GIS boundaries of designated site data (data accessed via NPWS website).

- Site synopsis and Conservation Objectives for the Lower River Shannon SAC [site code 002165] (NPWS, 2013; 2012b)
- Aerial photography (supplied by Limerick County Council).
- Records of *Groenlandia densa* in County Limerick held by National Parks and Wildlife Service (NPWS).
- *A survey of rare and scarce vascular plants in County Limerick* (Reynolds et al., 2006).
- *Flora of County Limerick* (Reynolds, 2013).
- *New Atlas of Britain and Ireland* Preston et al., 2002)
- Botanical Society of Britain and Ireland (BSBI) online mapping.
- Geological Survey of Ireland (GSI) 1:100,000 Bedrock data (downloaded shapefiles)
- Reports on *Groenlandia densa* translocation projects, as cited in text.
- Additional publications and documents, cited in text where relevant.

2.3 Consultation

The following organisations and individuals were consulted for this project:

- National Parks and Wildlife Service
- BSBI Vice-County recorder for H8 (Limerick)
- Dr Simon Barron, Director of Ecology, Botanical, Environmental & Conservation (BEC) Consultants Ltd
- Stephen Heery, Ecologist
- Eamonn Horgan, Environment and Heritage Officer, Waterways Ireland

2.4 Field Survey

The survey method was based on the following standard methodologies for surveying macrophytes in ditches: UK Common Standards Monitoring (CSM) Guidance for Ditches (JNCC, 2005)

2.4.1 Walk-over and mapping of Groenlandia densa

The entire length of the drainage ditch was walked to determine the extent and abundance of the *Groenlandia densa* population. The location of populations of *Groenlandia densa* were mapped using GPS. Where the plant was easily visible from the bank, grapnel sampling was not necessary. A grapnel was only used where no plants of *Groenlandia densa* were visible from the bank, to assess whether any plants are actually present. This ensured the full extend of the plant within the ditch is recorded.

2.4.2 Detailed transect survey

The length of ditch where *Groenlandia densa* had been recently recorded is quite short (c200m) and has relatively homogenous vegetation. Therefore one continuous 100m transect was recorded rather than the recommended minimum 5 x 20m transect lengths (which would have been very close together). This is not considered to affect the detail of the information obtained, as the recorded parameters (e.g. water depth, species composition etc.) did not show much diversity in this section of ditch. The transect was located in the area where *Groenlandia densa* was most consistently abundant.

The transect was surveyed from one ditch bank using a grapnel. In addition the entire length of the ditch section with *Groenlandia densa* and most of the remaining ditch length on King's Island was walked to look for *Groenlandia densa.* The survey focused on aquatic macrophytes (submerged and floating) and the DOMIN value (Table 2.1) for each species was recorded. Brief notes were made on the ditch physical characteristics and bank vegetation. The transect location (start and end point) was recorded with a GPS in the field.

Table 2.1. DOMIN scale of abundance

DOMIN value	Percentage cover range
10	91-100%
9	76-90%
8	51-75%
7	34-50%
6	26–33%
5	11-25%
4	4-10%
3	<4%, many individuals
2	<4%, several individuals
1	<4%, few individuals

The following habitat information was recorded (based on JNCC, 2005):

- Ditch length
- Water depth
- Water clarity
- Algal dominance
- Rare/ quality species
- Channel form
- In-channel vegetation (successional stage of ditch)
- Bankside vegetation cover
- Native macrophyte species richness
- Non-native macrophyte species
- Salinity
- pH: measured during survey using handheld device and subsequent water sampling by Limerick County Council.

The ditch survey was undertaken in March 2017. This is outside of the optimal season (May to September) for surveying aquatic plants. However, *Groenlandia densa* was producing winter shoots in this location in January 2017, which enabled an assessment of the population to be made in early spring. If it is considered that it is not possible to fully assess the *Groenlandia densa* population and associated aquatic macrophyte flora, further survey work will be recommended.
Where possible, all taxa (excluding macroalage) will be identified to species level. For some species, identification to species level required particular features, such as fruits or flowers, to be present. If these are absent then it may not be possible to identify to species level, or a repeat survey visit may be required.

2.5 Voucher specimens

A small voucher specimen from the site was collected and will be subsequently lodged at the herbarium in the National Botanic Gardens, Glasnevin (DBN). *Groenlandia densa* is locally abundant at this site (and in the general area e.g. Reynolds, 2013), therefore a small disturbance of a healthy population will not lead to an overall negative impact on the survival of the *Groenlandia densa* population at the survey site.

2.6 Section 21 Licence

A 'Licence to Take or Interfere with Protected Plant Species' under Section 21 of the Wildlife Act in relation to the aquatic plants: Opposite-leaved Pondweed *Groenlandia densa* was obtained from NPWS before any in-channel aquatic macrophyte surveys were undertaken in this ditch. A detailed methods statement was submitted to NPWS and these methods were followed during the surveys (as described in this report).

2.7 Microscope identification, voucher specimens and referees

A small voucher specimen of *Groenlandia densa* was collected and will be subsequently lodged at the herbarium in the National Botanic Gardens, Glasnevin (DBN). *Groenlandia densa* is locally abundant at this site (and in the general area e.g. Reynolds, 2013), therefore a small disturbance of a healthy population will not lead to an overall negative impact on the survival of the *Groenlandia densa* population at the survey site.
In addition, small samples of species requiring microscope identification (e.g. charophytes) were collected as necessary.

2.8 Plant species nomenclature

Plant nomenclature follows that of the New Flora of the British Isles. 3rd Edition. (Stace, 2010). Specialist publications for species groups were referred to as relevant.

2.9 Limitations

Where possible, all taxa (excluding macroalgae) were identified to species level. For some species, identification to species level required particular features, such as fruits or flowers, to be present. Where these were absent, it was not always possible to identify to species level. The surveys were undertaken in March 2017, which is outside the optimal survey season for ditches: mid June to late August (JNCC, 2005). However, *Groenlandia densa* is producing winter shoots in this location, which enabled an assessment of the population to be made at this time, which was the primary aim of the survey.

3 RESULTS

3.1 Desktop survey results

3.1.1 Distribution in Ireland

Groenlandia densa is rare in Ireland. It is currently known from the north-east (Co. Antrim) and the Grand and Royal Canals in Co. Dublin (e.g. Downey, 1991); but is more frequent in the southern half of the country (Parnell and Curtis, 2012; Preston et al., 2002). *G. densa* is listed as 'Near Threatened' on the Irish Vascular Plant Red List (Wyse Jackson et al., 2016) and is protected under the Flora (Protection) Order, 2015.
G. densa has been recorded from 18 hectads in Ireland since 1987 (Preston et al., 2002). This is a decrease from earlier records (23 hectads pre-1970). *G. densa* is considered to have declined in Britain and Ireland due to the effects of eutrophication and habitat loss (e.g. urbanisation and the loss of spring-fed streams and ditches because of falling water tables) (Preston et al., 2002; Preston & Crofts, 1997 & Preston, 1995). It is now extinct as a native species in Scotland (Preston et al., 2002).
Groenlandia densa is listed in the Conservation Objectives for Annex I 3260 Floating River Vegetation for a number of SACs in Ireland including: Slaney River Valley SAC [000781]; Lower River Suir SAC [002137]; Lower River Shannon SAC [002165]; and, Blackwater River (Cork/Waterford) SAC [002170].

3.1.2 Distribution in Co. Limerick

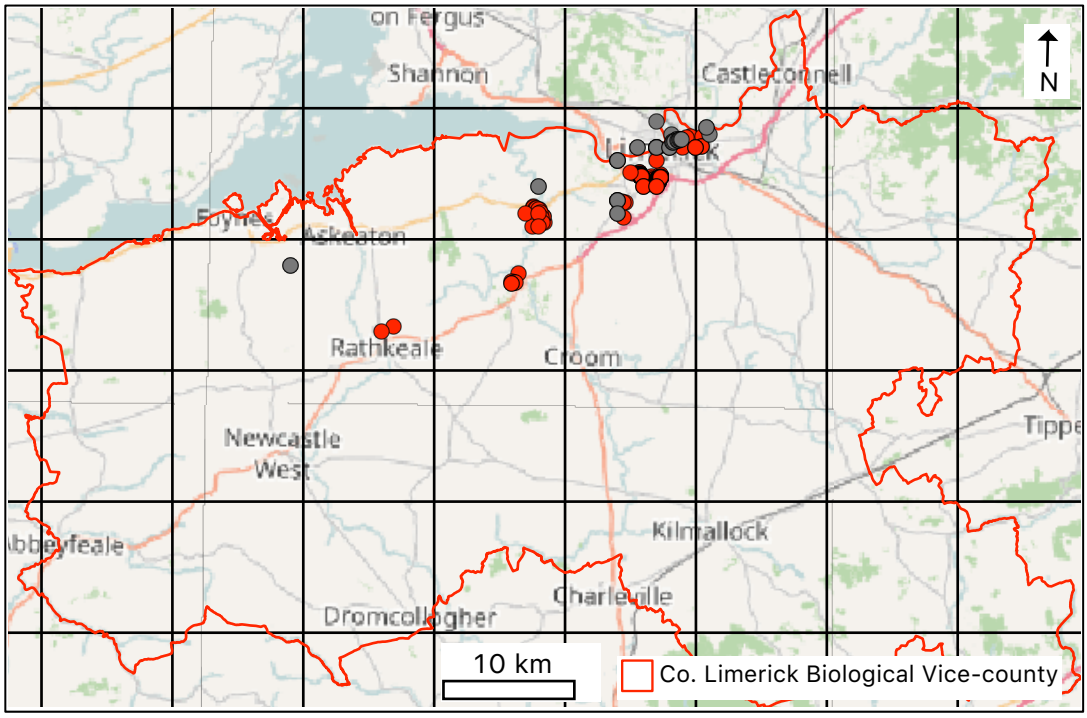
Groenlandia densa is locally abundant around Limerick City and near the lower River Maigue (Reynolds, 2013; Figures 3.1 & 3.2). It has been recorded from 6 hectads in Co. Limerick (Vice-county H8) pre-2000: R24, R34, R44, R45, R55 and R65 (BSBI Maps, 2017; Figure 3.1). It has not been recorded from R24 since 2000 (1904 record from Ahacronane River) and so is currently known from five hectads (Reynolds, 2013; Figure 3.1). It has been recorded from 13 tetrads in Co. Limerick post-2000 (BSBI Maps, 2017).
Groenlandia densa is present within the Lower River Shannon SAC (NPWS 2013, NPWS 2102). Figure 3.2 shows the distribution of *G. densa* in Limerick (from NPWS records) in relation to the SAC boundary. The main areas for *G. densa* within the SAC are: River Maigue (although some records are

in drainage ditches adjacent to the river and outside of the SAC), the Limerick Canal and a few records from the River Shannon. The ditches adjacent to Ballynaclough River (SW of Limerick City) are not within the SAC, but have abundant *G. densa* in an approximately 1km long stretch (see Table 3.1). Another key site outside of the SAC boundary is the ditch associated with Loughmore Common (see Table 3.1).

In 2006, a number of sites in Co. Limerick were surveyed for *Groenlandia densa* as part of a survey of rare and scarce vascular plants in the county (Reynolds et al., 2006). This states that *G. densa* is quite common around Limerick City in ditches, rivers and canals. However, *G. densa* is noted as having declined in the Abbey River and tidal River Shannon, where there have been extensive drainage works. A summary of the key features of nine sites that were surveyed in 2006 is shown in Table 3.1. These include drainage ditches, a canal and tidal mud. Some have been surveyed post 2006 and *Groenlandia densa* is still present (e.g. Adare, 2009; Ballynaclough River, 2007 and Ferry Bridge, 2012) (Reynolds, 2013). However, a survey of the Limerick Canal in 2009 failed to refind *G. densa*, despite it having been recorded from a 1.5km stretch in 2006 (Reynolds, 2013). A survey for the OPW in 2007 found *G. densa* to be the dominant species in large sections of back drains of the Ballynaclough River (Ní Bhroin, 2007).

There is one record from the Abbey River on the west side of King's Island (from 1998 but not re-found post-2000). However there are no current or historic records from the eastern side of King's Island, where the project site ditch is located. The closest recent records are from the Limerick Canal, to the south-east of King's Island (2006).

Figure 3.1. Distribution of *Groenlandia densa* in County Limerick (NPWS data)



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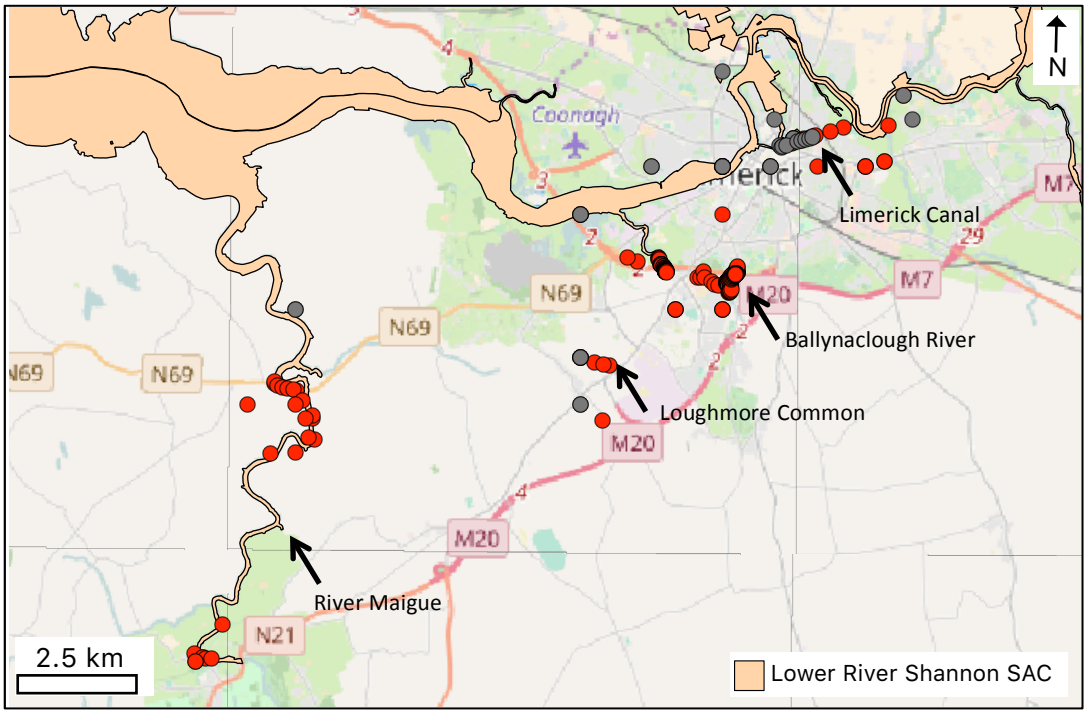
Grid = hectad boundaries (10 x 10km squares). Red circles = post-2000 records; Grey circles = pre-2000 records. Records at hectad level only, excluded.

Figure 3.2. Distribution of *Groenlandia densa* in Lower River Shannon in Co. Limerick (NPWS data)



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Red circles = post-2000 records; Grey circles = pre-2000 records. Records at hectad level only excluded.

Table 3.1. Summary of 2006 NPWS Rare plant survey results for keys sites of *Groenlandia densa* in Co. Limerick (Reynolds et al., 2006)

Site	Waterbody type	Population	Associated submerged aquatics	Management & threats
Adare, near River Maigue	Ditch with relatively clean water	Frequent in the ditch along a 200m stretch with locally dense patches	*Callitriche* sp., *Lemna minor, Elodea canadensis*	No recent dredging or vegetation clearance. Threats include natural infilling by vegetation growth
Ballynaclough River and area, east of Dooradoyle	On tidal mud in Ballynaclough River and in a number of drainage ditches behind the high river embankments	Several areas along a 1km stretch or river and abundant in ditches on both sides of the river	*Callitriche obtusangula Elodea canadensis, Lemna minor, L. trisulca, Myriophyllum verticillatum, Potamogeton berchtoldii, P. pectinatus, Zannichellia palustris*	Ditches had not been cleared recently but were not overgrown. No apparent threats.
Ferry Bridge, east of Kildimo	Deep drainage ditch through pasture	Five patches along a c 500m section of ditch	*Callitriche* sp*., Lemna minor, L. trisulca*	Adjacent grazing and some alluvial mud removed recently. No apparent threats.
Glascurram, south of Ferry Bridge	Deep drainage ditch parallel to the river behind the river embankment at the edge of grazed pasture	Two patches <5m in extent	*Myriophyllum verticillatum*	Adjacent grazing, no recent dredging. Population small and could be impacted by ditch cleaning.
Limerick Canal	Canal, mostly in 1-2m of water	Eight locations along a c1.5km stretch of the canal	*Myriophyllum verticillatum, and Callitriche obtusangula, charophytes, Nuphar lutea, Potamogeton crispus, P. natans, P. pectinatus*	Some recent dredging. Lack of regular clearance could lead to infilling.
Loughmore Common, south-east of Mungret	Wide (>6m) and deep drainage ditch	Dominant and abundant along 300m length of the ditch in shallow water, in places directly on mud not covered by water	Extensive patches of *Callitriche sp.*	No recent drainage work but vegetation sparse suggesting regular cleaning must be undertaken. No apparent threats.
North-east of Patrickswell	Drainage ditch with soft bottom and shallow water	A few plants in one location	Sparsely vegetated. Some *Lemna minor.*	Ditch appeared to have been recently cleared. No apparent threats.
Reboge, north-east Limerick City	Drainage ditches across flat grazed pasture	One small patch of plants (ditch nearly dried out by hot weather at time of survey)	*Callitriche* sp*., Elodea canadensis, Lemna minor, Chara* sp.	No recent clearance. Lack of regular clearance could lead to infilling.
River Shannon at Shannon Bridge, Limerick City	Rivulet and seepage area across tidal mud at edge of River Shannon. Freshwater clear and fairly fast flowing.	Few small patches each in rivulet and seepage areas	*Zannichellia palustris and Callitriche* sp.	No specific management. Decline in plants in this area likely to be due to drainage works leading to changes in water quality, substrate and vegetation on river margins

3.1.3 Relevant ecology

3.1.3.1 Growth and regeneration

Groenlandia densa is a perennial hydrophyte (perennating buds submerged during winter) (Hill et al., 2004). It can grow up to 0.65m, with unbranched to highly branched stems and submerged leaves only (Preston, 1995). It has far-creeping rhizomes (Hill et al., 2004), which lie on or just beneath the substrate surface (Preston, 1995). The rhizomes are white when under the substrate surface, but have a greenish colour when exposed to light (Preston, 1995). Unlike many broad-leaved *Potamogeton* species, the rhizomes are not highly differentiated from the stem and stems often root at the lower nodes (Preston, 1995). It does not produce turions (specialised vegetative propagules found in some *Potamogeton* species) and overwinters as leafy shoots (Preston, 1995). It can reproduce both by seed and vegetatively by sending out rhizomes (Greulich & Bornette, 1999) and irregularly fragmenting (Hill et al., 2004).

Groenlandia densa is considered to have an intermediate secondary ecological strategy: Competitive-Ruderal (C-R) (Greulich & Bornette, 1999). This strategy is adapted to habitats that are productive (which suits competitors), but intermittently disturbed (which suits ruderal species) e.g. eutrophic to mesotrophic ditches, streams and rivers that are subject to vegetation clearance or other disturbance. C-R strategists are able to spread rapidly by vegetative means (e.g. rhizomes) and can efficiently colonise temporary vegetation gaps (Grime, 1979). *G. densa* is outcompeted if tall vegetation becomes dominant and a high abundance of *G. densa* may indicate that a waterbody has been recently disturbed (Greulich & Bornette, 1999).

Groenlandia densa can grow in any season, including winter, but peak growth (including horizontal spread and new ground colonisation) occurs early in the growing season (Haslam, 1997). One study found that the highest production rate was during spring-early summer (end of April to mid-June); growth was then reduced by half in the summer (end of June to mid-August) and reduced further in late summer (end August to end September) (Greulich & Bornette, 1999). Whilst the cover of individual plants was low, *G. densa* had a high growth rate due to fast and abundant production of new, densely packed individuals (Greulich & Bornette, 1999). Damage to plants is followed by regrowth, but this will be slow at certain times of year (e.g. winter) (Haslam, 1997). If damage occurs prior to the peak growing season then the population will recover if some plants remain (Haslam, 1997). *G. densa* can then rapidly invade bare areas by spreading from adjacent undisturbed vegetation, with plants appearing in disturbed areas within a few weeks (Barrat-Segretain & Amoros, 1996; Chiarello & Barrat-Segretain, 1997). However damage at the end of the annual growth period can leave the population sparse and susceptible to further damage (Haslam, 1997).

In addition to vegetative spread by rhizomes, *G. densa* is considered to spread by plant fragments, which are easily detached (Preston & Croft, 1997). It produces flowers (which are self-pollinated), seed-set is normally very high (Preston & Croft, 1997). It has been shown to occur in the propagule bank of a riverine channel as both seeds and rhizomes (Combroux, 2004). However, it is not known to what extent it reproduces by seed and it rarely colonises new habitats (Preston & Croft, 1997).

When *G. densa* plants are newly established the small plants cannot trap silt efficiently (Haslam, 1997). Therefore this species does not regenerate well on coarse or low nutrient substrates unless bands of temporary silt are present (Haslam, 1997). Rhizome growth is in all directions in still water or low flows, but rhizome growth tends to be mainly across the channel, with little upstream growth, in channels with faster flow (Haslam, 1997).

3.1.3.2 Ecological requirements

The Ellenberg values for *Groenlandia densa* from PLANTATT (Hill et al., 2004) are summarised below:

- Light (L) – light-loving plant, rarely found where relative illumination in summer is less than 40%
- Moisture (F) – submerged plant, permanently or almost constantly under water
- Reaction (R) - found on calcareous or other high-pH soils

- Nitrogen (N) – indicator of sites of intermediate fertility
- Salt (S) – slightly salt-tolerant species, rare to occasional on saline soils but capable of persisting in the presence of salt – includes dune and dune-slack species where the groundwater is fresh, but where some inputs of salt spray are likely

(Haslam, 1997) also states that *G. densa* occurs where flow is still to moderate, in eutrophic to moderately mesotrophic water with high alkalinity, in usually shallow, clear, unpolluted water.

3.1.3.3 Habitat

Groenlandia densa has a European temperate element (Preston et al., 2002). At a European level, the EUNIS habitat classification system lists the following habitats for *Groenlandia densa*:

- C1.232 - Small pondweed communities
- C2.1A - Mesotrophic vegetation of spring brooks
- C2.27 - Mesotrophic vegetation of fast-flowing streams
- C2.33 - Mesotrophic vegetation of slow-flowing rivers
- C2.43 - Mesotrophic vegetation of tidal rivers

The habitats for *G. densa* are described as being moderately rich in nutrients.

The vegetation has affinity with the Annex I habitat: 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation [3260]' (EC, 2007). In the Lower River Shannon SAC, the Conservation Objectives list a high-conservation value sub-type of 3260 with *Groenlandia densa*. This is described as being associated with the tidal reaches of rivers (NPWS, 2012a). Whilst drainage ditches are mentioned as a habitat for *Groenlandia densa* in the area, the focus on *Groenlandia densa* in 3260 habitat is the tidal rivers and Limerick Canal.

Within Britain and Ireland, PLANTATT (Hill et al., 2004) lists the main habitats for this species as 'standing water and canals' and 'rivers and streams'. The New Atlas of the British and Irish Flora (Preston et al., 2002) states that it is found in '*shallow, clear, base-rich water which may grow in lakes and rivers but is more frequent in smaller waters such as streams, canals, ditches and ponds. It rarely colonises newly available habitats, although it is sometimes found as an introduction in ponds.*' *Generally lowland*.' In addition, Preston and Crofts (1997) mention that it is particularly characteristic of streams flowing from calcareous springs (e.g. growing with *Callitriche obtusangula)* and Preston (1995) that it can occur in calcareous water over an acidic substrate (e.g. peat or sandstone). Haslam (1997) describes *G. densa* as being typical of the lower reaches of chalk streams, or watercourses on hard limestone or mixed-limestone clay, in semi-eutrophic to eutrophic waters and not flow limited.

In Ireland, Parnell and Curtis (2012) list the habitat of *G. densa* as being rivers, canals and estuarine muds. This corresponds to the Habitat Survey classification habitats (Fossitt, 2000): Depositing/lowland rivers (FW2); FW3 Canals (FW3); Drainage ditches (FW4); and, Tidal rivers (CW2).

In Co. Limerick, the habitat of *G. densa* comprises ditches, rivers and canals (Reynolds et al., 2006). This includes the Limerick Canal, tidal rivers and tidal mud by the River Shannon (Reynolds et al., 2006). It particularly thrives in drainage ditches in the area, which act as an important refuge for some aquatic plants (Reynolds, 2013). The ditches that support this species are often deep and regularly cleared of vegetation (Reynolds, 2013). But it is also found in ditches with shallow water (e.g. back drains of the Ballynaclough River; Ní Bhroin, 2007) and on mud (e.g. Loughmore Common; Reynolds, 2013).

Groenlandia densa tends to occur in sites that are in an early to mid-successional stage and free from heavy shading by tall monocots and bankside trees (e.g. back drains of the Ballynaclough River; Ní Bhroin, 2007). *G. densa* is sensitive to eutrophication (Preston, 1995) and is usually found in waterbodies with low turbidity. It survives regular maintenance, as long as some vegetation is left from which it can recolonise (Reynolds et al., 2006). Without this regular maintenance, ditches in particular can become shaded and overgrown, with a build up of sediment and associated reduced water flow, and become unsuitable for *G. densa* (Ní Bhroin, 2007). The main current threats to *G. densa* habitats in Co. Limerick are lack of maintenance leading to succession; decreases in water quality or quantity; and disturbance of the substrate and complete removal of vegetation.

3.1.3.4 Associate species

There are a number of associate species that have been recorded growing with *Groenlandia densa*. In Ireland these include:

Azolla filiculoides (non-native)
Berula erecta
Callitriche species
Callitriche obtusangula
Callitriche stagnalis
Ceratophyllum demersum
Charophytes
Elodea canadensis (non-native)
Elodea nuttallii (non-native)
Lemna gibba
Lemna minor
Lemna minuta (non-native)
Lemna trisulca
Myriophyllum verticillatum
Nuphar lutea
Potamogeton berchtoldii
Potamogeton coloratus
Potamogeton crispus
Potamogeton lucens
Potamogeton natans
Potamogeton pectinatus
Ranunculus circinatus
Ranunculus trichophyllus
Schoenoplectus triqueter
Spirodela polyrhiza
Veronica beccabunga
Veronica catenata
Zannichellia palustris
(Sources: Deegan, 2004; Ní Bhroin, 2007; Reynolds, 2013; Reynolds et al., 2006)

3.2 Ditch survey results

Refer to Appendix A for full details of the field survey. This includes a site map, location of mapped *Groenlandia densa*, transect grid reference, representative photographs, ditch physical characteristics and species composition.

3.2.1 Ditch section with *Groenlandia densa*

The ditch section with *Groenlandia densa* had relatively clear water with low overall algal cover at the time of survey. Aquatic macrophytes were abundant in the channel and the ditch had a shallow eastern bank, grading into wet grassland to the east. There was no shading by scrub or tall vegetation and the ditch was in mid-successional stage with small amounts of open water and a mixture of submerged, floating and emergent vegetation.

The following 11 native aquatic macrophyte species (refer to reference list in JNCC, 2005) were recorded from the ditch:

- *Chara vulgaris**
- *Callitriche* cf *obtusangula*[1]
- *Equisetum fluviatile*
- *Glyceria maxima*
- *Groenlandia densa**
- *Iris pseudacorus*
- *Lemna minor*
- *Ranunculus* cf *trichophyllus*[1]
- *Sparganium* sp.
- *Veronica beccabunga*
- *Veronica catenata*

*Macrophyte species considered to be 'Ditch Quality indicators' (JNCC, 2005).
[1]not possible to confirm species as non-flowering at time of survey

Chara vulgaris, Callitriche cf *obtusangula* and *Groenlandia densa* are typical of highly calcareous water (in Ireland). The pH recorded from the ditch during survey (using handheld pH device) was pH 8.24 to 8.43. Subsequent water sampling by Limerick County Council (Appendix B) gave three sampling points with pH 8 and one point near the end of the transect with pH 7.5 (see Appendix B for a table with the results of the detailed water chemistry sampling). Both the species composition and water chemistry data therefore show that the water in the ditch is highly calcareous. It is interesting that the lower value was recorded near the end of the recorded distribution of *Groenlandia densa* and it may be that it depends on a high pH for its abundance in this location.

Chara vulgaris, Callitriche cf *obtusangula* and *Groenlandia densa* can also tolerate brackish conditions. Electrical Conductivity measurements were collected in the field using a handheld device (value range of 650-820 µS/cm recorded) and also measured during the water sampling by Limerick County Council (327-540 µS/cm recorded, Appendix B). A conductivity of >2000 µS/cm indicates either brackish water or highly polluted water (JNCC, 2005). As the recorded values are <1000 µS/cm, this shows that the ditch is neither brackish or highly polluted.

There is little/no data available on the water chemistry of ditches in Ireland. However, some comparison can be made with the data collected from calcareous springs across Ireland by Lyons (2015). Dissolved calcium ranged from 57.59 to 102.7 mg/l in this ditch section (Appendix B), which is comparable with the data recorded from calcareous springs in Ireland (mean of 87.80 mg/l; Lyons, 2015). Nitrate (as NO_3 mg/l) was <0.62 in the ditch section, which is low compared to the data collected from calcareous springs (mean 5.09; range <0.07-44.05 mg/l; Lyons, 2015). However phosphate in the ditch section 0.032-0.082 mg/l is at the upper end of that recorded from calcareous springs (mean 0.016; range 0.002-0.14; Lyons, 2015). This suggests low nitrate pollution, but possibly some input of phosphates in this ditch section. It would also be expected that the water in a ditch with input from surface (and possibly river water) would be more eutrophic than

calcareous spring water. It is perhaps surprising that the levels of nitrate and phosphates are not higher.

3.2.2 Adjacent ditch sections without *Groenlandia densa*

In addition to the detailed study of the ditch section with *Groenlandia densa,* the remaining ditches on King's Island were walked to look for *Groenlandia densa* and to compare characteristics:

- The ditch to the south of the ditch section with *Groenlandia densa* (outside but adjacent to the SAC, on the western side of the Island) did not support *Groenlandia densa.* The channel was overgrown by tall monocots and scattered scrub, with little open water and the surface of any open water present was dominated by Lemna *spp.* This ditch section is considered to be mid to late successional. The pH in this area was 7.3 (Appendix B). It was not brackish (484 µS/cm, Appendix B). The highest values of nitrate and phosphate were recorded from this area (0.71mg/l NO_3 and 0.087 PO_4, Appendix B) and calcium was slightly higher (Appendix B). The main difference between this area and the *Groenlandia densa* section appears to be the successional stage, increased eutrophication and pH. It is not clear whether conditions would be suitable for *Groenlandia densa* if the ditch was cleared to provide the early to mid-successional habitat favoured by *Groenlandia densa,* as the pH is lower. As the ditches are connected, it is also not clear why there should be such a difference in pH or successional stage (there were no obvious signs of past management). It is possible that the ditch section with *Groenlandia densa* has a different water source (e.g. a spring), which creates and maintains the high pH and perhaps reduces/ slows competition and succession within the ditch section.
- The ditch to the north of the *Groenlandia densa* ditch section was overgrown with scrub, had little open water and frequent litter from dumping. It was not suitable for *Groenlandia densa.*
- The ditches on the eastern side of King's Island are located within the SAC. *Groenlandia densa* was not recorded from any of the ditches. In addition, macrophyte species richness was generally lower in these ditches, many areas were overgrown with scrub or tall monocots and water was frequently turbid. Water sampling of the area with the most open and clear water, gave a pH reading of 7.4. As above, the ditch was not brackish (603 µS/cm, Appendix B). Nitrate and phosphate levels were similar to those within the *Groenlandia densa* ditch section (Appendix B). As above, it is not clear whether conditions would be suitable for *Groenlandia densa* if the ditch was cleared to provide the early to mid-successional habitat favoured by *Groenlandia densa,* as the pH is lower.

4 TRANSLOCATION REVIEW

There have been a small number of projects involving the translocation of *Groenlandia densa* in Ireland (under licence). These have generally involved removing plants whilst maintenance work was undertaken and replacement of the plants back in their original habitat/ site. In addition there is one study in France that involved translocation of *Groenlandia densa* to a new site as part of an experiment to assess competitive ability of four aquatic macrophyte species (see Section 4.5). The key methods and outcomes of these projects are summarised below.

4.1 *Groenlandia densa* in canal at Meelick, Co. Galway

Refer to unpublished reports prepared by S.Heery for ESB (Heery, 2011a & 2012a) for full details. Key points from these report summarised below.

- Removal of *Groenlandia densa* from canal prior to cement grouting of an embankment and in-situ protection of *Groenlandia densa* populations in areas not directly impacted by grouting.
- Canal c3m wide, constructed in 1929 to prevent flooding of callows to the west of the River Shannon as part of Ardnacrusha Hydro-electric Scheme.

- *Groenlandia densa* first recorded at site in 1991, in 2010 it was recorded from a 130m section of the canal.
- The vegetation within the canal was cut by ESB as part of annual maintenance
- Plants of *Groenlandia densa* from a 6m section of the canal were removed under license and placed in a planting basket in a nearby trench. Two 1.5m wide JCB buckets of silt from the same area (presumed to contain *Groenlandia densa* propagules and fragments) were removed and deposited in a nearby clean skip.
- Translocated material was **stored for 43 weeks** in three different receptors: skip, two wicker hanging-baskets and a small plastic bowl. *Groenlandia densa* grew in abundance in all receptors.
- After completion of the works, **some *Groenlandia densa* remained** in unimpacted sections of the canal.
- Material was **translocated back** into the canal in **September** 2011.
- **Long-term survival of plants** individually relocated (in small receptacles) **uncertain** (no plants recorded in 2012)
- **Plants from skip found to be severely limited by competition** from *Elodea canadensis* (only a single plant recorded in this location in 2012)
- However, there is now a well-established population in an area that was re-profiled (presumably regeneration from dormant propagules or rhizomes). This area had only ever had one plant recorded from it.
- The lack of success of transplantation was not considered to be due to the timing of re-planting (autumn), but most likely that that the roots needed to grow in very loose silt and they could not function in the substrate at the transplant site.

Outcome of translocation: Low survival and growth of translocated plants and competition from non-native macrophyte species. However *Groenlandia densa* regenerated from dormant propagules in less disturbed areas.
Potential issues: Not possible to replant material back into loose silt to promote establishment of roots and rhizomes.

4.2 *Groenlandia densa* at Shannon Harbour, Co. Offaly

Refer to unpublished reports prepared by S.Heery for OPW (Heery, 2011b & 2012b) for full details. Key points from these report summarised below.

- **Removal** of *Groenlandia densa* from 300m section of drain prior to maintenance (**October** 2011).
- *Groenlandia densa* plants removed from 7 recorded locations. One location was not dredged and at four other locations, the plants were left in situ.
- Plants were removed from digger bucket during maintenance work at these 7 locations.
- Plants **replaced back into drain immediately after dredging**. Method: '*After consideration the following method was used. The rooted rhizomes were encased by hand in a compressed ball of silt/marl/soil, with as much as possible of the green leafy stems free. This was then dropped carefully into the water at a point close to the edge of the newly profiled drain. Examination with a spade indicated that there was a dense suspension of silt at the bottom and it was expected/hoped that the Groenlandia material would embed itself in this. The depth of water into which the Groenlandia was replaced (on 12th October 2011) was about 60-70cm but will be significantly less during the growing season*.'
- It was **difficult to remove *Groenlandia densa* long rhizomes fully**, without breaking or removing different plant species. Therefore the amount of material removed at each location was less than expected.

- Monitoring in 2012 showed that **no plants of *Groenlandia densa* were recorded at 5 of the 7 translocation locations**. Plants were recorded at the remaining 2 locations, but it was unclear if this was growth of translocated plants or regeneration from rhizomes.
- It was suggested that translocated material should ideally be replanted into very loose silt, into which the roots and rhizomes can establish. This was not possible at the subject site.

Outcome of translocation: Low survival and growth of translocated plants (did not survive at most locations. At 2 sites where *Groenlandia densa* did persist, it is possible that this was from dormant propagules rather than translocated plants.
Potential issues: Difficult to fully remove long rhizomes; not possible to replant material back into loose silt to promote establishment of roots and rhizomes.

4.3 *Groenlandia densa* in the Grand and Royal Canals, Co. Dublin

Refer to unpublished reports prepared for Waterways Ireland by BEC Consultants (Baron, 2010a, 2010b, 2011a, 2011b, 2012a, 2012b, 2013, 2014 & 2015) for full details. Key points from these report summarised below.

1) Monitoring of *Groenlandia densa* in Grand and Royal canals to assess population growth post-dredging (undertaken in 2010-2011). Dredging found to have a positive effect on *Groenlandia densa* populations post-dredging (significant increase in the number of individuals, area covered, and range of the populations), presumably by removing competition.

- Some plants were present in areas where they were not recorded immediately post-dredging, but where there were historic records (suggesting regeneration from dormant propagules).
- Observations from the Grand Canal suggest that despite the stem and leaves of *G. densa* dying back when exposed above the water level for a sustained period, the root-stock remained viable, with the stem and leaves re-growing once the rootstock was submerged again.
- Considered that **recolonisation of areas where *Groenlandia densa* had been recorded** immediately prior to dredging was **most likely from extant rootstock** remaining within the dredged canal levels (in combination with recruitment from seed and development of plants from floating stems).

2) Rescue translocation and reinstatement of *Groenlandia densa* populations in the Grand Canal

- Survey for *Groenlandia densa* plants undertaken in May 2012 (pre-dredging survey). Location of plants recorded using GPS.
- Locations where *Groenlandia densa* plants had been recorded were relocated in **October** 2012 and marked with weighted floats.
- The initial translocation of plants was undertaken from a dewatered section of canal. A base layer of approximately 300mm was removed and loaded into sacks. Where plants were present, the plant and surrounding sediment was either lifted using an excavator (or using shovels if accessible from the bank) and transferred into a sack.
- The sacks with sediment and plants were then submerged in an area of canal that was not going to be dredged. The sacks were held in place (and open) by 1m bars.
- In another location (Ringsend), the sacks were placed in watertight skips filled with water from the Grand Canal. The plants were only stored for 17-18 days so there was no requirement for weeding.
- Plants **returned to the canal** (after dredging) in **December** 2012.
- Sacks were lifted to 0.5m above sediment surface and then bottom of sack opened to allow contents to fall out.

- The **time of year and short storage time mean that there was little/ no growth of plants during the storage phase**. It was expected that even if the plant foliage was lost during storage, that plant rhizomes and propagules would persist in the sediment.
- Monitoring in 2013 recorded growth of plants at some of the translocation location sites and also the appearance of plants in locations where none had previously been recorded (and no translocation had taken place).
- Monitoring in 2014 showed that at the main translocation site, whilst plant numbers had initially increased in 2013 (from 12 to 24), only 9 plants were recorded in 2014. However there was an increase the number and area of records at the second site.
- **Monitoring in 2015 recorded no plants of *Groenlandia densa* at the main site**. Only two plants were recorded at the second site and it was not possible to determine if these were translocated plants.
- It was considered that the **growth of the non-native aquatic macrophytes** *Elodea* sp. and *Crassula helmsii* may have had an **impact** on *Groenlandia densa* populations.
- The conclusion was that the translocation was not successful and that careful consideration should be given to alternative approaches to conservation of *Groenlandia densa* during future dredging projects.

Outcome of translocation: Low survival and growth of translocated plants (did not survive at main translocation site) and competition from non-native macrophyte species. At 2nd site where *Groenlandia densa* did persist, it is possible that this was from dormant propagules rather than translocated plants.
Potential issues: Difficult to fully remove long rhizomes; not possible to replant material back into loose silt to promote establishment of roots and rhizomes.

4.4 *Groenlandia densa* at Rossbrien and Ballykeefe, Co. Limerick

Refer to unpublished reports prepared by BEC Consultants for White Young Green and Direct Route (Baron, 2007 & 2010c) for full details. Key points from these report summarised below.

- Mitigation measures to protect *Groenlandia densa* plants during crossing of watercourses for the Limerick City southern ring road.
- *Groenlandia densa* recorded in Rossbrien ditch (drainage channel that runs parallel to Ballynaclogh River); within the main channel of the Ballynaclogh River and Ballykeefe ditch (drainage ditch that runs parallel to the Ballinacurra Creek). All three sites were subject to tidal cycles.
- Plants **conserved both in situ and ex situ** from the two ditches.
- Plants were removed manually with a substantial volume of sediment with which they were growing. The plants were then transferred to porous planting baskets lined with hessian sacking (biodegradable). The baskets were held within solid containers and transferred to Trinity Botanic Gardens.
- **In situ plants increased after dredging** in 2009 and then **subsequently declined** as *Groenlandia densa* is intolerant of shade. **Plants stored ex situ in good condition**, although regular weeding of non-target species required. The most successful growth is from floating stems which were manually rooted into the sediment in one crate. As the in situ plant populations were healthy, it was not considered necessary to translocate the ex situ plants back to the donor sites.

Outcome of translocation: Plants not translocated back to subject site as in situ conservation was successful.
Potential issues: Although mitigation measures were successful in protecting in situ vegetation, long-term management (regular vegetation clearance) required to maintain healthy *Groenlandia densa* populations.

4.5 *Groenlandia densa* competition field experiment, Upper Rhone River (France)

Refer to published paper for full details (Greulich & Bornette, 1999). Key points from this paper summarised below.

- Competition experiment involving four macrophyte species in an intermediately disturbed, species-rich macrophyte habitat in the Upper Rhone River (France)
- Individual plants removed from nearby habitat and translocated to cut-off channel where they had **not previously been recorded**. This channel had similar water and sediment characteristics to the original habitat.
- **Small plants** chosen for translocation.
- Plants placed in plastic containers (30 x 40 cm, with a depth of 18 cm), filled with sediment from the translocation site. The distances between neighbouring boxes placed perpendicular to water flow were about 5 cm. Since plants tend to bend with water flow, distances in this direction were larger (about 20 cm), to limit interferences with plants from neighbouring boxes.
- Planting (**translocation**) took place in **April** 1996. Experiment continued to end of October 1996.
- **Losses of translocated plants** appeared mainly due to **insufficient anchorage** after transplantation and occurred mainly at the beginning of the experiment.
- There was an unexpected flooding event during the experiment, which did not impact on the abundance of translocated *Groenlandia densa.*
- There was a large variation in how individual *Groenlandia densa* plants performed. However, this species produced the highest number (and high density) of new clonal individuals (ramets) of all species during the experiment.
- **Growth** of *Groenlandia densa* was **particularly high between end April to mid-June**; reduced by half between end June to mid-August and then further decreased between end August to end September.

Outcome of translocation: Plants successfully translocated to a new site and grew well in first season (experiment did not continue more than one season so no long-term data).
Potential issues: Loss of plants after translocation appeared to be due to anchorage in sediment.

4.6 Summary of translocation outcomes

In all of the Irish translocation projects, there was low long-term translocation success. This is despite the plants being translocated back to their original habitat and sometimes only being stored for a short period and/ or growing well during storage.
The main issue described is the lack of loose silt to promote establishment of roots and rhizomes of *Groenlandia densa*. Most of the projects involved dredging or re-profiling of the original habitat, which would have removed silt and impacted the substrate present. Timing of translocation was not considered to be an issue with any of the Irish projects. However, as described in Section 3.1.3.1 and 4.5, *Groenlandia densa* exhibits peak growth in spring to early summer (e.g. end April to mid June). The Irish projects removed and translocated material during late autumn/ winter (when growth is much reduced). The French experiment (Section 4.5) translocated small *G. densa* plants prior to the peak growing season (early April) and had a high translocation success rate.
The results of this review suggest that if translocation is undertaken for this project (King's Island), it is important that: the translocation site has loose silt for root and rhizome establishment (i.e. not recently completely dredged/ some sediment retained after dredging) and that translocation of living plants prior to the growing season is undertaken in addition to (or instead of) removal and translocation of late season plants and rhizomes)

5 REVIEW OF PROJECT OPTIONS

5.1 Review of measures

An initial review of measures to protect *Groenlandia densa* at this site (King's Island) are outlined in Table 5.1.

5.2 Potential impact to SAC from loss/ disturbance of the project ditch

One of the Conservation Objectives of the Lower River Shannon SAC is 'To maintain the favourable conservation condition of Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation in the Lower River Shannon SAC' (NPWS, 2012a; 2012b). *Groenlandia densa* is listed as one of three high conservation elements (sub-types) of 3260 within the SAC (NPWS, 2012a). The mapped distribution for the *G. densa* sub-type within the SAC is 1.6 km; this is considered an underestimate, as the species is likely to be more widespread than current records suggest (NPWS, 2012a). This is shown by the new records from this project at King's Island, a site that has botanical records from the wetland and ditch areas but had no previous records of *G. densa* in the east.

Within the SAC the key management objectives for *G. densa* are:

- to maintain the provision of appropriate substrata;
- maintain river flow variation and tidal regime;
- maintain freshwater seepage areas that diffuse onto tidal mud;
- undertake suitable vegetation clearance in canals and drains (regular clearance whilst leaving some plants in situ to allow re-growth); and,
- maintain sufficiently low concentration of nutrients in the water column to prevent changes in species composition or habitat condition (*G. densa* is sensitive to eutrophication).

The project ditch is located outside of (but adjacent to) the Lower River Shannon SAC. It does not appear to be hydrologically connected to the River Shannon. In addition, as a small drainage ditch, it is not considered to be an example of the Annex I habitat 3260 Floating River Vegetation (see also Section 3.1.3.3 and Appendix A).

The nearest population of *G. densa* within the SAC is in Limerick Canal, where it was recorded along a 1.5km stretch in 2006. The project ditch is not hydrologically connected to the Canal. Therefore it is not considered that the loss of *G. densa* from the project ditch would have a direct affect on *G. densa* populations within the River Shannon or Limerick Canal. Although *Groenlandia densa* is abundant within the project ditch along a 200m stretch, it is also abundant elsewhere within Limerick City and environs, within and outside of the SAC. Some key populations outside of the SAC include Loughmore Common, NE of Patrickswell, adjacent to the Ballynaclough River and adjacent to the River Maguire (Figure 3.2 and Table 3.1). Therefore it is not considered that the loss of *G. densa* from the project ditch would lead to a negative impact on the Conservation Objectives of the SAC. However, *G. densa* has shown a decline in Co. Limerick in recent years and also shows a national decline (e.g. Reynolds, 2013; Reynolds et al., 2006 and Preston et al., 2002). The project ditch has a healthy population of *G. densa* with a relatively high quality associated ditch flora. It is therefore considered that the loss of *G. densa* and associated species from the project ditch would have a local negative impact on biodiversity in Limerick City and that the project should include options to either retain the ditch or translocate the key species to a suitable alternative ditch/ site.

Table 5.1. Possible options to protect *Groenlandia densa* as part of flood defence works

Possible option	Positive features	Negative features
1) Retain ditch and relocate new embankment to eastern side of bank	Existing ditch retained with *Groenlandia densa* and additional macrophyte species.	Design footprint may mean that a large amount of wet grassland to the east of the ditch would be lost. May be limitations on whether embankment can feasibly be re-located here. **Best option. However, this is not considered to be feasible within project design constraints.**
2. Create new ditch and translocate *Groenlandia densa* prior to losing old ditch	*Groenlandia densa* can be translocated to new ditch (recipient site) immediately after removal from donor site (existing ditch). No storage of plants required. If time permits then it may be possible to assess whether translocation has been successful prior to the loss of the existing ditch. However, this would require at least one growing season between translocation and loss of the existing ditch. This method creates new ditch habitat (cf option 4).	It may be difficult to recreate the hydrological conditions in the existing ditch (and physical characteristics such as sediment amount and type which are key to *Groenlandia densa* establishment). The water in the present ditch is highly calcareous and may potentially be spring-fed, which would be hard to recreate. Studies on translocation of *Groenlandia densa* back to existing sites after dredging have had limited success (see Section 4). As this would be a new ditch site, successful translocation of *Groenlandia densa* plants cannot be guaranteed.
3. Translocate to holding area and then translocate into new ditch	The existing ditch can be removed prior to the new ditch being created, which may be more practical depending on the works design and timing.	As for no. 2, it may be difficult to recreate the required ditch conditions. Although plants appear to survive in storage areas (see Section 4), this may reduce the success of translocation to the new ditch.
4. Translocate plants into existing ditch system on site (e.g. a ditch that will be retained, inside or outside of the SAC).	The ditches are already present and therefore there will be no issue of high fertility from disturbed soil as for a newly created ditch. Management to remove tall vegetation etc. will improve biodiversity of SAC ditches in the area, even if *Groenlandia densa* translocation not successful. It may be that *Groenlandia densa* was present in these ditches before they became overgrown with tall monocots and scrub with little open water (although there are no historic records).	There may be legal restrictions on introducing a plant to ditches within the SAC system (as *Groenlandia* densa is not currently present in these ditches and there do not appear to be any historic records for King's Island). These may be the only ditches that are retained post-works. Ditch section would need to be dredged to remove tall monocots/ scrub and to provide the open water conditions required by *Groenlandia densa.* The pH of the water in the ditches where *Groenlandia densa* was not recorded was lower than the *Groenlandia densa* area. Even where open water was present (e.g. within the SAC), *Groenlandia densa* was not recorded. It may be that there is a different water source (e.g. spring), which feed the ditch with *Groenlandia densa* and helps to maintain open conditions. This option does not create new ditch habitat to replace that being lost (cf options 2 and 3). **Best option if feasible (legal restrictions) as SAC ditches within same area as project ditch and SAC ditch management would improve biodiversity as the SAC ditches are overgrown and currently have lower biodiversity than the project ditch.**

5.3 Conclusions

This report has reviewed the desktop data for *Groenlandia densa* in relation to its distribution, growth and ecology in Ireland and Europe (Section 3.1). A field survey of the project site on King's Island assessed the ecological value of the project ditch and the population of *G. densa* that it supports (Section 3.2 and Appendix A).

The project ditch on King's Island supports a healthy population of *G. densa* in addition to several other macrophyte species that are indicators of good water quality and ditch conditions. Whilst it is not considered that the loss of this ditch would impact on the Conservation Objectives of the Lower River Shannon SAC (see Section 5.2), the ditch is of biodiversity importance for macrophyte vegetation and *G. densa*. It is therefore important that, if retention of the ditch is not possible, that ditch creation and/ or translocation of *G. densa* is undertaken. Translocation attempts for *G. densa* have not been shown to be successful in Ireland in the long-term (see Sections 4.1, 4.2, 4.3, 4.4 and 4.6). However, whilst it cannot be certain that translocation would be successful in this case, there are amendments to the translocation protocols used thus far (e.g. timing of replanting) that are likely to increase the chance of successful translocation (e.g. see example in Section 4.5). A review of project options (Section 5.1 and Table 5.1) concludes that if ditch retention is not possible, the best alternative option is translocation to the ditch on the eastern side of King's Island (within the SAC). The potential benefits and disadvantages of this option are discussed in Table 5.1. Whilst this ditch system would require some management (e.g. vegetation clearance) to make them suitable for *G. densa* (and this cannot be guaranteed), it is more likely that they will be suitable than a newly created ditch (e.g. due to lack of suitable substrate for *G. densa* root into and potential water quality issues). The feasibility of this translocation option should be discussed with a macrophyte ecologist, NPWS and the project team.

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APPENDIX A - *GROENLANDIA DENSA* SURVEY RESULTS

Site details

Site name: King's Island, County Limerick	**Grid Reference**: R 573 586
Vice-county No.: H8	**SAC**: Adjacent to 002165 Lower River Shannon SAC
Surveyor(s): Dr Joanne Denyer & Slattery	**Survey date:** 01/04/2017
Elevation (m): <5m	**Solid geology**: Limestone

Site notes

Site location

The ditch section with *Groenlandia densa* is located on the north-western edge of King's Island, Limerick (Figure 1). To the east of the ditch there is an area of wet grassland (GS4) (Photograph 1) and to the west a river embankment, alluvial woodland on flooded, low-lying ground by the river and the River Shannon (Figure 1).

Figure 1. Location of ditch section with *Groenlandia densa* on King's Island

Site description

The ditch is adjacent to the River Shannon, which may be connected to the ditch. It is 3-4m wide and generally less than 1m deep (Photograph 2). The water was high at the time of survey and was slightly flooding adjacent wet grassland to the east of the ditch (Photographs 1 and 2). The wet grassland to the east is grazed by horses and the embankment to the west is used for recreation (e.g. dog walking).

Protected sites

This section of ditch is adjacent to the Lower River Shannon Special Area of Conservation (SAC)

Habitat type

Fossitt: Drainage ditch (FW4)

Annex I: n/a (Vegetation has some affinity 3260, but the habitat is not a river (or canal) and there is only a low number (and cover) of most typical indicator species. It is therefore not considered to be an example of 3260 as described in the Lower River Shannon SAC Conservation Objectives)

APPENDIX A - *GROENLANDIA DENSA* SURVEY RESULTS

Population description

Groenlandia densa is abundant in a ditch section approximately 200m in length (e.g. Photographs 3 and 4). Figure 2 shows the main areas of *Groenlandia densa* plants (mapped using GPS). In the southern section of the ditch (where the transect was located), *Groenlandia densa* was present throughout the channel and only particularly dense populations have been mapped. The plants appeared healthy at the time of survey and had been present in the ditch during January, suggesting they had overwintered in the ditch.

GPS points: *Groenlandia densa* is abundant between the GPS locations R 57386 58700 (N) and R 57396 58521 (S) (red line on map)

Figure 2. Location of main areas of *Groenlandia densa* plants mapped using GPS

Associated species/ vegetation

Macrophytes growing with *Groenlandia densa* at the time of survey included *Chara vulgaris, Ranunculus* cf *trichophyllus* (not flowering), *Callitriche* cf *obtusangula* (not flowering or fruiting), *Glyceria maxima*, *Sparganium* sp. (not flowering), *Lemna minuta, L. minuta, Equisetum fluviatile,* filamentous algae *Veronica beccabunga* and *Iris pseudacorus* (see transect T1 for more detail).

Current management

The ditch did not appear to be under any management. To the north and south of the section with *Groenlandia densa* (Figures 1 and 2), the ditch is infilling and overgrown suggesting that no ditch clearance has been undertaken recently. To the north, the channel is shaded by scrub and dense patches of *Lemna* spp. and litter dominate the water surface (e.g. Photograph 5). To the south the ditch channel is dominated by tall monocots such as *Typha latifolia, Glyceria maxima* and *Sparganium* sp. (e.g. Photograph 6). *Groenlandia densa* was not recorded from these overgrown ditch sections.

Threats

Infilling of the ditch due to lack of management, pollution from dumping of litter.

Conservation measures

Regular (sensitive) ditch clearance, removal of overhanging scrub and removal of dumped material.

APPENDIX A - *GROENLANDIA DENSA* SURVEY RESULTS

Comments

Groenlandia densa was first recorded from this ditch in January 2017. There are no records from this ditch (or King's Island) in the *Flora of County Limerick* (Reynolds, 2013), *A survey of rare and scarce vascular plants in County Limerick* (Reynolds et al., 2006) or in the NPWS database (NPWS data provided March 2017). There are other vascular plant records in the *Flora of County Limerick* (Reynolds, 2013) from King's Island. The lack of records for *Groenlandia densa* in this location may either be because this section of ditch was not surveyed, or because the plant was not present until recently. As *Groenlandia densa* is present only in a 200m ditch section in a ditch that is otherwise overgrown with litter dumping, it may have been overlooked. *Groenlandia densa* can respond positively to ditch clearance, however there are no obvious signs that this section of ditch has been recently cleared.

***Groenlandia densa* in adjacent ditches on King's Island**

All of the ditches on King's Island were walked during the survey to search for *Groenlandia densa* and to assess the potential of the ditch to support this species. As described above, the ditch sections immediately north and south of the *Groenlandia densa* populations were overgrown with little open water. The ditch sections within the SAC on the northern and eastern boundaries of King's Island had some areas with open water (e.g. Photographs 7, 8 and 10), but there were few/ no aquatic macrophytes in these areas and other sections were overgrown (e.g. Photograph 9).

PHOTOGRAPHS

Main survey area – ditch section with *Groenlandia densa* adjacent to SAC

Photograph 1. Low area of wet grassland adjacent to the ditch which was slightly flooded at the time of survey (view to NW)

Photograph 2. Ditch with *Groenlandia densa*, showing embankment to west and flooded wet grassland to east (view to N)

Photograph 3. *Groenlandia densa* plant underwater in ditch

Photograph 4. Abundant *Groenlandia densa* (centre and top left) growing with *Callitriche* sp. and *Chara vulgaris*

APPENDIX A - *GROENLANDIA DENSA* SURVEY RESULTS

Photograph 5. Ditch to north of *Groenlandia densa*, showing overhanging scrub, litter and dense *Lemna* spp. on water surface.

Photograph 6. Ditch to south of *Groenlandia densa*, showing channel dominated by tall monocots with dense *Lemna* spp. on water surface.

Adjacent ditches to main survey area (SAC on E side of King's Island)

Photograph 7. Ditch section with open water (view to S)

Photograph 8. Channel dominated by wetland species (e.g. monocots and *Veronica* spp.) but no true aquatic macrophytes seen.

Photograph 9. Ditch channel overgrown with monocots (view to S)

Photograph 10. Ditch channel with open water but little macrophyte growth within channel

Transect details

King's Island *Groenlandia densa* survey 2017

APPENDIX A - *GROENLANDIA DENSA* SURVEY RESULTS

Transect no.: T1
Length: 100m
Location: Ditch in NE corner of King's Island
Grid Ref. (N end of transect): R 57346 58619

Ditch section attributes

- Ditch length: surveyed section of ditch = 200m
- Water depth: c1m
- Water clarity: 60% clear; 40% slight turbidity
- Algal dominance: 8%
- Rare/ quality species: *Groenlandia densa, Chara vulgaris*
- Channel form: 100% non-trapezoidal (eastern bank with shallow areas and grading into wet grassland)
- In-channel vegetation: 100% mid-successional (small amounts of open water and a mixture of submerged, floating and emergent vegetation)
- Bankside vegetation cover: 0% heavily shaded
- Native macrophyte species richness: 11 species present (*Chara vulgaris, Callitriche* cf *obtusangula, Equisetum fluviatile, Glyceria maxima, Groenlandia densa, Iris pseudacorus, Lemna minor, Ranunculus* cf *trichophyllus, Sparganium* sp., *Veronica beccabunga, Veronica catenata*)
- Non-native macrophyte species: *Lemna minuta* (<4%)
- Salinity: 327-540 µS/cm (= <2000 µS/cm = not brackish)
- pH: measured during survey using handheld device = pH 8.24 to 8.43. Subsequent water sampling by Limerick County Council = pH 8 (3 sampling points) and pH 7.5 (one point near end of transect).

Notes

Water clarity good and aquatic macrophytes visible from water surface. No obvious flow. Aquatic macrophyte cover present throughout survey section from a few scattered plants to relatively dense communities with submerged and floating plants. Filamentous algae present in most areas but of low cover overall. The 'quality' indicator species *Groenlandia densa* was present throughout the section and locally abundant. *Chara vulgaris* was restricted to one area but was locally abundant there. *Ranunculus* cf *trichophyllus* was present as a few scattered immature (non-flowering) plants only. *Callitriche* cf *obtusangula* (not flowering or fruiting) was the second most abundant macrophyte after *Groenlandia densa* and was present throughout the ditch section. Tall monocots were restricted to the banks and edges of the channel.

Aquatic macrophytes (and main bank vegetation species)

Species name	**DOMIN**	**Species name**	**DOMIN**
Vascular plants		**Vascular plants cont'd**	
Agrostis stolonifera	5	*Lythrum salicaria*	2
Callitriche cf *obtusangula**	5	*Mentha aquatica*	3
Chara vulgaris	4	*Ranunculus* cf *trichophyllus**	1
Cirsium palustre	1	*Ranunculus repens*	4
Equisetum fluviatile	2	*Salix* sp.	2
Filamentous algae	3	*Scrophularia auriculata*	1
Filipendula ulmaria	2	*Senecio aquatica*	3
Glyceria maxima	4	*Sparganium* sp.*	3
Groenlandia densa	6	*Veronica beccabunga*	4
Iris pseudacorus	4	*Veronica catenata*	1
Juncus effusus	3	**Bryophytes**	
Juncus inflexus	2	*Brachythecium rutabulum*	2
Lemna minor	1	*Calliergonella cuspidata*	3
Lemna minuta	3	*Physcomitrium pyriforme*	1

*not flowering so not possible to confirm species

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Your Ref: 2015s3353 12 June 2019
Our Ref: **G Pre00001/2019**
(Please quote in all related correspondence)

JBA Consulting
24 Grove Island
Corbally
Limerick
Ireland
V94 312N
Via email: Emily.Rick@jbaconsulting.ie cc: bernadette.oconnell@jbaconsulting.ie

Re: Pre-planning consultation regarding the proposal by Limerick City and County Council to construct a Flood Relief Scheme for King's Island.

A chara

On behalf of the Department of Culture, Heritage and the Gaeltacht, I refer to correspondence received in connection with the above.

Outlined below are heritage-related observations/recommendations of the Department under the stated headings.

Underwater Archaeology

The Department welcomes being consulted in regard to the proposed Environmental Impact Assessment Report (EIAR) for King's Island Flood Relief Scheme.

The Department notes in the Scoping Document that there is an intention to address the Underwater Cultural Heritage, which is welcome. As part of assessing the Underwater Cultural Heritage and potential impacts to same, results from all previous underwater archaeological impact assessments should be considered, as should any monitoring of dredging programmes that have taken place as part of previous associated works (e.g. at Verdant Place, etc.). The proposed desktop study should contain a detailed overview of the maritime cultural heritage of King's Island and associated areas, including Athlunkard, the Abbey River, etc. as conduits and sites of particular maritime importance over time. The results from the Limerick Main Drainage scheme, particularly from within the Abbey River, attest to the high potential for Underwater Cultural Heritage to exist within and adjacent to the main river courses into and around Limerick City.

King's Island would have been the central focus of maritime activity during the heyday of medieval settlement on the island, from the Viking period through to 17th century events and later. There is therefore a high potential that previously unrecorded cultural heritage, and particularly that associated with maritime activity (e.g. the remains of logboats, larger vessels, early quays, jetties, fish traps, maritime-context artefactual material, etc.) could be

encountered during proposed works to streams, along the river's edge, in what could be reclaimed ground etc.

The EIAR Cultural Heritage section should assess the potential for this, which should include archaeologically assessing any in-stream or river bank/intra-riverine impacts. The services of suitably qualified archaeological personnel with underwater archaeological experience should be engaged to carry this out. The EIAR should also put forward recommendations to archaeologically mitigate in advance of any in-water works, to ensure there are no delays to works going forward should substantial Underwater Cultural Heritage be encountered.

The EIAR Cultural Heritage Section should also address the potential for identification of water-logged material and make provision for a defined finds retrieval strategy and post-excavation strategy to be included in all proposed works from the beginning.

Nature Conservation

The Department refers to your application (dated 20 March 2019) for a Wildlife Act Section 21 derogation licence to translocate the protected plant opposite-leaved pondweed, and to your e-mails to the National Parks & Wildlife Service (NPWS) Regional Ecologist (dated 17 May 2019 and 20 May 2019) concerning the candidate Special Area of Conservation (cSAC) boundary and juvenile lamprey.

Translocation of opposite-leaved pondweed

With regard to the proposed translocation of opposite-leaved pondweed, it would be the Department's preference that the existing drain, where the plant occurs, is retained. The reason for this preference is the low success of translocation projects for this species in the past. The implications of this would be construction of the embankment inside the existing drain, or possibly increasing the interior slope angle of the embankment. The Department is available to discuss this in more detail, if you wish.

Marshland at cSAC boundary

Three pieces of information are required for the Department to advise fully on this question:

- It needs to be calculated how much marsh habitat *within* the cSAC will be lost to the embankment.
- The type of marsh vegetation proposed to be lost within the cSAC needs to be described.
- The extent to which the marsh vegetation is dependent on poor drainage (perched water), as opposed to water due to groundwater backup due to river flooding, needs to be established.

Translocation of juvenile lamprey

The Department accepts the advice of fish experts concerning the preference against an invasive survey as part of the Natura Impact Statement (NIS), and proceeding with the

assumption of their presence. Nevertheless, the Department recommends that the following information should be included in the Natura Impact Statement:

- A statement of the efficiency of the removal of the juvenile lamprey (i.e. how many are likely to be left behind);
- A statement of where the juvenile lamprey will be translocated to, and their likelihood of survival;
- A clear description of how the jack-up barge will be operated and supported, and whether rock infill will be required, and if so, how this will be removed post-construction;
- A prediction of how quickly un-compacted silt habitat will naturally regenerate, and how soon the area will be fully recolonized to baseline condition.

The above observations/recommendations are based on the papers submitted to this Department on a pre-planning basis and are made without prejudice to any observations that the Minister may make in the context of any consultation arising on foot of any development application referred to the Minister, by the planning authority, in her role as statutory consultee under the Planning and Development Act, 2000, as amended.

You are requested to send further communications to this Department's Development Applications Unit (DAU) at **manager.dau@chg.gov.ie** (team monitored); if this is not possible, correspondence may alternatively be sent to:

The Manager
Development Applications Unit (DAU)
Department of Culture, Heritage and the Gaeltacht
Newtown Road
Wexford
Y35 AP90

Is mise, le meas

Sinéad O' Brien

Sinéad O' Brien
Development Applications Unit

SECTION 21 APPLICATION
Groenlandia densa

METHODS STATEMENT

March 2019

CONTENTS

1 BACKGROUND INFORMATION

Denyer Ecology (on behalf of Limerick City and County Council) is applying for a 'Licence to Take or Interfere with Protected Plant Species' under Section 21 of the Wildlife Act in relation to the aquatic plant: Opposite-leaved Pondweed *Groenlandia densa* within/ adjacent to the Lower River Shannon Special Area of Conservation (SAC) [002165].

1.1 Relevant experience

Dr Joanne Denyer is a highly experienced botanist and bryologist with over 20 years' experience of ecological survey and research. She holds a first class honours degree in Environmental Science from Leicester University. She completed a DPhil in Plant Ecology at the University of Sussex and subsequently worked on the impacts of land-use, climate change and grazing on upland plant communities and plant functional traits at the Macaulay Institute in Aberdeen (now James Hutton Institute). She is a full member of the Chartered Institute of Ecology and Environmental Management (IEEM). Skills from her academic and research background include a high standard in experimental design, report writing, data collation, literature review and data analysis. Dr Denyer has published in high-ranking international peer-reviewed journals and presented data at over ten international conferences. She is a Guest Lecturer at University College Dublin (UCD) and Trinity College Dublin (TCD).

Joanne Denyer has considerable experience of macrophyte identification and ecology in Ireland and the UK. She has knowledge of all groups of aquatic macrophytes, including difficult groups such as *Potamogeton*, *Ranunculus*, bryophytes and charophytes. She gave an invited talk on macrophyte identification '*How to tackle aquatics*' at the Irish BSBI conference in May 2017. She has undertaken macrophyte surveys on a range of waterbody types and is experienced in survey techniques such as boat survey, grapnel survey, wading, and snorkel diving. In addition, she has undertaken monitoring and condition assessment of aquatic macrophytes in streams, ditches, lakes and reservoirs and has conducted research into macrophyte regeneration and ecology.

1.2 Groenlandia densa

The species that is the subject of this licence application is the aquatic plant *Groenlandia densa*. This species is protected by Section 21 of the Wildlife Act (1976) and is listed on the Flora (Protection) Order (2015). *Groenlandia densa* is listed as 'Near Threatened' on the Irish Vascular Plant Red List (Wyse Jackson et al., 2016); and is identified as one of the three high conservation elements (sub-types) of the Feature of Interest of the Annex I habitat Water courses of plain to montane levels with the *Ranunculion fluitanis* and *Callitricho-Batrachion* vegetation [3260] within the Lower River Shannon Special Area of Conservation (SAC) (NPWS, 2012a & b).

1.3 Project

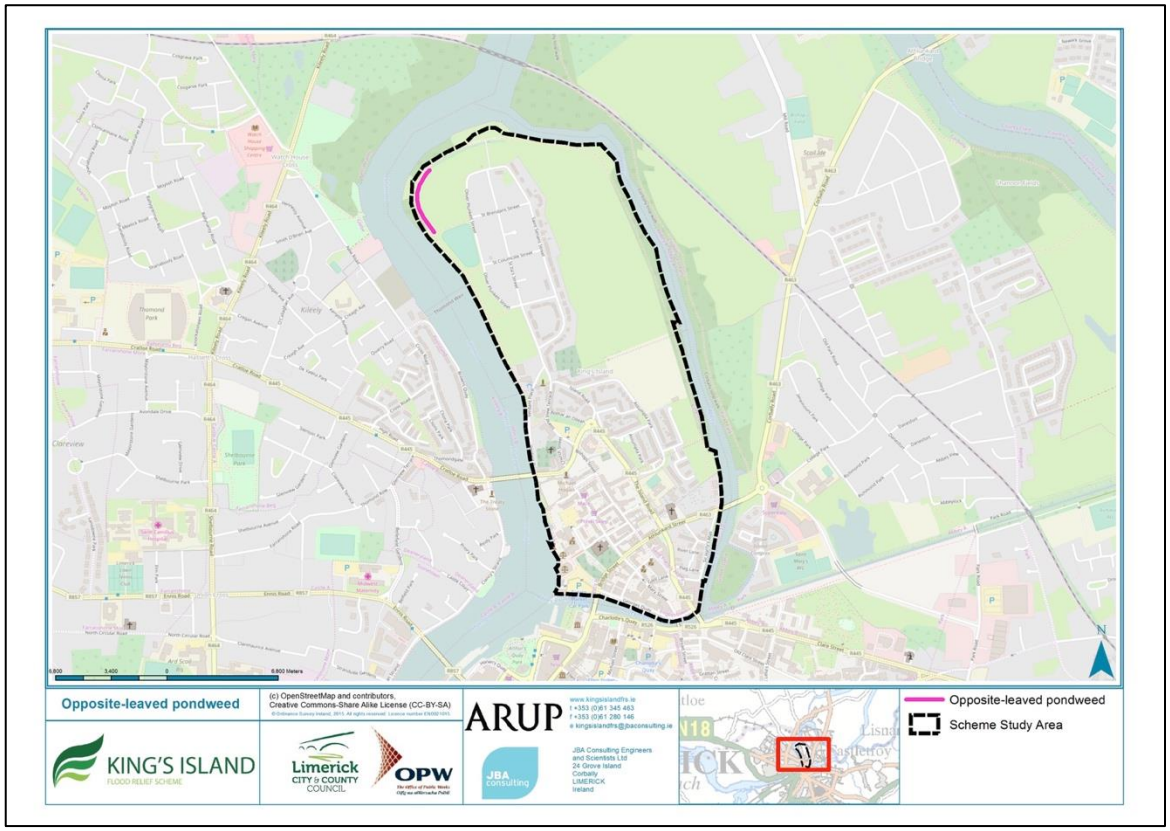
King's Island is susceptible to both coastal and fluvial flood risk and very significant flooding occurred in spring 2014 when existing defences failed locally, both overtopping the through breaching. A proposed flood relief scheme at King's Island will construct an embankment on the western side of King's Island. The proposed embankment will be constructed on the landward side of the existing sandbags/hedgerow that separates the riparian habitat of the River Shannon and the amenity grassland area adjacent to St. Oliver Plunkett Street. An existing ditch, where *Groenlandia densa* has recently been recorded, falls within the footprint of the proposed embankment. The construction of the embankment will result in the ditch being filled in and permanently lost. A Section 21 Licence Application is being sought for permission to translocate the *Groenlandia densa* population into a new ditch.

1.4 Project area (existing ditch)

The project area is a drainage ditch located in the north-eastern area of King's Island (Figure 1.1 and Photograph 1.1). The ditch is approximately 1m deep throughout the length and 3-4m wide at water

level (Photograph 1.2). The western bank is relatively steep, but the eastern bank has a shallow gradient which floods near the ditch in winter (Photographs 1.1 and 1.2). The wet grassland to the east is grazed by horses and the embankment to the west is used for recreation (e.g. dog walking). Nearby borehole and trial pit investigations have shown that the ditch is located in an area of relatively impermeable clay, underlain by sands and gravels. The existing ditch is fed both by surface water run-off from surrounding lands and groundwater through the lower sand/ gravels layer. The invert level of the ditch is *c*. 1.14mOD and there is an outfall (via a non-return valve) to the River Shannon to the south of the population of *Groenlandia densa*. It is not significantly influenced by the tidal waters in the River Shannon. Further details and photographs are shown in Appendix A. Water sampling shows that the ditch has a pH between 7.5 and 8 (highly calcareous) and is neither brackish nor highly polluted.

Figure 1.1: Project area (King's Island, Limerick). Pink line shows section of ditch where *Groenlandia densa* was recorded in 2017.



Photograph 1.1. Project survey area (drainage ditch). View to north (March 2019).

Photograph 1.2. Drainage ditch showing steep western bank and shallow eastern bank. View to north-west (March 2019).

1.5 *Groenlandia densa* records within the ditch

The population of *Groenlandia densa* within the ditch was first recorded by JBA Consulting in January 2017. Prior to this, there were no current or historic records from the western side of King's Island, where the project site ditch is located. The closest recent records were from the Limerick Canal, to the south-east of King's Island (2006) (Denyer Ecology, 2017).

In March 2017, Denyer Ecology undertook a survey of the population of *Groenlandia densa* present in the ditch (detailed results and ditch description are shown in Appendix A). *Groenlandia densa* was found to be frequent within a 200m ditch section, but absent in all other areas of ditch on the site. In March 2019 a repeat site visit was undertaken to assess the population of *Groenlandia densa* (by non-invasive bank survey as the plant is very visible when present). No over-wintering plants of *Groenlandia densa* were recorded. *Groenlandia densa* has persistent rhizomes and therefore the absence of over-wintering plants does not mean the plant will not be present later in the growing season. Therefore, the translocation method statement assumes the continuing presence of *Groenlandia densa* at this site. It may be that the population was affected by the very hot and dry conditions in summer 2018, or that the population is declining due to natural succession (there are no signs of recent management in the ditch). There did not appear to be any change in disturbance or water depth or clarity between 2017 and 2019.

1.6 Review of options to conserve the local population of *Groenlandia densa*

As part of the design of the Flood Relief Scheme, different options to conserve the population of *Groenlandia densa* in this area were reviewed. The potential options were:

- Option 1: Retain ditch and relocate new embankment to eastern side of bank.
- Option 2: Translocate plants into existing ditch system on site (e.g. a ditch that will be retained, inside or outside of the SAC).
- Option 3: Create new ditch and translocate *Groenlandia densa* prior to losing old ditch.
- Option 4: Remove *Groenlandia plants* to holding area and then translocate into new ditch.

It was not considered possible to retain the existing ditch (Option 1) for the following reasons:

- The new embankment needs to be on the inside of the existing embankment to avoid impacts to the SAC and Annex I priority habitat Alluvial Woodland on the west side of the existing defence.
- If the embankment was to move further inland to avoid the existing open drain, then the embankment structure would move closer to the existing houses on the site. This is not considered desirable from the Public Consultation Day 20th December 2017.
- If the embankment was to move further inland to avoid the existing open drain, then the existing open drain would be on the outer side of new flood embankment and risk being within future flood plain if the existing embankment fails due to collapse or erosion over time.

It is therefore concluded that the existing open drain needs to be infilled to accommodate the new embankment works on the inside of the existing flood defence/embankment.

The potential to translocate the *Groenlandia densa* plants into an existing ditch on site (Option 2) was reviewed. The SAC ditches to the east of the King's Island have a different hydrology/ ecology to the eastern ditch (lower pH, more regularly flooded, later successional stage) and *Groenlandia densa* has not been recorded here, despite areas of apparently suitable open water. The ditch to the south of the existing population of *Groenlandia densa* (which is currently overgrown and unsuitable for this species), will also be infilled during the proposed Flood Relied Works and will not be available for translocation. In addition, translocation to an existing ditch does not create new ditch habitat to replace that being lost during embankment construction in the west of the King's Island. The creation of a new ditch and translocation of the *Groenlandia densa* plants to the new ditch (Option 3 and Option 4) are therefore the preferred options. Due to the nature of the works (embankment construction) it is not possible to create the new ditch prior to losing the existing ditch (Option 3). *Groenlandia densa* plants will therefore need to be removed and stored (Option 4), prior to being translocated to the new ditch.

1.7 Desktop data

The following resources were consulted for this project:

- Site synopsis and Conservation Objectives for the Lower River Shannon SAC [site code 002165] (NPWS, 2013; 2012b)
- Aerial photography (supplied by Limerick County Council).
- Records of *Groenlandia densa* in County Limerick held by National Parks and Wildlife Service (NPWS).
- *A survey of rare and scarce vascular plants in County Limerick* (Reynolds et al., 2006).
- *Flora of County Limerick* (Reynolds, 2013).
- *New Atlas of Britain and Ireland* (Preston et al., 2002)
- Botanical Society of Britain and Ireland (BSBI) online mapping.
- Reports on *Groenlandia densa* translocation projects, as cited in text.
- Additional publications and documents, cited in text where relevant.

1.8 Identification and nomenclature

Vascular plant nomenclature will follow that of the *New Flora of the British Isles*. 4th Edition (Stace, 2019). The bryophyte nomenclature adopted by Blockeel et al. (2014a & b) is used; this is based on the *Checklist of British and Irish bryophytes* (Hill et al., 2008) with minor modifications to reflect recent taxonomic changes.

2 METHODOLOGY

2.1 New ditch design

2.1.1 Ditch length and profile

As outlined in Section 1.4 and 1.5, *Groenlandia densa* has been recorded in a *c*. 200m stretch of drainage ditch in the north-west of King's Island. The replacement ditch will be created to the east of the new embankment (east of the existing ditch). The location of the ditch, ditch cross-section and level of new and existing ditch are shown in Appendix B. The replacement ditch will be *c*. 230m in length. The new ditch will be a similar depth (1.16m) to the existing ditch (Appendix B). It will be wider, however (8m at top water level; 12.9m width from top of the banks). The side slopes of the ditch will have a shallower profile than the current western bank (Appendix B) and will have a varying profile to re-create a natural ditch bank profile. This will allow greater colonisation by wetland vegetation, easier fauna access and will facilitate future maintenance.

2.1.2 Water source and levels

The new ditch invert level will be the same as the existing ditch invert level (*c.* 1.14m). To accommodate this, the new ditch is slightly deeper than the existing ditch, as the ground rises to the east (Appendix B). The existing ditch is fed both by surface water run-off from surrounding lands and groundwater through the lower sand/ gravels layer. The location and depth of the new ditch has been designed so that it will intercept the lower sand/ gravels layer beneath the relatively impermeable clay layer above. This will ensure that the new ditch is fed by both surface and ground water and will function hydrologically as the existing ditch, with low fluctuations in water levels. As with the current ditch, there will be an outfall with a non-return valve into the River Shannon (Appendix B). The outfall will be set above the invert level of the ditch, so ditch will always retain a depth of water (*c*. 1m). As with the existing ditch, rises in water levels are only envisaged during exceedance rainfall and/ or during a surcharged outfall due to high tidal waters in the Shannon, whereby overland flows from the surrounding green areas are conveyed to the open drain leading to a temporary rise in water level. In addition (as with the existing ditch), there could be a possible drop in water levels during an extended dry period/ summer drought.

2.1.3 Landscaping

The side slopes of the embankment will be reseeded with meadow grassland once earthworks are complete. There will be amenity grassland planted elsewhere on the embankment. Once the new drain is excavated there will be no reinstatement with topsoil or topsoil sods on the banks, these will be seeded with either meadow grassland or amenity seed. There will be no other planting and wetland plants will be allowed to recolonise naturally to preserve local population genetics.

2.2 Timing of works

The works are likely to start in the third quarter of 2020 and the construction programme for the whole island is *c*. 2 years. At this stage it is not possible to state when the earthworks will commence (including infilling of the existing ditch) but this is likely to be in the drier months of the year.

It is likely that it will not be possible to create the new ditch until near the end of the project as the earthworks (embankment etc.) need to be completed before the new ditch can be created. The existing ditch will need to be infilled during embankment construction. Therefore, there will be a period where any *Groenlandia densa* present in the existing ditch will need to be stored prior to translocation to the new ditch.

2.3 Plant translocation

2.3.1 Detailed translocation plan

Once the contract has been awarded for the construction works, a detailed translocation plan will be finalised by an experienced macrophyte ecologist and agreed with NPWS. At this stage it will be possible to detail the exact timing of works including the season in which plants will be removed, the storage length of removed plants and season in which they will be returned to the ditch. All stages of the translocation plan (plant removal, storage and translocation to new ditch) must be overseen and monitored by an experienced macrophyte ecologist.

2.3.2 Review of methods

There have been a small number of projects involving the translocation of *Groenlandia densa* in Ireland (under licence). These have generally involved removing plants whilst maintenance work was undertaken and replacement of the plants back in their original habitat/ site. In addition, there is one study in France that involved translocation of *Groenlandia densa* to a new site as part of an experiment to assess competitive ability of four aquatic macrophyte species. These projects were reviewed in Denyer Ecology (2017) and the key outcomes are summarised in Table 2.1. There is one known licence application for *Groenlandia densa* translocation since this review in 2017 (included in Table 2.1; information provided by NPWS), but the translocation has not yet been undertaken and no results are available for review.

In all of the Irish translocation projects, there was low long-term translocation success (Table 2.1). This is despite the plants being translocated back to their original habitat and sometimes only being stored for a short period and/ or growing well during storage. The main issue described is the lack of loose silt to promote establishment of roots and rhizomes of *Groenlandia densa*. Most of the projects involved dredging or re-profiling of the original habitat, which would have removed silt and impacted the substrate present. Timing of translocation was not considered to be an issue with any of the Irish projects. However, *Groenlandia densa* exhibits peak growth in spring to early summer (e.g. end April to mid June) (Greulich & Bornette, 1999). The Irish projects removed and translocated material during late autumn/ winter (when growth is much reduced). The French experiment (Table 2.1) translocated small *G. densa* plants prior to the peak growing season (early April) and had a high translocation success rate (Greulich & Bornette, 1999). *Groenlandia densa* tends to be typical of sites that are in an early to mid-successional stage and free from heavy shading by tall monocots and bankside trees (see review of *Groenlandia densa* ecology in Denyer Ecology; 2017), therefore ongoing ditch maintenance is important to maintain suitable habitat for this species.

Key factors for successful translocation of *Groenlandia densa* are therefore:

- that the translocation site has loose silt for root and rhizome establishment (i.e. not recently completely dredged/ some sediment retained after dredging); and,
- translocation of living plants prior to the growing season is undertaken in addition to (or instead of) removal and translocation of late season plants and rhizomes).
- long-term management (regular vegetation clearance) is required to maintain healthy *Groenlandia densa* populations

Table 2.1. Review of *Groenlandia translocation* projects

Project	Data source	Translocation method	Outcome of translocation	Potential issues
Canal at Meelick, Co. Galway	Unpublished reports prepared by S.Heery for ESB (Heery, 2011a & 2012a)	Removal of *Groenlandia densa* from canal prior to cement grouting of an embankment; storage of plants for 43 weeks and translocation back into donor site.	Low survival and growth of translocated plants and competition from non-native macrophyte species. However, *Groenlandia densa* regenerated from dormant propagules in less disturbed areas	Not possible to replant material back into loose silt to promote establishment of roots and rhizomes.
Shannon Harbour, Co. Offaly	Unpublished reports prepared by S.Heery for OPW (Heery, 2011b & 2012b)	Removal of *Groenlandia densa* drain prior to maintenance and plants replaced back into drain immediately after dredging.	Low survival and growth of translocated plants (did not survive at most locations. At 2 sites where *Groenlandia densa* did persist, it is possible that this was from dormant propagules rather than translocated plants.	Difficult to fully remove long rhizomes; not possible to replant material back into loose silt to promote establishment of roots and rhizomes
Grand and Royal Canals, Co. Dublin	Unpublished reports prepared for Waterways Ireland by BEC Consultants (Baron, 2010a, 2010b, 2011a, 2011b, 2012a, 2012b, 2013, 2014 & 2015)	Removal of plants from canal prior to dredging; storage in skip (<20 days) or canal (c 2 months); plants replaced back into canal post-dredging	Low survival and growth of translocated plants (did not survive at main translocation site) and competition from non-native macrophyte species. At 2nd site where *Groenlandia densa* did persist, it is possible that this was from dormant propagules rather than translocated plants.	Difficult to fully remove long rhizomes; not possible to replant material back into loose silt to promote establishment of roots and rhizomes.
Rossbrien and Ballykeefe, Co. Limerick	Unpublished reports prepared by BEC Consultants for White Young Green and Direct Route (Baron, 2007 & 2010c)	Removal of plants prior to construction works (road crossing watercourse); plants conserved both in situ and ex situ.	Plants not translocated back to subject site as in situ conservation was successful. Ex situ stored plants were in good condition but required weeding of non-target species.	Although mitigation measures were successful in protecting in situ vegetation, long-term management (regular vegetation clearance) required to maintain healthy *Groenlandia densa* populations.
Competition experiment, Upper Rhone River (France)	Published paper (Greulich & Bornette, 1999)	Individual plants removed from nearby habitat and translocated to cut-off channel where they had not previously been recorded.	Plants successfully translocated to a new site and grew well in first season (experiment did not continue more than one season so no long-term data).	Loss of plants after translocation appeared to be due to anchorage in sediment.
Loughmore Common Turlough, Co. Limerick.	Unpublished report for NPWS (Macklin et al, 2018) and Macklin (pers. comm.)	Removal of plants prior to dredging; storage in during works and replacement back into canal post-dredging	Translocation not yet undertaken.	Translocation not yet undertaken.

2.3.3 Proposed method

As outlined in Section 2.3.1, a detailed translocation plan will be finalised by an experienced macrophyte ecologist and agreed with NPWS prior to any translocation works beginning on the site. This will confirm exact details such as the timing of plant removal, length of plant storage, location of plant storage and timing of plant translocation to new ditch. It is not possible to confirm these until the contractor has been appointed and there is a detailed timeline of construction works.

The proposed translocation plan is outlined below:

- The project is likely to commence in autumn 2020, with earthworks in the north west of the Ireland being undertaken in the dry season (e.g. summer 2021). The construction programme for the whole island is *c*. 2 years. It is therefore expected that plants of *Groenlandia densa* would be removed in the early growing season in 2021 and be translocated to the new ditch by the end of 2022.
- Ideally, **removal of plants** from the existing ditch will be undertaken **prior to the growing season** (e.g. April 2021), as this has shown to have a higher translocation success rate than translocation of late season plants and rhizomes.
- Similarly, if possible, the stored plants should be **translocated** to the new ditch **prior to the growing season** (e.g. April 2022), as this has shown to have a higher translocation success rate than translocation of late season plants and rhizomes.
- Prior to the infilling of the existing ditch, the ditch will be **surveyed** by an experienced macrophyte ecologist. The location of any *Groenlandia densa* plants should be marked, for instance with sticks and signage. However, if this survey is undertaken at a stage in the construction programme where there is public access to the ditch, it will be necessary to also mark the locations using GPS in case the sticks are removed. If no plants of *Groenlandia densa* are visible and this pre-construction survey is undertaken during winter, then ideally a second survey during the growing season (e.g. April to September 2020) should be undertaken to confirm the presence/ absence of growing plants of *Groenlandia densa* in the ditch. This could also be undertaken in the growing season prior to works beginning (e.g. summer 2019).
- As the above-ground plant material of *Groenlandia densa* may not be visible in the pre-construction survey, **removal of sediment and rhizomes** (if present) should be undertaken prior to infilling of the ditch. This should be undertaken whether or not above-ground plants of *Groenlandia densa* are present. Sediment should be taken from the ditch section where *Groenlandia densa* was recorded in March 2017, or its most recent recorded location (if detected in later pre-construction surveys). This can be marked wither with sticks or GPS. The sediment in the ditch will contain propagules of other macrophyte species present in the existing ditch and aid recolonisation of the new ditch. Loose silt/ sediment is important for *Groenlandia densa* root and rhizome establishment and translocation of sediment into the new ditch will assist in the successful establishment of *Groenlandia densa* in the new ditch.
- If possible, **removal of plants of *Groenlandia densa*** should be undertaken whilst there is still some water in the existing ditch (as the ditch is shallow). However, it may be necessary to fully drain the ditch to remove rhizomes and roots. If ditch drainage is required then *Groenlandia densa* plant, root and rhizome and sediment removal should be undertaken in the dry channel within 2-3 days of it being drained. Removal of material should be undertaken using a digger bucket or similar, under supervision from a macrophyte ecologist.
- Plants of *Groenlandia densa* should be removed with the sediment surrounding the plant and **transferred either into a sack or directly into the storage container**. The top layer of 200mm of sediment from suitable locations along the ditch will also be removed and placed either into separate sacks or directly into the storage container.
- *Groenlandia densa* plants, rhizomes and sediment should be placed in a suitable **storage container.** Plants with above-ground growth and sediment should be places in separate containers. *Groenlandia densa* has been found to survive and grow well in a watertight skip

for 43 weeks (Heery, 2011a & 2012a) and this may be suitable for this project. Alternative storage options include putting the plants and sediment into sacks or buckets and storing submerged in an area of undisturbed ditch. However, as the existing ditch will be completely removed and the ditches on the eastern side of King's Island have a different water chemistry (and are publicly accessible), this is unlikely to be suitable in this case.

- The **storage container(s)** will need to be **located in an area without public access** to prevent vandalism. Ideally this should be on-site. The container(s) should not be shaded and should be easily accessible for monitoring.
- During storage, the storage containers (for plants and sediment) will need **regular monitoring** (at least once a month during the growing season of April to September and bi-monthly during the winter). Monitoring will include: assessment of the growth and health of any *Groenlandia densa* plants; ensuring that water levels are sufficient to cover plants and sediment by at least 0.5-1m of water; weeding if non-target species outcompete in storage containers with *Groenlandia densa* plants; and removal of litter (e.g. windblown).
- When the **new ditch is created**, soil at the bottom of the ditch should not be compacted. The water depth within the channel will be c1m but some areas can be deeper or more shallow to create diversity and avoid a uniform channel profile.
- The **new ditch** will need to have **standing water** prior to the translocation of *Groenlandia densa* plants, roots, rhizomes and sediment. This should occur naturally given the levels of the ditch. In a dry period/ summer the water level may be less than 1m deep.
- Prior to translocation the **stored plant and sediment material** should be **checked** to ensure that there are no **unwanted or invasive alien macrophyte species** present in the containers. None were recorded from the existing ditch in the 2017 or 2019 ditch surveys and it is not anticipated that this will be an issue.
- The removed and **stored sediment** from the existing dich should be **translocated** at intervals within the **new ditch**. This will aid the regeneration of *Groenlandia densa* from fragments but also other macrophyte species. It may be that plants will have grown from the sediment during storage. These can be translocated to the new ditch, once a check for unwanted or invasive alien macrophyte species has been undertaken).
- To **translocate *Groenlandia densa*** plants and rhizomes into the **new ditch**: plants should be lifted carefully from the storage container with their rhizomes and any sediment around the base of the plant. This can be dropped/ placed into the water near the edge of the new ditch in areas with non-compacted silt. The plants should be spaced out along the ditch (spacing will depend on how many plants were removed and have survived/ regenerated during storage).

2.4 Monitoring

The new ditch will be monitored by a macrophyte ecologist for at least three years post translocation (period to be agreed with NPWS). A suitable monitoring protocol would include monitoring 1 month, 3 months and 6 months after the translocation and then annually. However, this will vary depending on the time of year that translocation takes place (e.g. a lower initial frequency of monitoring would be relevant outside of the growing season). This will allow monitoring of the survival and of *Groenlandia densa* and identification and application of management/ remedial measures as required. A short report will be produced after each site visit.

2.5 Ditch maintenance

In order to prevent infilling of the ditch, ongoing ditch maintenance will be required. The new ditch will be relatively shallow (as this suits *Groenlandia densa* at this site) which will mean it is at risk of infilling with sediment and vegetation over time. A licence will be required to undertake dredging within the ditch. No dredging or disturbance should be undertaken within the first 3 years post translocation to allow the *Groenlandia densa* and macrophyte population to establish. After the final

monitoring survey 3 years post translocation, the growth of vegetation within the ditch will be established. A suitable maintenance (dredging) plan will then be created. It is likely that this will include dredging of sections of the drain every 3-5 years. It is important that dredging is undertaken in sections only, either one half of the channel or small non-continuous sections, so that macrophytes can re-establish from in situ plants and propagules within the seedbank.

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APPENDIX A - *GROENLANDIA DENSA* 2017 SURVEY RESULTS

Site details

Site name: King's Island, County Limerick	**Grid Reference**: R 573 586
Vice-county No.: H8	**SAC**: Adjacent to 002165 Lower River Shannon SAC
Surveyor(s): Dr Joanne Denyer & Tanya Slattery	**Survey date:** 01/04/2017
Elevation (m): <5m	**Solid geology**: Limestone

Site notes

Site location

The ditch section with *Groenlandia densa* is located on the north-western edge of King's Island, Limerick (Figure 1). To the east of the ditch there is an area of wet grassland (GS4) (Photograph 1) and to the west a river embankment, alluvial woodland on flooded, low-lying ground by the river and the River Shannon (Figure 1).

Figure 1. Location of ditch section with *Groenlandia densa* on King's Island

Site description

The ditch is adjacent to the River Shannon, which may be connected to the ditch. It is 3-4m wide and generally less than 1m deep (Photograph 2). The water was high at the time of survey and was slightly flooding adjacent wet grassland to the east of the ditch (Photographs 1 and 2). The wet grassland to the east is grazed by horses and the embankment to the west is used for recreation (e.g. dog walking).

Protected sites

This section of ditch is adjacent to the Lower River Shannon Special Area of Conservation (SAC)

Habitat type

Fossitt: Drainage ditch (FW4)

Annex I: n/a (Vegetation has some affinity 3260, but the habitat is not a river (or canal) and there is only a low number (and cover) of most typical indicator species. It is therefore not considered to be an example of 3260 as described in the Lower River Shannon SAC Conservation Objectives)

APPENDIX A - *GROENLANDIA DENSA* 2017 SURVEY RESULTS

Population description

Groenlandia densa is abundant in a ditch section approximately 200m in length (e.g. Photographs 3 and 4). Figure 2 shows the main areas of *Groenlandia densa* plants (mapped using GPS). In the southern section of the ditch (where the transect was located), *Groenlandia densa* was present throughout the channel and only particularly dense populations have been mapped. The plants appeared healthy at the time of survey and had been present in the ditch during January, suggesting they had overwintered in the ditch.

GPS points: *Groenlandia densa* is abundant between the GPS locations R 57386 58700 (N) and R 57396 58521 (S) (red line on map)

Figure 2. Location of main areas of *Groenlandia densa* plants mapped using GPS

Associated species/ vegetation

Macrophytes growing with *Groenlandia densa* at the time of survey included *Chara vulgaris, Ranunculus* cf *trichophyllus* (not flowering), *Callitriche* cf *obtusangula* (not flowering or fruiting), *Glyceria maxima*, *Sparganium* sp. (not flowering), *Lemna minuta, L. minuta, Equisetum fluviatile,* filamentous algae *Veronica beccabunga* and *Iris pseudacorus* (see transect T1 for more detail).

Current management

The ditch did not appear to be under any management. To the north and south of the section with *Groenlandia densa* (Figures 1 and 2), the ditch is infilling and overgrown suggesting that no ditch clearance has been undertaken recently. To the north, the channel is shaded by scrub and dense patches of *Lemna* spp. and litter dominate the water surface (e.g. Photograph 5). To the south the ditch channel is dominated by tall monocots such as *Typha latifolia, Glyceria maxima* and *Sparganium* sp. (e.g. Photograph 6). *Groenlandia densa* was not recorded from these overgrown ditch sections.

Threats

Infilling of the ditch due to lack of management, pollution from dumping of litter.

Conservation measures

Regular (sensitive) ditch clearance, removal of overhanging scrub and removal of dumped material.

APPENDIX A - *GROENLANDIA DENSA* 2017 SURVEY RESULTS

Comments

Groenlandia densa was first recorded from this ditch in January 2017. There are no records from this ditch (or King's Island) in the *Flora of County Limerick* (Reynolds, 2013), *A survey of rare and scarce vascular plants in County Limerick* (Reynolds et al., 2006) or in the NPWS database (NPWS data provided March 2017). There are other vascular plant records in the *Flora of County Limerick* (Reynolds, 2013) from King's Island. The lack of records for *Groenlandia densa* in this location may either be because this section of ditch was not surveyed, or because the plant was not present until recently. As *Groenlandia densa* is present only in a 200m ditch section in a ditch that is otherwise overgrown with litter dumping, it may have been overlooked. *Groenlandia densa* can respond positively to ditch clearance, however there are no obvious signs that this section of ditch has been recently cleared.

***Groenlandia densa* in adjacent ditches on King's Island**

All of the ditches on King's Island were walked during the survey to search for *Groenlandia densa* and to assess the potential of the ditch to support this species. As described above, the ditch sections immediately north and south of the *Groenlandia densa* populations were overgrown with little open water. The ditch sections within the SAC on the northern and eastern boundaries of King's Island had some areas with open water (e.g. Photographs 7, 8 and 10), but there were few/ no aquatic macrophytes in these areas and other sections were overgrown (e.g. Photograph 9).

PHOTOGRAPHS

Main survey area – ditch section with *Groenlandia densa* adjacent to SAC

Photograph 1. Low area of wet grassland adjacent to the ditch which was slightly flooded at the time of survey (view to NW)

Photograph 2. Ditch with *Groenlandia densa*, showing embankment to west and flooded wet grassland to east (view to N)

Photograph 3. *Groenlandia densa* plant underwater in ditch

Photograph 4. Abundant *Groenlandia densa* (centre and top left) growing with *Callitriche* sp. and *Chara vulgaris*

APPENDIX A - *GROENLANDIA DENSA* 2017 SURVEY RESULTS

Photograph 5. Ditch to north of *Groenlandia densa*, showing overhanging scrub, litter and dense *Lemna* spp. on water surface.

Photograph 6. Ditch to south of *Groenlandia densa*, showing channel dominated by tall monocots with dense *Lemna* spp. on water surface.

Adjacent ditches to main survey area (SAC on E side of King's Island)

Photograph 7. Ditch section with open water (view to S)

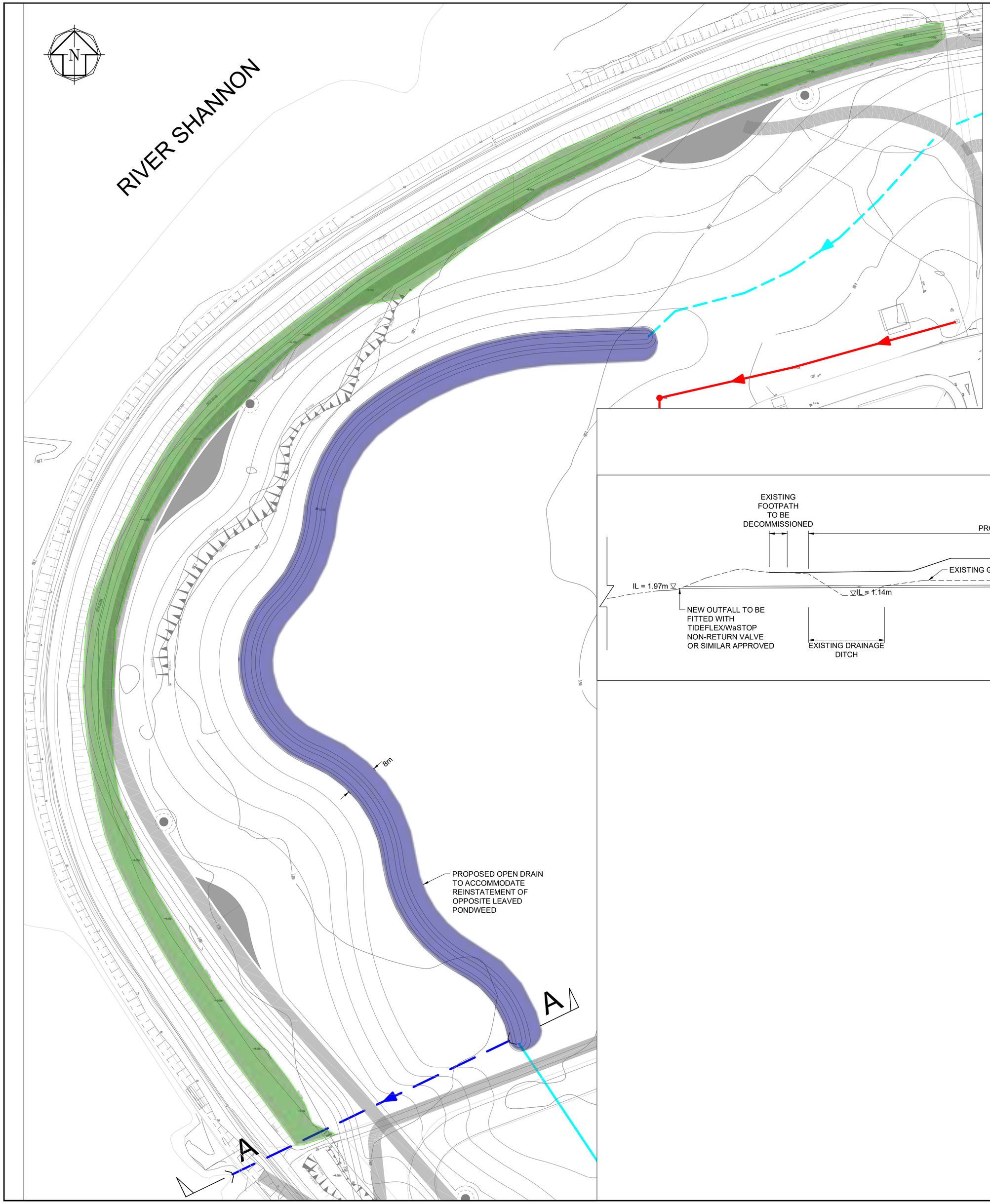
Photograph 8. Channel dominated by wetland species (e.g. monocots and *Veronica* spp.) but no true aquatic macrophytes seen.

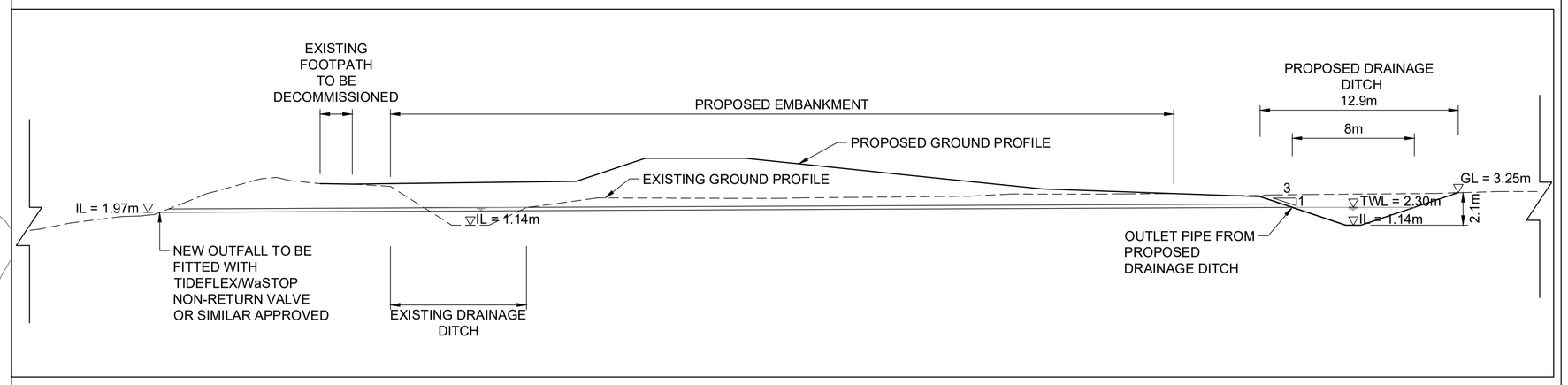
Photograph 9. Ditch channel overgrown with monocots (view to S)

Photograph 10. Ditch channel with open water but little macrophyte growth within channel

Transect details

King's Island *Groenlandia densa* survey 2017

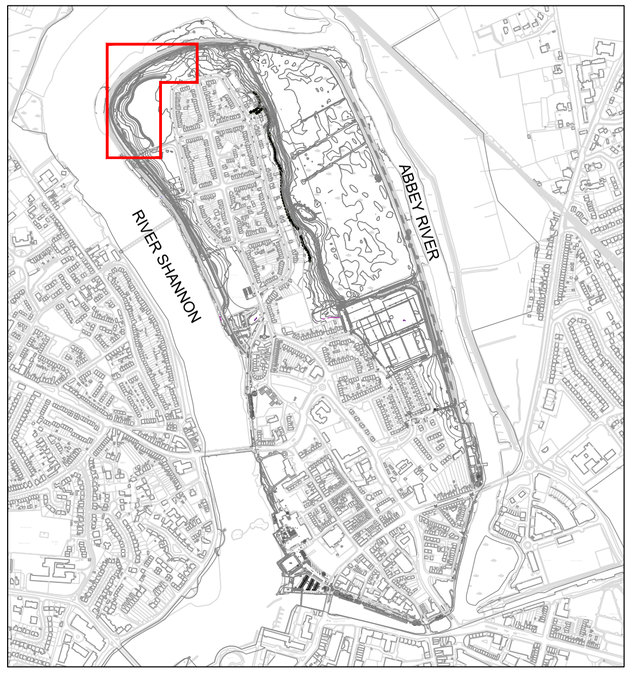




SECTION A-A
SCALE 1:250

General Notes

1. All dimensions shown are in metres unless otherwise stated and levels in metres to Ordnance Datum.
2. Do not scale from this drawing. All dimensions must be checked/verified on site.
3.
4. Any discrepancies noted on site are to be reported to the Engineer immediately.
5. All works in watercourses will be carried out with care to minimise the risk of pollution adhering to Pollution Prevention Guidelines.
6. The locations of any known services shown on drawing are approximate and for guidance only. The Contractor will confirm the location of any services prior to the commencement of any works.
7. The electronic model of this drawing is not to be used for setting out.



LEGEND

- EXISTING STORM SEWER
- EXISTING FOUL SEWER
- REDUNDANT SEWER
- PROPOSED STORM SEWER
- PROPOSED FOUL SEWER
- PROPOSED FILTER DRAIN
- PROPOSED SWALE
- EXISTING OPEN DRAIN
- PROPOSED OPEN DRAIN TO ACCOMMODATE REINSTATEMENT OF OPPOSITE LEAVED PONDWEED

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved
D1	PROPOSED POND PROFILE UPDATED	26/03/19	LL	LL	DW	DW
D0	DRAFT FOR REVIEW	19/03/19	LL	DW	DW	DW

JBA consulting

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Corbally
Limerick
Ireland

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f +00 353 (0)61 280146
e info@jbaconsulting.ie

for

LIMERICK CITY & COUNTY COUNCIL

KINGS ISLAND FLOOD RELIEF SCHEME

PROPOSED OPEN DRAIN

Scale: 1:500 @ A1	Drawn:	LL 19/03/2019
	Designed:	DW 19/03/2019
	Checked:	DW 19/03/2019
	Approved:	DW 19/03/2019

Digital File Name: 2015s3218-012 D1.pdf

Drawing Number:	Rev.:	Sheet No.:	Status:
012	D1	1 OF 1	NPWS SUBMISSION

WILDLIFE ACTS 1976 TO 2018 – SECTION 21

APPLICATION FOR A LICENCE TO TAKE ALTER OR OTHERWISE INTERFERE WITH THE HABITAT OR ENVIRONMENT OF A SPECIES OF PROTECTED FLORA FOR SCIENTIFIC, EDUCATIONAL OR OTHER PURPOSES

1. Name of applicant:	Denyer Ecology on behalf of Kieran O'Gorman Limerick City and County Council
Address:	Limerick City and County Council, Merchants Quay, Limerick, V94 EH90
[BLOCK LETTERS]	
Email Address:	joanne@denyerecology.com/ kieran.ogorman@limerick.ie
Telephone No.:	00353 86 2379153
2. Species:	Opposite-leaved Pondweed *Groenlandia densa*
3. Location(s): **(including maps where possible)**	See attached Methods Statement
4. Purpose for which alteration or interference with environment or habitat is proposed:	Flood Relief Scheme, King's Island, Limerick
5. Means by which specimens will be taken, altered or interfered with: (e.g. cutting, uprooting etc.)	Existing ditch to be removed and new ditch will be created on same site. Licence application to remove plants from existing ditch and translocate to new ditch (see Methods Statement for more details).
6. Organisation to which applicant is affiliated:	Denyer Ecology/ Limerick City and County Council
7. Period for which licence is required:	2020-22 (see Methods Statement for more details).

Signature: ……. Date: ……20 March 2019…..

Where applicable include copies of survey work etc carried out on the species & site to which this application refers.

Please return completed application form to:
Wildlife Licensing Unit (R. 2.03)
National Parks & Wildlife Service
90 North King Street
Smithfield
Dublin 7
D07 N7CV

Tel.: (01) 888 3242

Email: wildlifelicence@chg.gov.ie

An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht

License application under the Wildlife Act 1976 to 2018

PRIVACY STATEMENT

The Department of Culture, Heritage and the Gaeltacht is committed to protecting and respecting your privacy and employs appropriate technical and organisational measures to protect your information from unauthorised access. The Department will not process your personal data for any purpose other than that for which they were collected. Personal data may be exchanged with other Government Departments, local authorities, agencies under the aegis of the Department, or other public bodies, in certain circumstances where this is provided for by law. The Department will only retain your personal data for as long as it is necessary for the purposes for which they were collected and subsequently processed. When the business need to retain this information has expired, it will be examined with a view to destroying the personal data as soon as possible, and in line with Department policy. Further information on Data Protection can be found on our website at:
https://www.chg.gov.ie/help/legal-notices/data-protection/

National Parks & Wildlife Services
LICENCE

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Licence No. FL08/2019

NATIONAL PARKS AND WILDLIFE SERVICE

Wildlife Acts 1976 to 2018- Section 21

LICENCE TO TAKE PROTECTED FLORA, ALTER OR OTHERWISE INTERFERE WITH THE HABITAT OR ENVIRONMENT OF A SPECIES OF PROTECTED FLORA

The Minister for Culture, Heritage and the Gaeltacht in exercise of the powers conferred on her by Sections 9 and 21 of the Wildlife Acts 1976 to 2018 authorises:

Denyer Ecology on behalf of Kieran O'Gorman, Limerick City and County Council, Merchants Quay, Limerick, V94 EH90

To take, alter or otherwise interfere with the habitat or environment of a species of protected flora as specified in Column 1 of the Schedule hereunder, in the manner specified in Column 2, in the location specified in Column 3 for the purpose of implementation of a conservation management plan to mitigate impacts of proposed development and future sea level rises subject to the conditions listed below during the period beginning on the 1st day of January 2020 and ending on the 31st day of December 2023.

SCHEDULE

1	2	3
Species	**Manner of taking protected species and/or altering or otherwise interfering with its habitat or environment.**	**Location**
Groenlandia densa	As described in "*Section 21 Application.* Groenlandia densa *Methods Statement, March 2019*. Unpublished report to NPWS, in support of Section 21 Licence application prepared by Denyer Ecology" its two appendices A&B, the detailed translocation plan (to be finalised and agreed with NPWS and incorporated, with a revised and finalised *Methods Statement*, into a *Conservation Management Plan*), as well as any subsequent modifications to these as may be proposed and agreed NPWS: • Removal of plants, plant fragments and sediment; • Transfer of removed material to secure storage;	King's Island, Limerick

	• Monitoring and maintenance of stored plants; • Direct transfer of removed material to other ditch/es, as may be agreed with NPWS; • Transfer of stored material to suitable habitat, as may be agreed with NPWS; • Monitoring, maintenance of transferred plants; • Management of habitat for the species; • In-filling of ditch following rescue translocation of protected species. Others actions, as may be agreed with NPWS	

Dated 25th July 2019

For the Minister for Culture, Heritage and the Gaeltacht

National Parks & Wildlife Services LICENCE

Conditions

1) All conservation work connected with *Groenlandia densa* and its habitat to follow and implement the strategies, methods and actions described in the report "*Section 21 Application.* Groenlandia densa *Methods Statement. March 2019*. Unpublished report to NPWS, in support of Section 21 Licence application prepared by Denyer Ecology" its two appendices A&B and the finalised detailed translocation plan (see condition 2), below) and any subsequent modifications to these as may be proposed and agreed with the National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht (NPWS).
2) The detailed translocation plan noted in sections 2.3.1 and 2.3.3 of the above report to be finalised in agreement with NPWS and incorporated with a finalised *Methods Statement* report into a *Conservation Management Plan* for the species at the site, in advance of commencement of any of the works covered by this licence – this plan to include finalised details of actions to be undertaken and the order and timeline for these.
3) Reports detailing progress, the results of surveys/monitoring/maintenance/management as well as recommendations for additional or modified management/remedial measures as may be required to ensure the survival of the species, to be provided to NPWS 6-monthly in the first two years following commencement of the works and annually for the three years post translocation.
4) All work directly on *Groenlandia densa* to be carried out by a qualified botanist with expertise in rare vascular plants and familiarity with the protected species and the site.

5) On expiry of this licence a return should be sent to Wildlife Licensing Unit, National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, 90 North King Street, Smithfield, Dublin 7, DO7 N7CV, whether or not this licence was used.
6) This licence shall be produced for inspection in a request being made in that behalf by a member of An Garda Síochána or any person appointed by the Minister for Culture, Heritage and the Gaeltacht, under Section 72 of the Wildlife Acts 1976 to 2018, to be an authorised person for the purposes of the Acts.
7) Any query in relation to this licence should be made to Wildlife Licensing Unit, National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, 90 North King Street, Smithfield, Dublin 7, DO7 N7CV. Telephone: 01 8883298.

Note: This permission does not confer right of access to any lands – permission from landowners should be sought prior to carrying out work

Wildlife Licensing Unit,
National Parks and Wildlife Service,
Department of Culture, Heritage and the Gaeltacht,
90 North King Street,
Dublin 7

Section 23 (7)(iv) Application - Badger *Meles meles*

Our Ref:2015s3353 - Section 23 (7)(iv) Application v0.1

2nd August 2019

Application of Licence to Interfere with or Destroy the Breeding Places of Any Wild Animals

1 BACKGROUND

Ms. Jean Hamilton (Senior Ecologist with JBA Consulting) is applying for a 'Licence to Interfere with or Destroy the Breeding Places of Any Wild Animals' under Section 23 (7)(iv) of the Wildlife Act 1976 as amended in relation to Badger *Meles meles* on King's Island, Limerick City.

1.1 Project

King's Island is historically susceptible to both tidal and fluvial flood risk. The island and surrounding area were badly flooded in early 2014 when an extremely high tide overtopped the embankments around the Island and caused them to fail in one location. Further flooding was experienced in 2016 as a result of another storm surge event in the Shannon Estuary. This flooding was confined to Merchants Quay, as the sandbags around the island contained the tidal surge.

A major improvement on the existing temporary flood defences is required to reduce the frequency of extreme events which inundate the island, which is why King's Island Flood Relief Scheme, led by Limerick City and County Council is proposed. This scheme will be designed to provide protection to properties in the study area from the 1 in 200-year tidal flood event (0.5% AEP event).

1.2 Badger records within the site

A mammal survey was carried out by Ecologists Jean Hamilton, BSc MSc MCIEEM and Hannah Mulcahy BSc MSc on 1st May and the 15th May 2019; this is outside the optimal season for badger surveys, but there were no major constraints. During a survey conducted on the 1st May 2019, several mammal burrows were found along the southern boundary of the marsh habitat on King's Island, north side of the football pitches, directly adjacent to the drainage ditch (Figure 1). The site was resurveyed by Jean and Hannah on the 15th May and several mammal burrows were noted on this bank.

A trail camera was deployed at the site for a week, and a badger was recorded on the camera on the 8th June 2019.

It is of note that this site is liable to flooding, which can be seen in attached photos from the survey in January 2017. This indicates that the badger sett is used only on a temporary, seasonal basis.

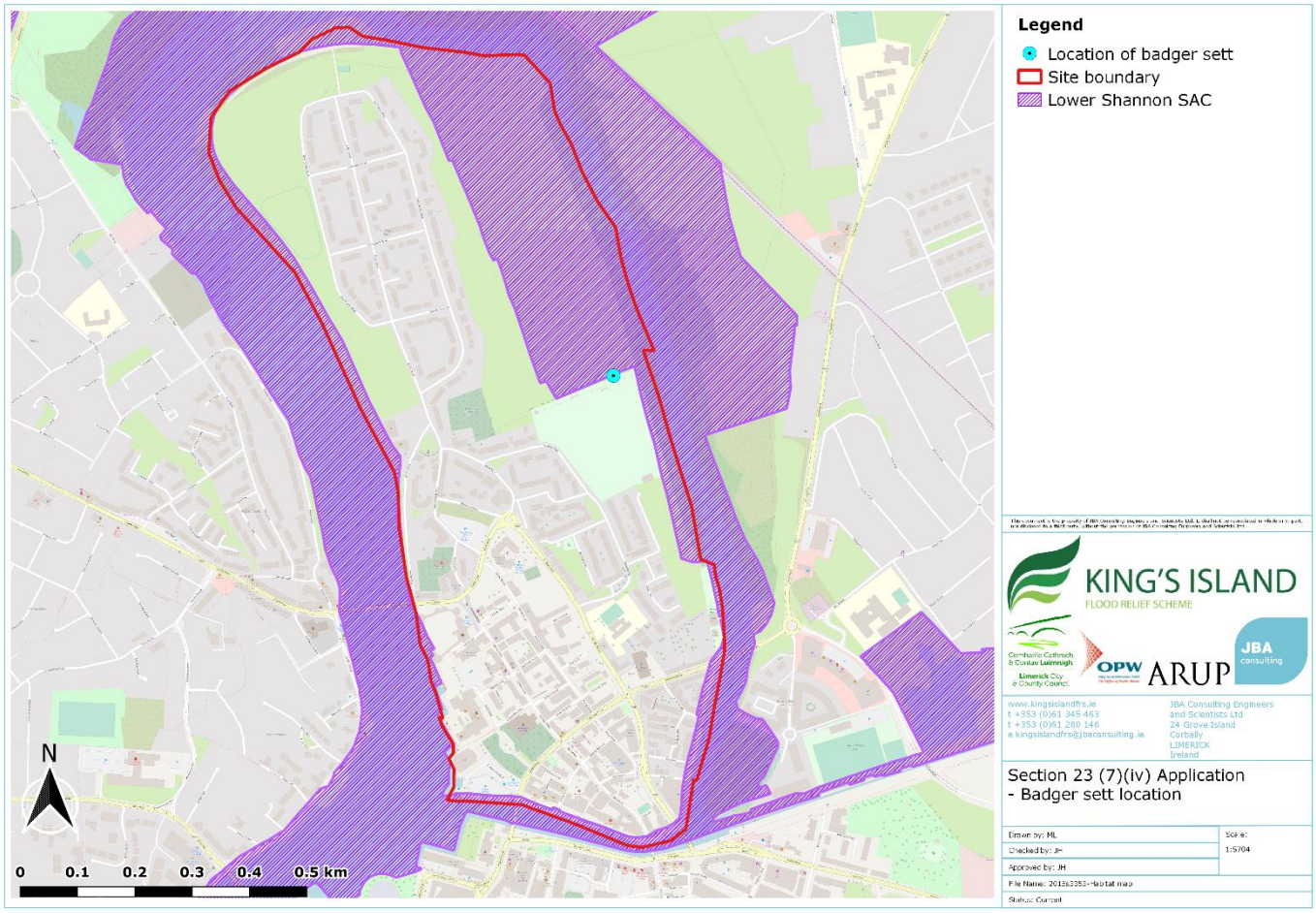

Figure 1: Location of badger sett on King's Island

Figure 2: Mammal holes are located along treeline above ditch

Figure 3: Mammal holes.

Figure 4: Mammal holes from survey in May 2019. Sticks being placed in entrance to monitor activity.

1.3 Disturbance to Badgers

Construction of new embankment to the south of marsh habitat may result in damage to the badger sett, which could have an effect on the badger population in this area.

1.4 Relevant experience

Jean Hamilton is a senior ecologist, with over twelve years' experience in environmental consultancy and has been a full member of the Chartered Institute of Ecology and Environmental Management (CIEEM) since 2014. Since 2007, Jean has worked on major infrastructural developments such as road schemes, which involved surveying over large areas to identify the presence of protected mammal species such as badgers and otters. She is highly skilled in the identification of field signs of badger, otter and other protected mammal species, and is competent in the use of trail cameras to monitor activity. She has also worked on the design and implementation of mammal mitigation on major infrastructural developments, including sett exclusions, supervision of sett destruction and construction of artificial badger setts.

2 PURPOSE OF LICENCE

A licence is applied for in order to undertake exclusion and destruction of a badger sett which is within the works area of the flood relief scheme. The sett lies in an area where a flood bund is being constructed and the works may result in collapse of tunnels which may result in badger injuries or mortalities if it is not excluded prior to the commencement of works.

2.1 Sett exclusion

Sett exclusion will be carried out during the period July 2019 - November 2020. Sett entrances will first be monitored for activity using sticks, sand pads or trails cameras, or a combination of methods. If sett entrances have not been in use for five days, they will be soft-blocked using vegetation and a light application of soil, and left for a further five days to confirm that the sett is unoccupied. If all entrances remain undisturbed for five days, the sett will be destroyed immediately, under the supervision of the named ecologist on the licence.

If the sett entrances are showing signs of current use, it will be assumed that badgers are present in the sett and they will have to be excluded prior to sett destruction. Badgers will be excluded from the sett by installing one-way gates and exclusion fencing at the entrances, to allow badgers to exit the sett but not re-enter. Following installation, the gates will be tied open for three days before they are set to exclude. The gates will then be left in place for a minimum of 21 days before the sett is deemed unoccupied. Regular visits will be carried out to check that the gates haven't been interfered with; if the sett exclusion shows signs of interference, the exclusion gates/fencing will be repaired, and the 21-day monitoring period will begin again.

2.2 Sett destruction

Provided there is no sign of current occupation, the sett will be destroyed under the supervision of the named ecologist on the licence immediately following the 21-day exclusion period.

Sett destruction will be carried out using a tracked 12-25 tonne digger. As the sett entrances open out into a drain to the north of the sett, it will not be feasible to work from the outside in. Therefore, the work will be carried out from the eastern side and/or the western side, starting from c. 25m from the outermost hole, working inwards towards the core of the sett. Once it is ensured that badgers are not present in the sett, the core will then be destroyed and the area back-filled.

If the supervising ecologist sees a badger at any time, the works will be stopped immediately and NPWS will be informed.

2.3 Other mitigation

The sett is a small outlier; it is in an area prone to flooding and so would only be used seasonally and is not presumed to be used during the breeding season. After the works have been completed, the bank will remain and this may be used for sett digging.

Therefore, the loss of the sett is not expected to have a significant effect on the local badger population, and so it is not considered necessary to construct an artificial sett.

3 POST-CONSTRUCTION

3.1 Reporting

Following the completion of works, a report will be prepared outlining the works carried out. This will include photos of the sett exclusion and destruction. The report will be sent to NPWS.

Yours faithfully,

Jean Hamilton
For and on behalf of JBA Consulting Engineers & Scientists Limited

BSc (Hons) MSc MCIEEM
Senior Ecologist
Jean.hamilton@jbaconsulting.ie

Encs.

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Jean Hamilton (Senior Ecologist with JBA Consulting)
JBA Consulting Engineers and Scientists Ltd.
24 Grove Island
Corbally
Limerick
Jean.Hamilton@jbaconsulting.ie

16/08/2019

Re: application to interfere with the breeding and resting places of badger *Meles Meles* under Section 23(5)(D) of the Wildlife Acts 1976 to 2012 for **King's Island Flood Relief Scheme**.

Dear Mr Ms agent

Further to application of **Limerick City and County Council** to destroy / disturb badger setts within the area proposed for works at **King's Island**, the Department of Culture, Heritage and the Gaeltacht (National Parks and Wildlife Service), does not oppose the works needed provided that:

1. No active setts (in any category) can be interfered with or disturbed during the badger breeding season (December to June inclusive).

2. Any badgers injured as a result of the works (either at the sett or during construction) must be reported to the local NPWS Conservation Ranger, **Ciara Powell, ciara.powell@chg.gov.ie .**

3. A report detailing any relevant issues must be submitted to the NPWS following completion of the works.

4. In order to minimize disturbance to badgers in the vicinity of the proposed works the mitigation (**Section (7)(iv) Application – Badger *Meles meles*, 2. Purpose of Licence, pp 5-6**) must be adhered to in full.

5. The works will be supervised by a qualified scientific agent(s): **Jean Hamilton BSc MSc MCIEEM, JBA Consulting.**

6. All works are to be undertaken in accordance with the Guidelines for the Treatment of Badgers prior to the Construction of National Road Schemes (http://www.tii.ie/tii-library/environment/construction-guidelines/Guidelines-for-the-Treatment-of-Badgers-prior-to-the-Construction-of-a-National-Road-Scheme.pdf).

7. The licensee shall, within 14 days of completion of the actions which this licence authorises, submit a written report to the address below, describing the activities carried out in pursuance of works requested.

8. NPWS Conservation Ranger, **Ciara Powell** must be contacted giving one week's notice before works commenced with the vicinity of the badger setts.

If you have any queries about this letter, please contact **Pádraig Shortt**, padraig.shortt@chg.gov.ie, 01-8883256.

Yours sincerely

Gabriel Staunton
Wildlife Licencing Unit

An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service
90 Sráid an Rí Thuaidh, Margadh na Feirme, Baile Átha Cliath 7, D07 N7CV
90 King Street North, Smithfield, Dublin 7, D07 N7CV

T +353 (0)1 888 3253| www.npws.ie

Roinn Cumarsáide, Gníomhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment

DEPARTMENT OF COMMUNICATIONS, CLIMATE ACTION AND ENVIRONMENT

CERTIFICATE OF AUTHORISATION UNDER SECTION 14 OF THE FISHERIES (CONSOLIDATION) ACT, 1959 AS SUBSTITUTED BY SECTION 4 OF THE FISHERIES (AMENDMENT) ACT, 1962.

The Minister for Communications, Climate Action and Environment in exercise of the powers conferred on him by Section 14 of the Fisheries (Consolidation) Act, 1959 as substituted by Section 4 of the Fisheries (Amendment) Act, 1962 hereby authorises: Ross Macklin, Senior Ecologist & Fisheries Scientist, Triturus Environmental Services, 42 Norwood Court, Rochestown, Cork (and or person(s) nominated by him to undertake a depletion survey at four locations at King's Island, Limerick City for the King's Island Flood Relief Scheme.

This authorisation is granted subject to the following conditions:

1. **This authorisation shall not confer on the holder thereof, independently of the conditions therein;**

   (a) **any rights or title which the holder would not have had if this authorisation had not been given, or;**

   (b) **any authority in any way to interfere with or infringe the lawful rights of any other person.**

2. **This authorisation is issued to and valid for use by Ross Macklin and or person(s) nominated by him.**

3. **This authorisation is valid to 30 September 2019.**

Teach Leamháin, Bóthar Ghleann an Iarla, An Cabhán, H12 A8H7
Elm House, Earlsvale Road, Cavan, H12 A8H7
T +353 1 678 2000 | 1890 44 99 00
www.dccae.gov.ie

4. Electro-fishing should be carried out between July 1st and September 30th when juvenile salmonids (if present) are of a sufficiently large size to be caught by electric fishing, to minimize damage and for them to be distinguished from similar species (refer to CEN (2001) and CFB (2008) 'Electric Fishing in Wadeable Reaches' manual).

5. The consultant should be mindful of other listed species that might be encountered during the electrical fishing exercise. The planned work is to take place within an SAC. If not already done so, it would be prudent to contact NPWS to inform them of the proposed survey and to seek their permission.

6. The applicant is aware of biosecurity concerns and must adhere to the Biosecurity Protocol for Field Survey Work, whereby equipment must be disinfected prior to and after use to prevent the spread of disease, parasites or invasive species (http://www.fisheriesireland.ie/Biosecurity/biosecurity-protocol-for-field-survey-work.html) and as directed by an officer of IFI.

7. The consultants should be mindful of the potential occurrence of invasive alien species, either in the watercourse being surveyed or in the adjoining riparian zone. Extra care should be taken to ensure that plant fragments and seeds of invasive balsam and knotweed species are not inadvertently transported on clothing, footware or equipment. It would be very helpful if the consultant could record presence of such species, along with geo-reference and indication of extent of occurrence, in report material submitted to IFI. If possible, surveying should commence at the uppermost site and proceed sequentially downstream.

8. The applicant and agents should desist, to the greatest extent possible, from walking in the general instream area and to avoid walking on instream gravelled areas if present, thereby limiting adverse impact to intra-gravel life stages of salmonids and other species.

9. The electro-fishing must be carried out only by nominated personnel with training and experience in such operations. All electric fishing equipment must be available for inspection by an IFI officer during each survey

10. The Director of the Shannon River Basin District and the appropriate Fisheries Inspector should be informed of exact date, location and scope of the planned survey, five working days prior to survey start. Contact details are as follows:

    Ms Amanda Mooney, Shannon River Basin District, Ashbourne Business Park, Dock Road, Limerick, V94 NPE0 Phone: 061 300238; Fax: +353 (0)61 300308

    Email: Limerick@fisheriesireland.ie / amanda.mooney@fisheriesireland.ie

11. All equipment must be available for inspection by an IFI officer during the survey.

12. In the event that the proposed survey is cancelled the relevant IFI office should be notified, initially by telephone and subsequently by e-mail. An indication of the proposed re-commencement date of the survey operation should also be advised.

13. The applicant should seek permission from fishery owners and informs local angling clubs of their plans for the surveys where relevant. The applicant must also seek permission from landowners to cross land, where relevant.

14. Electric fishing operations must be carried out during suitable weather and flow conditions.

15. No fish of any species should be sacrificed during the surveys. The number of fish killed (if any) is to be kept to an absolute minimum and IFI Limerick and Citywest are to be informed of any fish mortalities immediately after the survey. Details including the county, site number, river name, townland, Irish grid reference, and the species and numbers killed shall be communicated to IFI Limerick by telephone and a subsequent e-mail, for the attention of Michael Fitzsimons, Senior Environmental Officer.

16. A standard template for reporting survey data to IFI is attached. A survey report and qualitative/quantitative data (in the attached standard IFI format) must be provided, within 30 days of completion of the survey, in electronic format to Sandra Doyle (Sandra.Doyle@fisheriesireland.ie). These data will not be made publically available, for a period of 3 years, without the permission of the applicant.

17. When doing anything pursuant to this authorisation, the holder shall, if requested by any person affected, produce this authorisation to that person.

18. Failure to comply with any of the conditions of this authorisation may result in revocation of this authorisation.

19. The holder of this authorisation shall indemnify and keep indemnified the State, the Minister for Communications, Climate Action and Environment and the Minister for Finance against any claims, arising in any manner whatsoever in connection with the user of the fishing gear or in the exercise of the permission hereby granted.

20. Notwithstanding the foregoing, this authorisation may be revoked or amended by the Minister for Communications, Climate Action and Environment without the payment of compensation to the holder on giving one week's notice in writing to the holder if he considers it necessary in the public interest to do so.

Dated this 05 September 2019

For the Minister for Communications, Climate Action & Environment

Gerry Clerkin
An officer authorised on that behalf by the said Minister

IFI Biosecurity Protocol for Field Survey Work

December 2010

Iascach Intíre Éireann
Inland Fisheries Ireland

Biosecurity Protocol for Field Survey Work

Invasive species are an ever present threat in our aquatic and riparian systems and it is imperative that none of our field operations exacerbate the risks to the environment and to the economy that are posed by these species. Fish parasites, pathogens and diseases also represent a significant threat to the health status of our watercourses. The introduction or transfer of such pathogens or diseases has the potential to wipe out large populations of fish in affected waters or catchments. Vigilance is required if we are to stop the spread of invasive species and fish diseases, and it is imperative that we in IFI lead by example in the ongoing struggle against these significant threats to our fishery watercourses.

The need for basic biosecurity in our fisheries operations must become ingrained in the psyche of our staff if we are to do our part to stop the spread of hazardous invasive species and fish pathogens. Much to do with biosecurity involves awareness, common sense and agreed procedures. Listed below are some basic procedures that must be implemented when conducting field survey work.

Each field vehicle must carry a 'disinfection box'. This should contain Virkon Aquatic or another proprietary disinfectant, a spray bottle, cloths or sponges, a scrubbing brush and protective gloves.

On completion of any field operation, all equipment used must be treated according to the procedures listed below. Equipment in this respect includes the following:
boats, trailers, outboard motors, anchors and rope, weights, tanks, buckets and bins, all PPE (including boots, wellingtons, waders, wetsuits, dry suits, waterproof clothing, life jackets, diving apparatus, etc.) and any technical or sampling apparatus used as part of the survey. Protective gloves must be worn when using any disinfectant solution in any of the procedures listed below.

- Visually inspect all equipment that has come into contact with the water for evidence of attached plant or animal material, or adherent mud or debris. This should be done before leaving the site.

- Remove any attached or adherent material (fish, fish scales, vegetation and debris) before leaving the site of operation.

- Ensure that all water is drained from boats, live wells and other water retaining compartments, outboard motors, tanks and other equipment before transportation elsewhere.

- High-pressure steam cleaning, with water > 40 degrees C, is recommended for boats (including oars, row locks, attachment ropes, anchors and buoys), trailers and outboard motors that are being moved from one watercourse to another. Many roadside garages provide these facilities. If it is not possible to steam clean the equipment, a normal power hose must be used. After cleaning visually inspect the equipment to ensure that all adherent material and debris has been removed.

- It is recommended to apply disinfectant, using the spray bottle from the 'disinfection box', to the undercarriage and wheels of the vehicle and trailer after steam cleaning or power hosing.

- Wet or live wells and other water retaining compartments in survey boats must be cleaned, rinsed or flushed with a 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Rinse thoroughly with clean water.

- Tanks that are used to stock or transfer live fish should be thoroughly washed with a 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. All disinfected equipment must be thoroughly rinsed with clean water.

- Outboard motors should be flushed with a 1% solution of Virkon Aquatic or another proprietary disinfection product, or with water > 40 degrees C. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Facilities will be provided at IFI stores countrywide to accommodate this operation.

- Nets (to include monofilament and braided gill nets, fyke nets and seine nets) must be cleaned of all vegetation and debris before returning to base. The clean nets must then be placed in a freezer for a period of four days (3 days will suffice for monofilament nets). Following this treatment the nets must be soaked in a 1% solution of Virkon Aquatic or a proprietary disinfectant for a period of not less than 15 minutes and thoroughly rinsed thereafter. Where these proprietary disinfectants are not available the nets must be soaked in a 5% solution (100 ml / 20 litre solution) of chlorine bleach for 1 hour and thoroughly rinsed after.
  An SOP on 'Management and Disinfection of Survey Nets' is available on request from IFI Swords.

- Footwear should be dipped in or scrubbed with a disinfectant solution (e.g. 1% solution of Virkon Aquatic or another proprietary disinfection product) and thoroughly dried afterwards.

- All PPE should be visually inspected and any attached vegetation or debris removed. Where appropriate, the gear should be wiped down with a cloth soaked in 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Rubber gloves must be worn when undertaking this procedure.

- Sampling equipment (e.g. electrofishing electrodes and cable, grab samplers, meter sticks, buckets and bins, etc.) must be cleaned, rinsed or wiped down with or dipped in a suitable disinfectant solution.

- Landing nets and hand nets must be dipped in disinfectant solution and rinsed in clean water.

- All field equipment must be suitably disinfected before being returned to the IFI Swords warehouse for storage. Staff will be requested to sign a prepared form detailing the nature of the disinfection process carried out and the date on which this was conducted.

Note
Disinfectants must be used with care and in strict accordance with the manufacturer's instructions. They must be disposed of safely and never in close proximity to open waters,

For additional information, please contact:

Dr Joe Caffrey
Senior Research Officer

Inland Fisheries Ireland, Swords.
01 8842600

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Fax: +353 1 8360 060

D Surface and Groundwater

D1 Hydrogeological Summary

D2 Groundwater Testing Results

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
pH	U	1010	N/A		7.7	8.3	7.7	7.9	7.5	7.7	7.7	-
Electrical Conductivity	U	1020	µS/cm	1	630	410	1000	570	920	630	580	800-1875
Suspended Solids at 105C	U	1030	mg/l	5	7200	130	25000	47	4600	860	400	-
Total Dissolved Solids	N	1040	mg/l	1	380	250	600	340	550	380	350	-
Biochemical Oxygen Demand Low Level	N	1090	mg O2/l	1	[B] 4.0	[B] 1.0	[B] 2.0	[B] 1.0	[B] 1.0	[B] -.0	[B] -.0	-
Chemical Oxygen Demand	U	1100	mg O2/l	10	-	29	18	13	12	12	10	-
Dissolved Oxygen	N	1150	mg O2/l	0.5	8.1	8.1	6.7	9.1	7.6	7.7	7.4	-
Dissolved Oxygen	N	0.5	% saturation	0.5	89	89	74	100	84	85	81	-
Redox Potential	N	1170	mV	N/A	530	520	510	600	580	610	620	-
Alkalinity (Total)	U	1220	mg CaCO3/l	10	240	200	420	250	300	240	240	-
Chloride	U	1220	mg/l	1	20	23	28	22	39	20	21	24-187.5
Ammoniacal Nitrogen	U	1220	mg/l	0.01	0.51	0.14	0.93	0.23	0.39	0.33	0.64	-
Nitrate	U	1220	µg/l	500	-	2700	-	6400	-	-	-	-
Nitrate	U	1220	mg/l	0.5	-	2.7	-	6.4	-	-	-	37.5
Phosphate	U	1220	µg/l	50	-	-	-	-	-	-	-	-
Phosphate	U	1220	mg/l	0.05	-	-	-	-	-	-	-	-
Sulphate	U	1220	mg/l	1	19	13	120	18	110	19	16	187.5
Calcium	U	1415	mg/l	5	72	72	52	90	130	85	81	-
Potassium	U	1415	mg/l	0.5	1.1	1.7	3.4	1.5	5.5	1.1	0.73	-
Magnesium	U	1415	mg/l	0.5	21	7.3	9.1	25	30	24	20	-
Sodium	U	1415	µg/l	500	13000	9100	180000	16000	24000	13000	13000	-
Sodium	U	1415	mg/l	0.5	13	9.1	180	16	24	13	13	150
Arsenic (Dissolved)	U	1450	µg/l	1	5.3	-	4.1	-	2.3	2.9	2.2	7.5
Barium (Dissolved)	U	1450	µg/l	5	400	45	47	77	72	170	280	-
Cadmium (Dissolved)	U	1450	µg/l	0.08	-	-	-	-	-	-	0.13	3.75
Chromium (Dissolved)	U	1450	µg/l	1	1.5	-	2.6	6.6	2	-	1.7	37.5
Copper (Dissolved)	U	1450	µg/l	1	-	1.2	2.1	-	-	-	-	1500
Iron (Dissolved)	N	1480	µg/l	20	300	230	180	250	480	270	290	-
Manganese (Dissolved)	U	1450	µg/l	1	630	6.9	140	2.9	1800	160	600	-
Molybdenum (Dissolved)	U	1450	µg/l	1	1.2	-	4.5	-	1.5	3.3	1.9	-
Nickel (Dissolved)	U	1450	µg/l	1	1.3	1.2	2.9	-	2.3	2.8	1.7	15
Lead (Dissolved)	U	1450	µg/l	1	-	-	-	-	-	-	-	18.75
Antimony (Dissolved)	U	1450	µg/l	1	-	-	-	-	-	1.7	-	-
Selenium (Dissolved)	U	1450	µg/l	1	-	-	16	4.1	2.3	1.3	-	-
Vanadium (Dissolved)	U	1450	µg/l	1	-	-	9	-	-	-	-	-
Zinc (Dissolved)	U	1450	µg/l	1	3.7	2.9	4.6	2	5	2.1	2.1	-
Mercury Low Level	U	1460	µg/l	0.01	-	-	-	-	-	-	-	0.75
Chromium (Hexavalent)	U	1490	µg/l	20	-	-	-	-	-	-	-	-
TPH >C6-C10	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
TPH >C10-C21	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
TPH >C21-C40	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
Total TPH >C6-C40	U	1670	µg/l	10	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Chloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Vinyl Chloride	N	1760	µg/l	1	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
Bromomethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Chloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Trichlorofluoromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Trans 1,2-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloroethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
cis 1,2-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Bromochloromethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Trichloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tetrachloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloropropene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Benzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Trichloroethene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichloropropane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Dibromomethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
Bromodichloromethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	N	1760	µg/l	10	-	-	-	-	-	-	-	-
Toluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Trans-1,3-Dichloropropene	N	1760	µg/l	10	-	-	-	-	-	-	-	-
1,1,2-Trichloroethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
Tetrachloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3-Dichloropropane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Dibromochloromethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
1,2-Dibromoethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Chlorobenzene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1,1,2-Tetrachloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Ethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
m & p-Xylene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
o-Xylene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Styrene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tribromomethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Isopropylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Bromobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,3-Trichloropropane	N	1760	µg/l	50	-	-	-	-	-	-	-	-
N-Propylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
2-Chlorotoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
4-Chlorotoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tert-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,4-Trimethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Sec-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
4-Isopropyltoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

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Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
1,4-Dichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
N-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dibromo-3-Chloropropane	U	1760	µg/l	50	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Hexachlorobutadiene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,3-Trichlorobenzene	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Methyl Tert-Butyl Ether	N	1760	µg/l	1	-	-	-	-	-	-	-	-
N-Nitrosodimethylamine	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Phenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Chlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis-(2-Chloroethyl)Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methylphenol (o-Cresol)	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis(2-Chloroisopropyl)Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachloroethane	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
N-Nitrosodi-n-propylamine	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Methylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Nitrobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Isophorone	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Nitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dimethylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis(2-Chloroethoxy)Methane	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Naphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chloroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorobutadiene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chloro-3-Methylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methylnaphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorocyclopentadiene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4,6-Trichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Chloronaphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Acenaphthylene	N	1790	µg/l	0.5	0.9	-	-	-	-	-	-	-
Dimethylphthalate	N	1790	µg/l	0.5	0.5	-	-	-	-	-	-	-
2,6-Dinitrotoluene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Acenaphthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
3-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Dibenzofuran	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chlorophenylphenylether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dinitrotoluene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
Fluorene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Diethyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methyl-4,6-Dinitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Azobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Bromophenylphenyl Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Pentachlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Phenanthrene	N	1790	µg/l	0.5	0.7	-	-	-	-	-	-	-
Anthracene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Carbazole	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Di-N-Butyl Phthalate	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Fluoranthene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Pyrene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Butylbenzyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[a]anthracene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Chrysene	N	1790	µg/l	0.5	0.6	-	-	-	-	-	-	-
Bis(2-Ethylhexyl)Phthalate	N	1790	µg/l	0.5	3	-	-	-	-	-	-	-
Di-N-Octyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[b]fluoranthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[k]fluoranthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[a]pyrene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
4-Nitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
"-" indicates test result was below Limit of Detection (LOD)												

A number of geological cross sections have been produced for Kings Island in GINT, which are based on the additional information obtained in the ground investigation. The locations of these are shown on Figure 1 and the sections are presented as Sections A – D (Figures 2 – 5).

Automatic data loggers have been installed in groundwater locations around the site. These data loggers record groundwater levels at set intervals and have been moved around the site on a monthly basis to establish the relationship between surface water and groundwater in the various lithologies.

Further site survey data received has identified an outfall pipe on the eastern side of the SAC.

1.1 Summary of groundwater and surface water level data

The geology of the site comprises of overburden multi layered clay, gravel and made ground all overlying overlying limestone. Monitoring wells are designed for monitoring groundwater levels in either the subsoil or bedrock. A total of eight (8 No.) monitoring wells are set into subsoils and three monitoring wells are set in limestone (3 No.) bedrock. These water level data was recorded between May and June 2016, with between 2 and 8 records for each monitoring well (Table 1).

Monitoring well ID	**Response zone depth (mBGL)**	**Lithology**	**Depth to water (mBGL)**		**Depth to water (mOD)**	
			Average	Max	Average	Max
BH105	17 – 20	Limestone	-0.1	-0.1	2.21	2.21
BH106	5.5 – 6.5	Clay	0	0	2.16	2.16
BH107	3 – 4	Clay	0.24	0	1.88	2.12
BH108	1.5 – 2.5	Clay	2.01	1.67	1.83	2.17
BH109	4.9 – 6.1	Gravel and cobbles	0.33	0.2	2.23	2.35
BH110	7.7 – 8.7	Cobbles	1.80	1.61	2.08	2.27
BH111	5.3 – 6.3	Gravel and cobbles	0.03	0	1.85	1.88
BH113	5.5 – 6.3	Limestone	0.10	0	2.57	2.67
BH114	3.5 – 4.5	Clay	0.40	0	2.20	2.59
BH115A	7.3 – 8.3	Clay	2.19	1.86	1.59	1.92
BH115RC	16.9 – 19.9	Limestone	1.72	1.72	2.06	2.06

Table 1 Groundwater levels

Groundwater levels in the gravel and cobbles is highest in BH109 and BH110 located to the north of BH111. The hydraulic gradient extends from the north towards the south. Rising head tests in the gravel and cobbles unit indicate a permeability of between $1.3x10^{-6}$m/s and $3.5x10^{-6}$m/s.

The limestone groundwater level in the northern part of the site (BH105) is artesian and the aquifer unconfined beneath the clay. Groundwater levels in RC115A and BH113 are also confined beneath the clay as groundwater levels are lower in the adjacent clay boreholes. Groundwater levels in the limestone are higher in BH113 located further inland and to the south compared to BH105 and

BH115RC. This suggests a hydraulic gradient from the centre of the island towards the river. Groundwater levels in BH105 on both monitoring occasions were the same suggesting little fluctuation, however between three monitoring occasions in BH113 there was fluctuation. Due to the limited number of sampling occasions it is not possible to determine the influence of the tidal effect on the bedrock groundwater. Rising head tests in the bedrock at RC113 and RC115A suggest permeabilities of $1.8x10^{-6}$m/s and $9.8x10^{-5}$m/s.

Surface water levels were monitored in the Abby River, Kings Island in February 2016 (Figure 6). It is noted that the Abby River is tidal but also that these data are upstream of a weir located just before the Abbey re-joins the Shannon. Surface water data is not available for period of time between May and June 2016 (when the groundwater data was recorded).

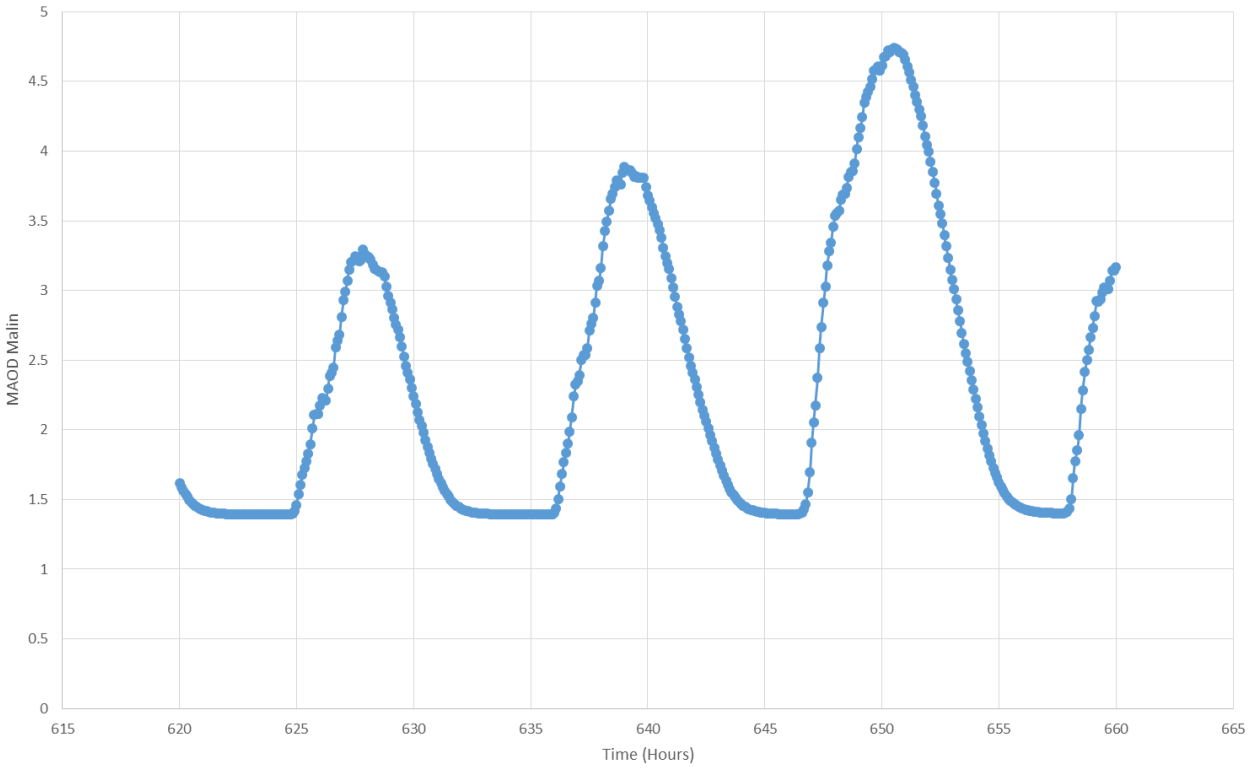

Figure 6. Hydrograph from the Abbey River, King's Island, Limerick (low tide 1.4m OD). (February 2016 data provided by JBA).

1.2 Outstanding information

Groundwater level loggers were installed in monitoring wells across the site. The data is still outstanding, as to date the compensated data has not been provided by the contractor.

2 Updated CSM

The updated conceptual site model (CSM) based on the additional information obtained during the GI is summarised below:

- The geology of Kings Island is composed of made ground and alluvial deposits (Silt, clay, sand, gravel) overlying limestone. According to geophysical profiles carried out across the site the clay and silt overlying the gravels is consistent across the site. The borehole logs and geophysical profiles suggest the clay and silt unit is by approximately 2m to over 15m thick. The gravel unit is not consistent across the site but is absent where the clay and silt directly overlies the limestone bedrock.
- The thickness and composition of the made ground is variable. Contaminated soils are likely to be present in St Marys Park (the site of an unregulated landfill).
- The depth of limestone is variable across the site. Ground investigation information shows rock head at approximately 10mbgl in the north of the site and approximately 4mbgl in the south of the site. The GSI groundwater vulnerability mapping notes an area of extreme vulnerability along the western walkway in the north west of the site indicating that rock may be present at or near the surface in this area, however the ground investigation indicated that this is not correct and that rock is up to 8mbgl in this area (BH121).
- Limited groundwater levels are available for the site at the time of this report, however, these data indicate there is a strong connection between river and groundwater level as indicated from groundwater logger data in RC01A at Verdant Place.
- Groundwater flow in the subsoils (in particular the gravels and cobbles) at Kings Island is from north to south, in the same direction as the flow of the river.
- The groundwater level data and King's River stage data show that the river and subsoils are hydraulically connected.
- There is likely to be an epikarstic layer at the top of the limestone that interconnects with groundwater flow through the subsoil. Groundwater flow will be generally be in the top 30m of the rock
- Groundwater in the limestone beneath the site is locally confined beneath the clay and highest in the centre of the site (BH113). The available data (three points) indicate that groundwater flow is likely to be radial from the centre outwards with surging effect close to the river reflecting tidal cycles.
- The upper layers of the subsoil comprise of peat, clay and silt. These low permeability subsoils will recharge to the underlying gravels and cobbles. It is suggested that water table in the underlying sands and gravels at Kings Island is a consequence of their connectivity to the surrounding rivers
- The recommended flood protection level is 5.8mOD Malin.

The SAC is of significant ecological importance. Additional commentary, specifically related to the SAC, is summarised below:

- Part of the SAC lies within the site boundaries. In the vicinity of the SAC, the site investigation illustrates that the peat / soil material is underlain by silt and clay. These in turn overlie sand / gravel and cobbles which overlie the bedrock.
- Made ground in the SAC is described as having 'tar inclusions' indicating that there may be minor contamination due to the presence of Made ground.
- Groundwater monitoring wells were installed in the limestone and the overburden to determine the interaction between these units. Available data indicates that one well (BH105) with a response zone beneath the clay (in limestone) is artesian or at ground indicating that the clay is acting as a confining unit. Shallower wells show water levels at or below ground level further illustrating this.
- The SAC is receiving recharge from rainfall which is likely to be limited from infiltrating into the underlying gravels due to the low permeability clay covering the site. Surface runoff flows towards drains which flow towards the eastern boundary of the site.
- A pipe located on the eastern side of the SAC has an invert level of 1.14 m. The water level at the time of the survey was 1.35 m. According to the survey drawing the area around the pipe is flooded and the flooding extends to the north and south adjacent to the embankment within the SAC, although the flooding to the south covers a larger area. The invert level of the flooded area generally increase to the south (from 0.39 up to 0.75 m). This suggests that the water is flowing to the lower area in the south. The hydrograph from the Abbey River shows that the river fluctuates between approx. 1.5 mOD and 4.8 mOD. As this is above the invert level of the pipe this suggests that the pipe is contributing surface water to the SAC. Once the water flows to the south, drainage is prevented by the underlying clay and the embankment resulting in the localised flooding. Removing or cutting off this pipe is likely to significantly affect the water balance of the SAC.
- During flooding events, the rate at which the groundwater levels in all the geological units will rise will be determined by the level of the flooding, the position in the tidal cycle, how saturated the deposits are and the permeability of the material.

3 Seepage analysis

The seepage assessment examines the likelihood of groundwater flooding occurring during flood levels in the River Shannon and Abbey River at the north east of the site. The existing bank conditions at the site comprise of an embankment which runs along the northern and eastern boundaries of the site and separates the river from the SAC. The model was run to determine seepage into and from the northern and eastern bank conditions of King's Island. The methodology for the seepage calculations are provided below and the results from these calculations follow.

The calculations on seepage were undertaken using Darcy's Law (Ref: Equation 1) and calculation of rate at which groundwater rises in a porous medium (Ref: Equation 2). These calculations are intended for guidance only and should not be taken as definitive.

The parameters used in the calculations are deliberately conservative.

Equation 1

$$Q = K.x.y.\left(\frac{h_1 - h_2}{L}\right)$$

Q is the calculated flow rate through the aquifer (m3/s)

K is the hydraulic conductivity of aquifer (m/day)

x is the width of the aquifer (m)

y is the thickness of the aquifer (m)

h_1 is the river flood level above the base of the aquifer (m)

h_2 is a groundwater level above the base of the aquifer (m)

L is the horizontal distance between h_1 and h_2 (m)

Equation 2

$$t = \frac{Z.x.2L.n}{Q}$$

Z is the distance between the ground level and initial groundwater level (m)

Q is the volumetric flow rate through the gravel (m3/s)

x is the width of the aquifer normal to the river (m)

2L is the width of the aquifer behind the flood defence (m)

n is the porosity of the gravel (m3/m3)

t is time (s)

The numerical modelling was undertaken using equations 1 and 2 in a spreadsheet format. Seepage is calculated as inflow from the river to groundwater when the river rises to the recommended flood protection level of 4.99mOD.

The calculations require input for aquifer parameters on hydraulic gradient, hydraulic conductivity, groundwater head and specific yield. These data were estimated from observations made in the field but also using approximations using guideline values made from literature and from experience. Hydraulic conductivity is based upon Kruseman & de Ridder Analysis and Evaluation of Pumping Test Data (2nd Ed) (1970).

Parameter		Unit	Number
Hydraulic conductivity	K	m/s	1.16×10^{-8}
River flood elevation	h	m	5.8
Groundwater elevation	h	m	2.1
Distance aquifer extends inland from flood defence	L	m	100
Specific Yield	N	ratio	0.3

Table 2. Parameters using in numerical model

The data presented in Table 1 is considered to represent a conservative representation of the values. In particular hydraulic conductivity is considered to represent the highest likely value for clay containing sand and gravel mixes. This calculation also assumes that the embankment material consists of very low permeability material and the principle flow pathway is through the clay. Furthermore, the calculations assume that the embankment height is greater than the flood height and as such overtopping is not considered.

Considering the conservative parameters chosen the seepage rate from the river to the land per m section. At this rate it would take 15 hours consistently at the flood level of 5.8 mOD for the water to breech through the clay layer on land side of embankment.

The calculation indicates that the existing embankment to the north of the SAC is sufficient to prevent flooding of the SAC.

Groundwater flooding may occur where there is a breech in the clay layer. It is unclear from the site investigations carried out to date if the clay is consistent within the central part of the SAC and beneath the houses to the west of the SAC. A cut off wall is proposed to the west of the SAC, between the houses and the SAC. This may prevent groundwater seepage through areas where the clay may be very thin of absent.

4 Summary

- The site located in the north east of Kings Island consists of clay, which is likely to be consistent across the site based on the SI information to date, over gravel overlying limestone bedrock. The low permeability clay layer will limit groundwater seepage.
- Gravel underlies the upper clay subsoils which is approximately 2 – 15m thick. The overlying clay prevents the gravel from receiving recharge. The gravels, whilst in hydraulic connectivity with the river, are hydraulically separate and disconnected with the SAC. The SAC is likely to be fed by incident rainfall and surface water via an existing pipe but not from groundwater.
- The analysis in the northern part of the island at BH105 indicates the seepage beneath the embankment would be circa 2 l/hr per m section.
- Based on the seepage calculations a cut off wall along the river bank is unlikely to provide significant additional protection from flooding to the SAC.
- There is an existing pipe in the eastern part of the SAC which appears to connect the SAC to the river and allow the river to contribute surface water to the SAC. Cutting off this connection is likely to influence the water balance of the SAC negatively.

E Soil and Geology

E1 Summary of Soil Testing Results

E2 Summary of Soil WAC Results

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:					BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103
Client Sample ID.:					ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3
Sample Type:					SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)					0.5	2.0	3.0	0.6	1.0	2.0	0.5	1.5	3.5	1.5	2.0	2.5
Date Sampled					20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand	Accred.	SOP	Units	LOD												
Moisture	N	2030	%	0.02	8.6	10	8.8	26	21	20	12	12	17	7	12	11
pH	U	2010	-	-	8.9	8.9	8.9	8.3	8.4	8.8	8.9	9	8.9	9	8.9	8.8
Arsenic	U	2450	mg/kg	1	16	16	14	12	9	11	17	21	14	20	10	13
Barium	U	2450	mg/kg	10	39	31	33	190	150	93	79	45	42	45	70	50
Cadmium	U	2450	mg/kg	0.1	-	0.12	0.15	0.3	0.39	0.34	0.21	0.22	0.18	0.2	0.15	0.15
Chromium	U	2450	mg/kg	1	11	13	7.2	20	16	17	8.4	6.4	6.7	18	21	17
Copper	U	2450	mg/kg	0.5	18	14	11	36	30	92	18	11	12	16	21	25
Mercury	U	2450	mg/kg	0.1	0.32	0.17	0.17	0.36	0.19	0.59	0.43	0.2	0.17	0.28	0.16	0.18
Molybdenum	U	2450	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	U	2450	mg/kg	0.5	19	24	10	26	20	25	14	10	9.2	20	36	31
Lead	U	2450	mg/kg	0.5	460	32	21	90	45	140	150	72	78	38	43	24
Antimony	N	2450	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	U	2450	mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	U	2450	mg/kg	0.5	26	25	19	64	200	210	71	31	25	37	58	61
Chromium (Hexavalent)	N	2490	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-
LOI	U	2610	%	0.1	0.64	1.1	1.1	7.2	4.3	2.5	2.1	1.4	1.2	1.1	1.6	1.5
Total Organic Carbon	U	2625	%	0.2	0.76	1.1	1.9	2.5	2.6	1	1.6	0.56	0.89	0.95	0.63	0.63
Mineral Oil	N	2670	mg/kg	10	-	59	-	-	-	-	-	-	-	24	-	-
Aliphatic TPH >C5-C6	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	2.5	-	-
Aliphatic TPH >C21-C35	U	2680	mg/kg	1	-	58	-	-	-	-	-	-	-	21	-	-
Aliphatic TPH >C35-C44	N	2680	mg/kg	1	-	1.4	-	-	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5	-	59	-	-	-	-	-	-	-	24	-	-
Aromatic TPH >C5-C7	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	79	-	-
Aromatic TPH >C21-C35	N	2680	mg/kg	1	-	16	-	-	-	-	-	-	-	580	-	-
Aromatic TPH >C35-C44	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	7.4	-	-
Total Aromatic Hydrocarbons	N	2680	mg/kg	5	-	16	-	-	-	-	-	-	-	670	-	-
Total Petroleum Hydrocarbons	N	2680	mg/kg	10	-	75	-	-	-	-	-	-	-	690	-	-
Benzene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
m & p-Xylene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	U	2800	mg/kg	0.1	-	-	-	-	-	0.12	0.16	-	-	-	-	-
Acenaphthylene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.49	-	-	-	-	-
Anthracene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.13	-	-	-	-	-
Fluoranthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.83	-	-	-	-	-
Pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.69	-	-	-	-	-
Benzo[a]anthracene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.23	-	-	-	-	-
Chrysene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.21	-	-	-	-	-
Benzo[b]fluoranthene	N	2800	mg/kg	0.1	-	-	-	-	-	-	0.27	-	-	-	-	-

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:					BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103
Client Sample ID.:					ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3
Sample Type:					SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)					0.5	2.0	3.0	0.6	1.0	2.0	0.5	1.5	3.5	1.5	2.0	2.5
Date Sampled					20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[a]pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.19	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Coronene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Total Of 17 PAH's	N	2800	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
PCB 28	U	2810	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 52	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 101	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 118	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	0.024	-	-	-
PCB 153	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 138	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 180	U	2810	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Total PCBs (7 Congeners)	N	2815	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-

"-" indicates that test result was below the Limit of Detection (LOD)

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113
Client Sample ID.:	ES1	ES2	ES3	ES1	ES2	ES1	ES2	ES1	ES2	ES3	ES1	ES1	ES2	ES3	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.0	2.0	4.0	0.8	1.5	0.8	1.5	0.5	2.0	2.5	0.5	1.0	1.7	2.7	0.5	1.0
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand																
Moisture	17	19	15	8.8	12	19	26	5.9	24	30	18	29	23	19	15	28
pH	9.3	9.3	9	11.4	9.1	8.6	8.2	9	8.3	8.3	8.1	7.8	8.4	8.4	8	7.8
Arsenic	14	18	9.7	13	9.4	12	6.2	15	9	8.1	16	20	27	15	14	25
Barium	66	85	38	75	35	100	85	73	75	91	190	300	310	210	190	460
Cadmium	0.1	-	-	0.13	-	0.21	0.18	0.19	0.13	0.22	0.53	0.62	0.59	0.33	0.62	0.89
Chromium	9.6	13	13	14	8.6	21	17	25	17	18	22	34	30	21	23	32
Copper	38	85	26	28	23	43	17	51	16	14	66	79	36	41	57	16
Mercury	0.39	0.65	0.31	0.2	0.24	0.27	-	0.23	-	-	0.29	0.24	0.12	0.13	0.4	0.18
Molybdenum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7
Nickel	14	19	15	25	14	30	24	37	26	24	36	34	59	42	33	43
Lead	82	180	39	45	71	51	27	37	20	22	120	110	92	40	150	64
Antimony	-	11	2.2	-	-	-	-	-	-	-	2.2	2.6	-	-	2.2	-
Selenium	-	-	-	-	-	-	-	-	-	-	-	0.31	-	-	-	0.77
Zinc	43	58	25	36	23	62	46	100	46	43	220	180	97	60	170	52
Chromium (Hexavalent)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LOI	2.8	2.6	2.3	1.3	3.6	3.2	8.9	1.7	3.6	3.8	7.6	8	3.3	2.2	9.5	9.4
Total Organic Carbon	1.5	1.1	1.1	0.91	1.6	1.1	1.4	1.4	2	1.6	11	5.1	0.65	0.3	5	1.1
Mineral Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C5-C6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C21-C35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C35-C44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C5-C7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C21-C35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C35-C44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aromatic Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Petroleum Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m & p-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-	-	0.34	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-	-	-	0.62	-	-	-	0.23	1.23
Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-	-	-	0.58	-	-	-	0.46	0.46
Pyrene	-	-	-	-	-	-	-	-	-	-	0.46	-	-	-	0.48	0.48
Benzo[a]anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	0.11
Chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	0.13
Benzo[b]fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	0.18

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113
Client Sample ID.:	ES1	ES2	ES3	ES1	ES2	ES1	ES2	ES1	ES2	ES3	ES1	ES1	ES2	ES3	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.0	2.0	4.0	0.8	1.5	0.8	1.5	0.5	2.0	2.5	0.5	1.0	1.7	2.7	0.5	1.0
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[a]pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coronene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Of 17 PAH's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 118	0.024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 138	0.048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 180	-	-	-	-	-	-	-	-	-	0.21	-	-	-	-	-	-
Total PCBs (7 Congeners)	-	-	-	-	-	-	-	-	-	0.21	-	-	-	-	-	-

"-" indicates that test result was below t

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	BH113	TP116	TP116	TP117	TP117
Client Sample ID.:	ES3	ES1	ES2	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.5	0.5	1.2	0.5	1.2
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand					
Moisture	27	18	20	17	27
pH	8.1	7.9	8.1	8.6	7.7
Arsenic	21	19	8	18	9.5
Barium	410	240	210	190	270
Cadmium	0.54	0.75	0.14	0.6	0.18
Chromium	27	24	22	19	27
Copper	16	93	21	71	16
Mercury	0.18	0.37	-	0.27	0.14
Molybdenum	2.5	2.1	-	-	-
Nickel	37	43	31	34	27
Lead	63	220	46	120	58
Antimony	-	5	-	2.7	-
Selenium	0.24	-	-	-	0.37
Zinc	56	300	74	270	80
Chromium (Hexavalent)	-	-	-	-	-
LOI	5.6	6.2	3.4	6.9	5.6
Total Organic Carbon	0.97	4	1	5	0.77
Mineral Oil	-	210	-	-	-
Aliphatic TPH >C5-C6	-	-	-	-	-
Aliphatic TPH >C6-C8	-	-	-	-	-
Aliphatic TPH >C8-C10	-	1.8	-	-	-
Aliphatic TPH >C10-C12	-	5.2	-	-	-
Aliphatic TPH >C12-C16	-	5	-	-	-
Aliphatic TPH >C16-C21	-	40	-	-	-
Aliphatic TPH >C21-C35	-	160	-	-	-
Aliphatic TPH >C35-C44	-	-	-	-	-
Total Aliphatic Hydrocarbons	-	210	-	-	-
Aromatic TPH >C5-C7	-	-	-	-	-
Aromatic TPH >C7-C8	-	-	-	-	-
Aromatic TPH >C8-C10	-	4	-	-	-
Aromatic TPH >C10-C12	-	-	-	-	-
Aromatic TPH >C12-C16	-	8.9	-	-	-
Aromatic TPH >C16-C21	-	4.2	-	2.9	-
Aromatic TPH >C21-C35	-	120	-	-	-
Aromatic TPH >C35-C44	-	-	-	-	-
Total Aromatic Hydrocarbons	-	130	-	-	-
Total Petroleum Hydrocarbons	-	340	-	-	-
Benzene	-	-	-	-	-
Toluene	-	-	-	-	-
Ethylbenzene	-	-	-	-	-
m & p-Xylene	-	-	-	-	-
o-Xylene	-	-	-	-	-
Naphthalene	-	0.47	-	-	-
Acenaphthylene	-	-	-	-	-
Acenaphthene	-	-	-	-	-
Fluorene	-	-	-	-	-
Phenanthrene	2.23	0.52	-	0.23	-
Anthracene	< 0.3	0.11	-	-	-
Fluoranthene	0.46	1.1	-	0.36	-
Pyrene	0.48	0.81	-	0.35	-
Benzo[a]anthracene	0.11	0.26	-	-	-
Chrysene	0.13	0.31	-	-	-
Benzo[b]fluoranthene	0.18	0.47	-	-	-

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	BH113	TP116	TP116	TP117	TP117
Client Sample ID.:	ES3	ES1	ES2	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.5	0.5	1.2	0.5	1.2
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	-	0.11	-	-	-
Benzo[a]pyrene	-	0.36	-	-	-
Indeno(1,2,3-c,d)Pyrene	-	-	-	-	-
Dibenz(a,h)Anthracene	-	-	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-
Coronene	-	-	-	-	-
Total Of 17 PAH's	-	4.5	-	-	-
PCB 28	-	-	-	-	-
PCB 52	-	-	-	-	-
PCB 101	-	-	-	-	-
PCB 118	-	-	-	-	-
PCB 153	-	-	-	-	-
PCB 138	-	-	-	-	-
PCB 180	-	-	-	-	-
Total PCBs (7 Congeners)	-	-	-	-	-

"-" indicates that test result was below t

King's Island Site Investigation
Soil WAC Results

Eluates CEN 10:1	Inert Landfill Limits	Non-hazardous Limits	Hazardous Landfill Limits	BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102
Depth (mbgl)	-	-	-	0.50	2.00	3.00	0.60	1.00	2.00	0.50	1.50	3.50	1.50	2.00	2.50	1.00	2.00	4.00	0.80	1.50	0.80
Arsenic	0.5	2	25	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.066	<0.050	0.082	0.066	0.091	<0.050	<0.050	<0.050
Barium	20	100	300	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.400	<0.5	<0.5
Cadmium	0.04	1	5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium	0.5	10	70	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.085	<0.050	<0.050	0.200	<0.050	<0.050
Copper	2	50	100	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.084	<0.050	0.066	0.180	<0.050	<0.050
Mercury	0.01	0.2	2	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.019	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	0.5	10	30	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.082	0.110	0.140	<0.050	<0.050	<0.050	0.510	0.083	0.150
Nickel	0.4	10	40	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead	0.5	10	50	<0.010	<0.010	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.021	<0.010	0.011	0.015	<0.010	<0.010
Antimony	0.06	0.7	50.1	0.013	0.015	0.026	<0.010	<0.010	0.011	<0.010	<0.010	<0.010	<0.010	0.034	0.021	0.027	0.032	0.038	<0.010	0.028	0.072
Selenium	0.1	0.5	7	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.018	<0.010	<0.010
Zinc	4	50	200	<0.50	<0.50	<0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloride	800	15000	25000	27	14	29	24	19	17	18	14	12	19	15	11	14	16	18	31	19	21
Fluoride	10	150	500	2.7	1.9	2.1	2.6	2.6	2.1	1.6	1.5	1.5	2.3	1.6	1.6	1.7	1.9	1.8	3.2	1.5	1.6
Sulphate	1000	20000	50000	79	110	100	61	63	97	69	70	55	120	240	190	240	300	200	86	170	440
Total Dissolved Solids	4000	60000	100000	740	870	840	910	810	870	700	690	740	710	490	950	880	1000	790	12000	880	910
Dissolved Organic Carbon	500	800	1000	150	< 50	< 50	< 50	50	54	59	< 50	< 50	< 50	< 50	< 50	72	55	50	93	< 50	< 50

King's Island Site Investigation
Soil WAC Results

Eluates CEN 10:1	Inert Landfill Limits	Non-hazardous Limits	Hazardous Landfill Limits	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113	BH113	TP116	TP116	TP117	TP117
Depth (mbgl)	-	-	-	1.50	0.50	2.00	2.50	0.50	1.00	1.70	2.70	0.50	1.00	1.50	0.50	1.20	0.50	1.20
Arsenic	0.5	2	25	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Barium	20	100	300	0.600	<0.5	0.750	0.740	0.630	0.800	<0.5	0.940	0.630	<0.5	<0.5	0.730	0.640	<0.5	0.610
Cadmium	0.04	1	5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium	0.5	10	70	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper	2	50	100	<0.050	0.055	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Mercury	0.01	0.2	2	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	0.5	10	30	0.056	0.058	<0.050	0.061	0.220	0.290	<0.050	<0.050	0.160	<0.050	<0.050	2.200	<0.050	0.083	0.054
Nickel	0.4	10	40	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead	0.5	10	50	<0.010	<0.010	<0.010	<0.010	<0.010	0.025	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Antimony	0.06	0.7	50.1	0.080	0.015	0.043	0.062	0.120	0.180	0.042	0.073	0.150	<0.010	<0.010	0.110	0.017	<0.010	0.057
Selenium	0.1	0.5	7	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc	4	50	200	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloride	800	15000	25000	17	38	24	25	46	74	35	65	28	31	20	34	33	25	21
Fluoride	10	150	500	1.4	2.4	1.7	1.4	2.1	1.7	3.8	3.4	1.9	5.4	6.3	2.1	4.9	1.9	2.4
Sulphate	1000	20000	50000	460	330	380	380	1700	1100	180	320	910	130	160	1500	130	490	440
Total Dissolved Solids	4000	60000	100000	1300	1000	1200	1800	2600	420	610	600	2500	580	560	3400	550	2000	800
Dissolved Organic Carbon	500	800	1000	50	55	59	78	92	130	68	< 50	97	55	< 50	83	< 50	68	110

F LVIA Receptor Tables

F1 Visual Receptor Tables

Appendix F1 Landscape Character and Visual Amenity Impacts

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Impact on Landscape Character Areas						
Area A1	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
Area A2	Temporary to Short Term, Slight, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey, lighting along upgraded footpath will be controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Positive
Area A3	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative
Area A4	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment where possible (north and south); seeding embankment with meadow grass to ensure natural appearance, lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties, connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative
Area A5	Temporary to Short Term, Moderate, Negative	Scheduling the works during summer (out of football season); pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment opposite Assumpta Park and Abbey View; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Area A6	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	New concrete wall 2.7m in height along the length of the Athlunkard Boat Club, Stone finish to dry side with random rubble with rough rack coping.	Permanent, Imperceptible, Positive
Area A7	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish to existing flood wall raised in height in a random rubble finish, laid to courses with a flat stone coping to match the existing wall along this extent. Footpath raised to maintain river edge views	Permanent, Imperceptible, Positive
Area A8	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	None necessary	Permanent, Imperceptible, Positive
Area A9	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; use of jack-up rig to avoid construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish with rough-hewn stone in sneck pattern with double chamfered rectangular stone coping. Impact remain as wall will be 1.4m in height and visibility of river edge will be lost to a minority of walkers (based on average eye level of 1.5m in height)	Permanent, Imperceptible, Negative
Area A10	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Negative
Area B1	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound. Trees to be stabilised and protected	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Area B2	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound. Trees to be stabilised and protected	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Inclusion of glass panelling to maintain connectivity with river corridor; quay wall cleaned, repaired, grouted and pointed	Permanent, Slight, Negative
Area B3	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Glass panelling to maintain connectivity with river corridor; quay wall cleaned, repaired, grouted and pointed	Permanent, Slight, Negative
Impact on Visually Sensitive Receivers						
R1	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
R2	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Positive
R3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R4	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative
R5	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties.	Permanent, Slight, Negative
R6	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Negative
R7	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Negative
R8	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R9	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties and replacement wall at Athlunkard Boat club with new stone facing and coping detail.	Permanent, Imperceptible, Negative
R10	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Replacement wall at Athlunkard Boat club with new stone facing coping detail	Permanent, Imperceptible, Negative
R11	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raised wall will be faced with stone to match existing stone pattern and new flat coping all along the stretch of wall to create a continuous stone wall design	Permanent, Slight, Negative
R12	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raised wall will be faced with stone to match existing stone pattern and new flat coping all along the stretch of wall to create a continuous stone wall design. New raised stepped footpath to allow views over wall towards river.	Permanent, Slight, Positive
R13	Short term, Imperceptible, Negative	None necessary	Short term, Imperceptible,	Permanent, Slight, Negative	Cleaning of wall surface, removal of railings will allow more transparency of heritage landscape	Permanent, Imperceptible, Positive
R14	Short term, Imperceptible, Negative	None necessary	Short term, Imperceptible,	Permanent, Slight, Negative	Painting of light coloured wall coping to a grey less visible tone to reduce visual intrusion in the heritage landscape	Permanent, Imperceptible, Positive
R15	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R16	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
R17	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
C1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Wall to be faced with roughhewn stone in a sneck pattern and double chamfered rectangular stone coping. Impact remain as short section of wall will be 1.4m in height, visibility of river may be lost to some walkers	Permanent, Slight, Negative
C2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Imperceptible, Negative I	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Positive
C3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
C5	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C6	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C7	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C8	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C9	Temporary to Short Term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey, lighting along upgraded footpath will be controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Positive
C10	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
C11	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
T1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials along the river edge	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
T2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials along the river edge	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible Positive
T3	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
T4	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river	Permanent, Imperceptible Positive
T5	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey	Permanent, Imperceptible Positive
OS1	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting from properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
OS2	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive
OS3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties.	Permanent, Slight, Negative
OS4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Moderate Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Slight, Negative
OS5	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive
OS6	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
V1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the coping a lighter shade of grey	Permanent, Imperceptible Positive
V2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Imperceptible Negative	Replacement wall at Athlunkard Boat club with new stone facing coping detail	Permanent, Imperceptible Positive
V3	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Wall to be faced with rough-hewn stone in a sneck pattern and double chamfered rectangular stone coping.	Permanent, Imperceptible Positive
V4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river	Permanent, Imperceptible Positive

G Cultural Heritage

G1 Gazetteer of Archaeological Monuments/Sites

G2 Proposed Archaeological Testing Regime

Appendix G1 - Gazetteer of Archaeological Monuments/Sites close to the KIFRS Works Area

The following gazetteer lists 16 archaeological monuments or sites that are within or close to the KIFRS words area, as indicated by the available designs. Each entry includes the site (SMR) code, class, grid coordinates (ITM), distance and direction from the nearest Area of the works and description of the site where available on the Historic Environment Viewer (HEV) (www.archaeology.ie).

RMP code: LI005-017---- Class: Historic town

Grid coordinates: E 557809, N 657730 (multiple locations)

Location: The historic town area includes the southern part of the works area in Areas A1, A7, A8, A9, A10, B1, B2 and B3.

Description:

The historic city of Limerick was described in the Urban Survey (Bradley et. al. 1989, 241-67) as following; 'The city of Limerick is situated on the river Shannon in the north-east corner of County Limerick. The placename is derived from Luimneach "bare or barren land", a name which originally appears to have been applied to part of the Shannon estuary rather than just the immediate site of the city itself. The handful of prehistoric finds from the city indicates only that the site of the future settlement was occasionally frequented by man in early times. The fact that there are not more is surprising because the presence of the Curragour Falls must have given Limerick a topographical significance even in prehistoric times. There are many artefacts in the collections of the National Museum and elsewhere which were found in the river Shannon "near Limerick" but only two stone axeheads and two bronze dirks can be pinned down to the actual vicinity of the old would seem to have been an into early historic times.

The Hiberno-Scandinavian Town

The first evidence for the presence of Scandinavians occurs in 845 (AFM: 843) when Viking fleets appeared on the Shannon estuary and launched raids into county Limerick. It is unlikely that they settled, however, but there are a few scattered references which may indicate that a base existed at or near Limerick for a short time in the later ninth century. An eleventh century saga states that the Vikings Hona and Tomrir Torra were at Limerick with an army in 860 (Radner 1978, 109); a Viking fleet is known to have raided along the Shannon from Limerick in 866; and the Chronicon Scottorum states that the "foreigners of Limerick" were slaughtered by the Connachtmen in 887. It is hard to know if these three references add up to a permanent settlement at late ninth century Limerick or not but they certainly show that there was Scandinavian activity in the area at this time.

The present city was founded in 922 by the Norse king Tamar mac Ailche (?Thormodr Helgason), "king of an immense fleet" who landed on Inis Sibtond (King's Island) and established a lonqphort there. The site afforded considerable natural advantages. Being an island it was easy to defend, there was immediate access to the open sea along the Shannon estuary and thereby to the lucrative Atlantic trade routes of Europe. The shallows at Curragour Falls formed a natural barrier restricting the flow of river traffic and the situation also afforded an entry into the rich heart of central Ireland along the Shannon basin. Tamar, indeed, lost no time in making his presence felt. His fleet proceeded to devastate the monasteries which could be reached from the Shannon: Terryglass, Lorrha, Clonfert and Clonmacnoise among others (Smyth 1979, 21). At Inis Cealtra, on Lough Derg, the raid was so fierce that two centuries later it was remembered that "they drowned its shrines, relics and its books" (Todd 1867, 38-9). They proceeded into Lough Ree and from there started to raid into Meath and Connacht, all the while presumably sending back the loot of plunder and slaves to the newly founded settlement at Limerick for auction and sale.

The history of Scandinavian Limerick can in fact be divided into four phases: (1) the period of foundation, 922-37; (2) the period of Dublin domination, 937-67; (3) period of Ua Briain domination 967-c.1065; and (4) the period as Ua Briain capital c.1065-c.1195. These periods

can only be briefly glanced at here. The period of foundation, 922-37, witnessed Limerick emerge as an independent Scandinavian settlement struggling to maintain its independence from the kings of Dublin. The events of these years, which witnessed raids by the Limerick Vikings all over central, western and northern Ireland are particularly well recorded in the annals. In 923 they captured Flaithbertach mac Inmainen, the retired king of Munster, from his island retreat at Loch Cré and brought him back to Limerick for ransom. In 924 they again placed a fleet on Lough Ree, this time under the command of Colla mac Bairid (Kolli Baardarson), described in the annals as king of Limerick (AFM: 922; CS: 923). In 924 the Dublin Vikings, worried that the growing number of Limerick raids in central Ireland would diminish their power, sent an army to subdue their Limerick kinsmen but they were defeated and had to retreat back to Dublin (AU). This victory seems to have encouraged the ambitions of Limerick's leaders.

In 928 Tamar mac Ailche put his fleet on Lough Neagh and burnt the islands of that lake (AU: 927). In 929 Limerick vessels are recorded on Lough Corrib and they remained there until the following year (AU: 928; AFM: 927; CS: 930). In 930 a Limerick army encamped in central Ossory, establishing their base at Loch Beathrach, an unidentified lake which appears to have been either on the Nore or its tributary the King's River (Smyth 1979, 25) and was only driven out by the appearance of Gothfrith, king of Dublin, with a rival army in the following year (AFM sa 929; AU sa 929). The year 931 saw a Limerick fleet on Lough Ree (AU: 931; AFM: 929; CS: 930) and the activities of the Limerick Vikings in Connacht and central Ireland between 931 and 937 has led to the suggestion that they must have established a base in Lough Ree (Smyth 1979, 250-1). Indeed Smyth (ibid) has speculated that the famous Hare Island (Co. Westmeath) hoard, the largest known gold find from Viking-age Europe, formed part of the treasure of the Limerick armies.

In 933 a new leader, Olafr Cenncairech ("scabby-head") lead them into Roscommon (AFM:932) and returned there again the following year (CS: 933). In 936 he transported his ships overland from the Shannon to the Erne and raided down into the present-day county of Cavan (AFM: 934; CS: 935; A. Clon., 149). He returned back to Lough Ree on Christmas night of 936 and he remained there for seven months plundering and looting the plains of Connacht (AFM: 934). In August 937 the long-awaited confrontation between the Dublin and Limerick Vikings occurred. Olafr Gothfrithson, king of Dublin, led his army to Lough Ree where he defeated the Limerick vikings, broke up their ships and carried Olafr Cenncairech back to Dublin as his prisoner (AFM: 935; CS: 935; A. Clon. 931).

That the defeat of Olafr Cenncairech marks a stage in Limerick's history is clear from the absence of references to it the succeeding years. Indeed, from what little evidence there is, it appears that the king of Dublin now imposed a member of his own family, Haraldr Sigtryggson (d. 940), king of Limerick (Smyth 1979, 35). The settlers now seem to have become more closely integrated into the local political scene. In 953 Limerick vikings assisted the king of Munster, Cellacháin Caisil, in plundering Clonmacnoise (AFM 951; AU 952). This integration was to reach a head in 967 (AU 966) with the capture of the town by Mathgamain mac Cennetig, who had seized the kingship of Cashel in 963. The Coqadh Gaedhel re Gallaibh, written some two hundred years later states that "the fort and good town (deabali) was burned and reduced ashes" (Todd 1867, 80-1). The booty obtained at the time had all the appearance of oriental origin as Smyth (1977, 165-6) has remarked: "they carried off their jewels and their best property, and their saddles beautiful and foreign; their gold and silver, their beautiful woven cloth of all colours and kinds; their satins and silken cloth, pleasing and variegated, both scarlet and green" (Todd 1867, 78-9). The captives "soft, youthful, bright, matchless girls ..blooming, silk-clad young women, large, active and well-formed boys" were rounded up on the hills of Saingel and "every one that was fit for war was killed and every one of them that was fit for a slave was enslaved" (ibid.,78-81).

The capture of Limerick in 967 marks the beginning of a period of Ua Briain domination that was to last until the coming of the Anglo-Normans. Within this period, however, there is a noticeable break which occurs during the reign of Toirrdelbach ua Briain, king of Munster (1063-86) when makes Limerick his capital (Ó Corráin 1972, 142). This development is all the more noticeable during the reign of his successor Muirchertach Ua Briain (1086-1116) who also spent part of his career as governor of another city, Dublin (Candon 1988). Muirchertach developed extensive overseas contacts and Limerick would appear to have been a busy centre during his

reign. It was at this time also that the town obtained its first bishop and established itself as an episcopal see.

Gilbert, Limerick's first bishop, was consecrated in 1107 and, as papal legate, he presided over the Synod of Rathbresaill in 1111 at which St Mary's was recognised as the diocesan cathedral of Limerick, much to the distress of Mungret nearby. Gilbert's successor, Patrick, was consecrated at Canterbury a fact which also emphasises Limerick's connections with Britain (Gwynn and Hadcock 1970, 90).

The full extent of Limerick's connections with Britain and the Continent in the pre-Norman period can only be guessed at in the absence of archaeological excavation. It is mentioned (once) in the Icelandic sagas (in Landnamabók) Hlymrek and it is to be assumed that it traded with Scandinavia itself. It has been suggested that the Viking finds in west Kerry, such as the runestone and steatite bowl from Beginish Is. and the placename Smerwick, that there was a staging post in this area of Kerry on the route between Limerick and the continent. The exotic description in the Coqadh Gaedhel for the sack of 967 certainly indicates that rich commodities were being imported into the town. The Caithréim Cellacháin Caisil, another twelfth century pseudo-history, mentions that Morann, son of the king of Lewis, fought with the Limerick vikings (Bugge 1905, 65) suggesting contacts with the Hebrides and Western Isles. The Caithréim Cellacháin Caisil also sheds a little light on the appearance of the Hiberno-Scandinavian town and describes it as a fortified stronghold having gates (doirrsi), houses (tighibh) and towers (toraibh) (Bugge, 1905, pp. 9, 66). The Cogadh Gaedhel speaks in similar terms when describing the sack of 967 but it adds the additional piece of information that there were streets and a fort, presumably the royal stronghold (Todd 1867, 79). Neither description sheds light on the appearance of the tenth century settlement, of course, but they do support a picture of Limerick in the twelfth century as a fortified town which had gates and towers on its walls, with streets inside the defences along which houses were probably regularly arranged in the manner which has been evidenced by excavations at Dublin, Wexford and Waterford; in addition there was St Mary's Cathedral and a royal fortress which was probably separated from the town and set within its own defences. From the account of Domhnall Mor Ua Briain's take-over of Limerick in 1176 it is also clear that there was a bridge, probably on the site of Baal's Bridge (Scott and Martin 1978, 167).

Reconciling this picture of the settlement, however, with the remains on the ground poses many problems. The documentary sources are simply not exact enough to provide the sort of detailed information about the size of the town, the course of its defences, the alignment of its streets, and the location of its houses that the archaeologist requires. Some help can be obtained from grants and inquisitions which were made in the years immediately following the Anglo-Norman occupation of the town (c.i195) and which survive, for the most part, in the Black Book of Limerick (MacCaffrey 1907). These make it clear that apart from St Mary's, there were a number of other churches already within the town: St. Munchin's, St. Nicholas', and probably the Augustinian nunnery of St. Peter ("St. Peter's Cell") on King's Island, St. John's in what was later to become Irishtown, and St. Michael's in the estuarine mud just outside Irishtown, St.

Laurence's on the west bank, and the unlocated churches of St. (?St Mark's) and St Brigid. From the distribution of these churches it is clear that settlement concentrated on King's Island but the description of St. John's Church as "within the city of Limerick" as early as 1204-6 suggests that settlement may have also spread to Irishtown in Hiberno-Scandinavian times. From this one may conclude that the axis formed by Nicholas Street and Mary Street was the principal thoroughfare of the pre-Norman town. The outline of the defences is more difficult to determine but the line formed by Dominic St - Bishop St Sheep St seems a likely boundary on the east. Giraldus Cambrensis tells us that the walls were bounded by the river (ab Urbis muralibus que ripe imminebant) Rut whether this coincided with the known line of the walls along the Shannon in the later middle ages or not is unclear (Scott and Martin 1978, 150). It is quite possible, on analogy with the evidence excavated at Waterford, that the defences of the Hiberno-Scandinavian town lay inside the line of the walls of the Anglo-Norman town. The pre-Norman walls, however, do not appear to have risen directly from the water all round the town. From Giraldus" account of its capture it would seem that there was dry ground outside the walls from which the inhabitants threw missiles at the Anglo-Normans endeavouring to cross the river (Scott and Martin 1978, 53). The other contemporary Anglo-Norman source, the Song of Dermot and the Earl adds that there was a fosse, which again implies the presence of some

dry ground: This city was surrounded by a river, a wall, and a dyke, so that no man could pass over without a ship or a bridge, neither in winter nor in summer, except by a difficult ford (Orpen 1892, ii. 3418-23). The exact extent of the area around Limerick which was settled by people of Scandinavian descent is also difficult to guage. The reference to the "cantred of the Ostmen" at Limerick (Sweetman 1875-86, i, no. 146) provides a starting point, however, and this has been identified as the eastern part of the rural deanery of Limerick, comprising land both on the north and south sides of the Shannon. There are also some indications that settlement may have extended over the remainder of the rural deanery and into the cantred of Tradree in Clare (Bradley 1988, 62-4).

The Anglo-Norman Town

Immediately after the submission of Domhnall Ua Briain in 1171 Henry II sent a constable to Limerick (Scott and Martin 1978, 95). The reception which greeted this constable is not recorded not is the duration of his stay. It is evident from the capture of the town in 1175-6 by a host consisting of Anglo-Normans and an army under Ruaidhri Ua Conchobair and that it had not remained loyal to the crown. After this capture an Anglo-Norman garrison was placed in the town and its custody was given to Milo FitzDavid (Orpen 1911-20, i, 349). In 1176 the town was besieged by Domhnall Mór Ua Briain but it was relieved by Raymond le Gros only to be evacuated by him when news came through that Strongbow had died. Domhnall Ua Briain then burnt the town. Giraldus Cambrensis describes the scene: "Just as they [the Anglo-Normans] were leaving, and indeed had scarcely crossed over the far end of the bridge, they suddenly saw that it had been broken down at the other end and this city, so strongly fortified, well furnished with fine buildings, and full to overflowing with provisions gathered in from every quarter, had been set on fire in four different places. It was a sight that grieved them sorely" (Scott and Martin 1978, 167).

In 1177 Henry II granted the kingdom of Limerick, with the exception of the city and the cantred of the Ostmen to Philip de Braose (Orpen 1911-20, ii, 33) but it was not until the closing years of the twelfth century that the Anglo-Normans began to settle the county (Empey 1981). The city of Limerick appears to have been occupied peacefully, by agreement with the Ostmen and Ua Briain (Orpen 1911-20, ii, 156, 158; Scott and Martin 1978, 334: n. 313). In 1196 the Anglo-Norman garrison was expelled by Diarmait Mac Carthaig, king of Desmond, but they were back the following year and thereafter Limerick was to remain in Anglo-Norman hands (Orpen 1911-20, ii, 157). Limerick's earliest charter, in which Prince John granted the inhabitants the same rights as the citizens of Dublin held, was made in 1197 (MacNiocaill 1964 and in the same year burgages within the town were granted to some of the Anglo-Norman colonists (Orpen 1911-20, ii, 157) and about the same time a mint was established (Dolley 1972).

As early as 1200-1 there is evidence that the town was beginning to expand outside its Hiberno-Scandinavian confines. Abstracts of a number of grants by King John survive in which he gave burgages to Anglo-Norman settlers "below the walls" and in the island towards the city, near the bridge" (Lenihan 1866, 48, n. i). From this it would appear that the area which was to develop into Irishtown was being settled although, as we have already seen, the churches of St. Michael and St. John seem to have been in existence before the coming of the Normans. Work commenced on Limerick castle during the first decade of the thirteenth century and part of it seems to have been built on property belonging to the bishop of Limerick (MacCaffrey 1907). The thirteenth century was a period of considerable prosperity which saw not only the expansion of the town but also the construction of new friaries belonging to the Franciscans and Dominicans, as well as considerable work on the town walls.

During the fourteenth and fifteenth centuries the city became increasingly isolated as a result of the Gaelic revival and it was actually stormed and plundered by Mac Con Mara in 1370. The royal records of this time are filled with petitions seeking relaxation of rents and grants in aid of maintaining the city (Tresham 1828, 27: no. 41; 95: no. 176; 100: no. 20). Its loyalty to the crown was never in doubt, however, and it received a series of royal privileges in 1414, 1423, 1433, 1464 and 1489 (Lenihan 1866, 65-8). The town remained an important port although during this period its overseas trade was overshadowed by that of Galway and there were also problems of piracy on the Shannon estuary to contend with (Lenihan 1866, 70).

With the revival of the English government's interest in Ireland during the second half of the sixteenth century the town became one of the principal administrative and provision centres of the Munster plantation. During the Confederate wars of the mid-seventeenth century it initially remained loyal to parliament but after the capture of the castle in 1642 it became one of the Confederate strongholds. The town was besieged by the Cromwellians in 1651 and eventually surrendered to their commander, Ireton. The town's most famous role in military history occurred in 1690-i when it was besieged by the Williamites and held out for almost a year. The story of these events has often been told and they are well covered in the pages of many histories, particularly that of Lenihan (1866, 148-287).

Compiled by: Caimin O'Brien

Date of upload: 14 November 2019

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RMP code: LI005-017001- Class: Bridge

Grid coordinates: E 558054, N 657423

Location: Directly beside Areas B2 and B3.

Description: 19th century Balls (Baals) Bridge (NIAH Reg. No. 21513031) traversing the Abbey River was built on the site of the four arched medieval Baal's Bridge. The medieval bridge was described in the Urban Survey of Limerick (Bradley et. al. 1989, 256) as following; 'The reference to the destruction of a bridge by Domhnall Mor Ua Briain in 1176 indicates that there has been a bridge at Limerick since Viking times. The location of this bridge, however, is not absolutely certain. From the context in which the reference occurs it is most unlikely that it is a bridge which straddles the Shannon but rather a bridge linking King's Island with Irish Town or the mainland probably on the site of the present Baal's Bridge (Scott and Martin 1978, 167). Ball's bridge may retain a medieval core although rebuilt in 1830 (Leask 1941,102). Both Baal's Bridge and Thomond Bridge (LI005-017002-) are shown many times on sixteenth and seventeenth century maps and there can be little doubt but that both are ancient crossing points'.

In 1998 three cuttings were excavated under licence No. 98E0581 on George's Quay and one at Broad Street before construction activity associated with the Limerick Main Drainage Scheme. In addition, a programme of excavation (50 trenches) was initiated in the Abbey River before the first phase of pipe-laying in the riverbed. Phase II of the construction work will see river gravels being investigated for archaeological structures and artefacts at the mouth of the Abbey River at its confluence with the River Shannon and another short programme of land-based excavation in the Potato Market. The summary of these excavations were described by Edmond O'Donovan for Margaret Gowen & Co. Ltd as following; 'Broad Street

Excavations at Broad Street (Cutting 3) uncovered two medieval bridge piers under the junction of Broad Street and Charlotte Quay. These structures formed part of the medieval bridge (on the site of Baal's Bridge) that formed the vital link between the Irishtown and the Englishtown on King's Island. When the Anglo-Normans launched their assault on Limerick in 1175 there was no bridge in the location later occupied by Baal's Bridge. Giraldus Cambrensis records that the attackers found a ford across the Abbey River and he 'hurled himself headlong into the swiftly flowing river...' and managed to cross to the opposite bank. It would appear that the bridge linking King's Island to the mainland to the south, on the site of what is now called Baal's Bridge, was non-existent when the Anglo-Normans arrived in Limerick in 1175.

The excavations at Broad Street indicated a long archaeological sequence commencing in the mid-13th century up to the present day. The cutting measured 35m east-west by between 5m and excavated to a depth of 5m below the street level. Three samples from oak timbers that revetted one of the bridge piers were submitted for dendrochronological dating (David Brown, The Queen's University of Belfast). The results suggested that the bridge piers were constructed in the early 13th century.

Organic deposits were identified abutting the bridge piers. Environmental analysis of macrofossil plant and insect remains (by Eileen Reilly and Penny Johnston of Margaret Gowen & Co.) has demonstrated that the deposits around the bridge piers accumulated slowly as a result of the dumping of organic refuse and the accumulation of river silts. The organic deposits originated from natural silting and contemporary settlement in the medieval city during the 13th and 14th centuries. The excavation revealed evidence for the growth and development of Broad Street, with evidence of house floors dating from the 14th/early 15th century built on top of ground reclaimed from the riverbed. This expansion of the Irishtown towards the Abbey River

is likely to have been associated with renewed town wall building extending into the Abbey River. The uppermost archaeological deposits in the cutting consisted of post-medieval cobbling, drains and culverts. The medieval bridge was demolished in 1830 before the construction of the current Baal's Bridge.

Baal's Bridge

Extensive excavations of the riverbed from Matthew Bridge to Baal's Bridge have been completed. These involved opening a large cutting under Baal's Bridge and fifty smaller trenches upstream and downstream of the ford on which the bridge is sited. The river gravels (c. 1m deep) in these locations are rich in archaeological artefacts. While no in situ structures have been uncovered, a large, important and eclectic collection of archaeological objects was found. The trenches were excavated in situ in the riverbed, and the artefacts were recovered layer by layer.

A preliminary summary of the artefacts found includes objects dating from the prehistoric period (worked flint) to the post-medieval period. To date, no Bronze Age objects have been recovered. Several pre-Viking Age artefacts have been recovered, including a possible Iron Age horse bit, an Early Christian bronze zoomorphic object and a spiral-headed pin. A number of Viking Age stick-pins and a coin (c. 1035), minted in London for King Cnut, were also found. Medieval and post-medieval artefacts include beads, coins, horse equipment, pins, brooches, tools and weapons. A small assemblage of locally manufactured and imported medieval pottery has been recovered from the riverbed. Fifty medieval coins dating from 1200 to 1540 have been recovered; they are largely Irish, although Scottish, French and English coins are also included. An early post-medieval (c. 1600) seal bearing the 'Lymerick Port' coat of arms was also recovered from the riverbed. Objects dating from the Williamite siege of the city, including iron and stone cannon, musket balls of various sizes, gun flints, spurs, fragments of iron mortar bombs, grenades, iron bayonets and coins (Jacobite gun money), have been retrieved.' (www.excavations.ie).

The present 19th century bridge was described by the National Inventory of Architectural Heritage [NIAH] as a, 'Single-arched hump-back limestone bridge, built between 1830-31, linking Mary Street to the north in English Town with Broad Street to the south within Irish Town and spans the Abbey River. Plaque to bridge reads: 'This bridge was erected by virtue of an Act of the XIth of Geo.e the IV. The Rt. Honble. Thos. Spring Rice M.P. for the city of Limerick. Commenced taking down the old bridge Nov. 1830. The new bridge finished Nov. 1831. J.A. & G. R. Pain Architects.' Another plaque reads: 'The ancient bridge of four arches which occupied this site was taken down and this bridge erected at the expense of the new Limerick Navigation Company incorporated 1830 - Chas. Wye Williams Esqr. Chief Director. J.A. & G. R. Pain Architects.' (www.buildingsofireland.ie).

Compiled by: Caimin O'Brien

Date of upload: 14 November 2019

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RMP code: LI005-017002- Class: Bridge

Grid coordinates: E 557575, N 657846

Location: Directly beside Area A1.

Description: The present 19th century Thomond Bridge (NIAH Reg. No. 21508001) crossing the River Shannon overlooked by King John's Castle (LI005-017014-) was described by the National Inventory of Architectural Heritage as a, 'Seven-arch rock-faced limestone road bridge, built in 1836, spanning the River Shannon, with pointed curved breakwaters and short quadrant abutments. Inscription to commemorative plaque, on road side of parapet reads: 'This bridge was built A.D. 1840 at the Expense of the Corporation of the Borough of Limerick. This tablet was placed there by order of the town council A.D. 1843. The Right Worshipful Martin Honan Mayor John F. Raleigh Esq. Town Clerk Francis O'Neil Esq. Treasurer James and G.R. Pain Architects.' The building of a wider and more accessible Thomond Bridge, which was constructed between 1836-1838 to the design of James Pain and George Pain, gave better access to the agricultural districts of Clare. It replaced a series of previous bridges dating to the twelfth or thirteenth century, linking the west side of the River Shannon with King's Island. The previous medieval bridge was of fourteen arches. It is believed to incorporate pier foundations from the bridge which it replaced, as survey drawings dated to 1814, demonstrating the re-use of existing historic fabric by James Pain' (www.buildingsofireland.ie).

Thomond medieval bridge crossing the River Shannon was described in the Urban Survey of Limerick (Bradley et. al. 1989, 256) as following; 'The reference to the destruction of a bridge by Domhnall Mor Ua Briain in 1176 indicates that there has been a bridge at Limerick since Viking times. The location of this bridge, however, is not absolutely certain. From the context in which the reference occurs it is most unlikely that it is a bridge which straddles the Shannon but rather a bridge linking King's Island with Irish Town or the mainland probably on the site of the present Baal's Bridge [LI005-017001-] (Scott and Martin 1978, 167). The bridge across the Shannon appears to have been built in the reign of John [1199-1216]. In 1358 the citizens received a grant to assist them in extending this bridge and adding towers to it in order to repel the Irish (Tresham 1828, 74: no. 82). Both Baal's Bridge and Thomond Bridge are shown many times on sixteenth and seventeenth century maps and there can be little doubt hat both are ancient crossing points'.

Compiled by: Caimin O'Brien

Date of upload: 14 November 2019

References:

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RMP code: LI005-017010- Class: Town defences

Grid coordinates: E 557639, N 657897 (multiple locations)

Location: Beside or at works areas in Areas A1, B1, B2, B3

Description: There is currently no description available for this record on the HEV, however a detailed review of the City Wall is contained in the Limerick City Walls Conservation Management Plan (Collins et al. 2008).

RMP code: LI005-017014- Class: Castle - Anglo-Norman masonry castle

Grid coordinates: E 557689, N657804

Location: Directly beside Area B3

Description: National monument No. 288. The Anglo-Normans first established a presence in Limerick in 1171 when Donal O'Brien, King of Limerick and Thomond, paid homage to King Henry II at Cashel, and afterwards King Henry II sent 'Keepers' to Cork and Limerick (Furnivall 1896, 60). In 1175, Donal O'Brien, King of Limerick, rebelled against the King of England and Raymond le Gros assembled an army of 120 men-at-arms, 300 horse solider and 400 archers on foot and marched on the 1st of October to attack Limerick (Scott and Martin 1978, 149-53). In 1217, King Henry III granted Reginald de Breouse [Braose], 'custody of the castle and city of Limerick, to hold till the K.'s 14th year' (Cal. doc. Ire. No. 787, 118). In this year the King notified the 'knights, free tenants, and others on the lands of William de Breouse in Ireland, that Reginald de Breouse having come to his fealty, the K. restores to him all the lands which belonged to his father ere Meyler Fitz Henry, then justiciary of Ireland, divided them between Munster and Desmond' (Cal. doc. Ire. No. 786, 118). In 1223 King Henry III granted Richard de Burgh the seneschalship of Munster along with the castle of Limerick with the condition that he serve as the king's bailiff under the justiciary (Cal. doc. Ire. No. 1114, 170).

The royal castle of Limerick known as King John's (1199-1216) Castle was described in the Urban Survey (Bradley et. al. 1989, 288-99) as following: 'Work on this castle appears to have commenced in the first decade of the thirteenth century possibly on the site of the "fort" (LI005-017124-) referred to in the Cogadh Gaedhel re Gaillibh (Todd 1867, 81). There was a substantial building here by 1211-12 because the Irish pipe roll of John states that £733 16s. 11d. was needed for repairs to the castle (Davies and Quinn 1941, 69; Sweetman 1980, 1327). Substantial repair works were also carried out in 1327 (Tresham 1828, 35: no. 34) but by 1585 the castle was again in need of considerable repair (Sweetman 1980, 208). Further repairs were carried out in 1608, 1618 and 1624 (ibid.).

The castle is situated on the west perimeter of English Town overlooking the Shannon and Thomond Bridge. It is based on a rough quardangle, measuring 75m north-south by 65m east-west externally. It originally had round towers at each angle and a large twin-towered gatehouse in the centre of the north wall. The buildings have been considerably modified, most of the towers and curtain wall have been lowered and topped with modern parapets. The south-east angle tower is completely missing and was replaced in the early seventeenth century by a rectangular bastion which itself survives only in a fragmentary state. The east curtain wall is entirely missing, while the west curtain wall is not visible above ground internally although much of it is visible externally where ground level is lower. The masonry of all phases consists of coursed limestone rubble. Much of the original masonry displays alternating courses of large blocks and small pinnings while the doors and windows have jambs of red and yellow sandstone.

Gatehouse

The castle is entered through a gatehouse of twin D-shaped towers (overall width 21.5m externally) with, originally, a barrel-vaulted chamber 7.3m wide (externally) behind the entrance passage. The towers are of three floors. The west tower is 17.6m high externally of which the upper 2.1m is modern parapet. The east tower is 15.5m high of which the upper 1.2m is modern parapet. Both have basal batters, 1.5m and 2m high respectively.

On the ground floor is an entrance passage c.2.5m wide leading to a door with a pointed arch and dressed sandstone jambs, which is c.5m high internally but externally is approached by a modern stair rising from street level, 2-3m below. The door was protected by a portcullis and a murder hole, concealed behind a round arch some 12m high between the towers externally. Each of the flanking towers has a round chamber, whose interiors are plastered, making it difficult to distinguish between original and later masonry. The west chamber is entered from the castle yard through an unsplayed doorway with segmental rear arch on the south; three tall splayed loops with dressed sandstone jambs and segmental rear arches, which seem to be of brick, face west, north and east respectively. The east chamber is entered from the castle yard

through a tall pointed doorway whose chamfered sandstone jamb seems to be modern; the pointed rear arch is of brick. Two splayed loops, with sandstone jambs and segmental rear arches face west and north. All that remains of the chamber behind the entrance passage are the north returns of the east and west walls, c.6.5m high with the line of a barrel vault c.6m high in between the south wall of the gatehouse.

It would appear that the only approach to first floor level was from the wall-walk of the curtain wall to the west, unless it was, as it is now, by means of an internal wooden stair within the towers. The two tower chambers are circular, with modern floors supported on ledges in the walls. The west chamber is entered from the curtain wall through a modern round headed door on the west via a short passage with pointed vault in which there are traces of plank centering. This passage overhung the curtain wall to the north. Two splayed loops, with sandstone jambs and pointed rear arches with plank centering face north-west and north-east. On the south east is another modern round-headed door and a passage with pointed vault leading to a balcony occupying the space above the entrance. A portcullis chamber presumably originally occupied this space and perhaps first floor level of the structure behind the entrance. At the E end of the balcony is another passsage with pointed vault entering the east chamber through a pointed door (probably modern) on the south-east. The chamber is lit by a splayed loop with sandstone jambs and segmental rear arch facing north-west and a twin-light rectangular window with chamfered limestone jambs, in a large flat lintelled embrasure with modern window seats facing north-east. On the south-east a round headed doorway leads to a spiral stair giving access to the upper floors, located at the junction of the east side of the tower with the north curtain wall.

The second-floor chambers are circular with modern roofs, flat in the east chamber, domed in the west chamber. This is approached through the mural stairs in the east from which the east chamber is entered through a modern rectangular doorway on the south-east. The chamber is lit by a splayed loop with sandstone jambs and a modern pointed rear arch facing north-west, while on the south-west is a modern rectangular doorway leading to a balcony connecting the east and west towers, which has on its south side a modern open arcade of three round-headed arches.

The west chamber is entered from the balcony through a modern rectangular door on the south-east. It is lit by a modern twin-light rectangular window with chamfered limestone jambs and segmental rear arch facing south (the wall on the south is refaced, if not rebuilt, externally), a modern broad segmental arched window splaying externally and internally with limestone jambs and segmental rear arch facing west and a splayed loop with sandstone jambs and a broad modern segmental arched window with limestone jambs, both set within the same large embrasure with segmental rear arch facing NNW.

The spiral stairs in the east tower rises to roof level, where it terminates in a modern turret c.2.5m high. Both towers are topped by modern parapets above string courses; that on the east tower is low (c. 1m high) and broad, while that on the west tower is taller (c.2.1m high) and has four crenels. Over the entrance is a passage connecting the towers.

NE Tower

A D-shaped tower, at present of one floor, with wall-walk above but originally of at least two floors. It is 13.4m in maximum external width, and c.13m high of which the upper 2m is a modern parapet. There is an external basal batter c.4m high. The main chamber is circular and is entered from the castle yard by a large pointed door with chamfered sandstone jambs (possibly modern) which is c.4m tall; however, the lower 1.8m are blocked, up to the internal floor level, which is modern concrete. The chamber is lit by three splayed loops with sandstone jambs, one facing WNW with pointed rear arch; the latter two are tall, c.l.5m. On the south east is a recess above which is a space apparently for a lintel and which seems to be a blocked fireplace. The chamber is roofed by a domed vault c.6m high in overall height (while the walls of the chamber are 4m high) which is apparently inserted as it seems to block a first floor level embrasure indicated externally by three blocked loops with sandstone jambs, facing NW, NNE and SSE.

The former presence of an upper floor is indicated by a spiral stair located in the south east angle of the tower, at its junction with the east curtain wall. This stair was entered directly from the castle yard through a pointed door with chamfered sandstone jambs, 1.9m tall and set 1.8m above the ground level of the castle yard, leading to a short passage with pointed barrel vault.

The stairs rise only 4-5m above which the stairwell is blocked, while most of the stairs below this are broken; they are lit on the south by a splayed loop with sandstone jambs and flat lintelled rear arch. On the internal south west face of the tower is a straight roof line, apparently of a lean-to building c.5.75m above present ground level of the castle yard.

NW Tower

A three-quarter round tower, at present of one floor with wall-walk above, but of two or more floors originally. It is 12.8m in external diameter and ll.4m high of which the upper section is modern parapet. On the south-west, however, where the tower is directly bordered by the Shannon, the height is c.17-18m above water level. There is an external basal batter, which is up to 4m high and 1.5m wide on the river side but hardly visible above ground level elsewhere.

The main chamber is entered from the castle yard through a modern porch built against the south-east face of the tower; a straight stair in a passage in the tower wall descends to internal floor level, which is 2.3m below ground level of the castle yard. The chamber is circular and is lit by three tall loops with limestone jambs facing south-west, west and north. The latter two have pointed rear arches with traces of plank centering, whereas the former has a round rear arch and is possibly modified. All three have modern window seats inserted. The west and north loops are extremely tall, 3.7m and 3.3m respectively, and are set up to 1.5m below floor level, causing the floors of the embrasures to slope sharply downwards near the loops. The chamber is roofed by a domed vault c.9m high (walls of the chamber c.6.8m high) which is probably inserted. A spiral stairs is located on the east side of the tower, at its junction with the north curtain wall; it is approached by a passage with pointed barrel vault opening off the main entrance passage, and is lit by a splayed loop with limestone jambs and flat lintelled rear arch facing north-east. There may be an intact first floor chamber, but if so, it is inaccessible. It may have been entered through a pointed door with modern arch, having sandstone jambs with heavy roll moulding, in the internal (SE) wall of the tower, now blocked. On the north east is a large embrasure or chamber with pointed vault with traces of plank centering, lit externally by a tall loop with limestone jambs and flat lintelled rear arch, facing ENE, and connected with the spiral stairs by a passage with pointed vault with traces of plank centering; the internal(SW) wall of the large embrasure or chamber is a modern insertion, and may block an entrance to the main first floor chamber.

Above first floor level the spiral stairs continue to rise, and a modernised doorway on the east leads onto the wall-walk of the north curtain wall. Just above this the stairs are abruptly cut off by a modern ceiling. The tower has a (modern?) domed roof with low, c.lm high, broad parapet.

SW Tower

A three-quarter round tower, at present probably of two floors with wall-walk above, but originally probably of at least three floors. It is 12.3m in external diameter and up to 17.3m high on the river side, of which the upper 2m is a modern parapet; there is a strong basal batter up to 3.2m

high. The tower is at present entered, at what appears to be first floor level, from the castle yard through a modern rectangular door in the angle between the west and south curtain walls. The inner wall of the tower is carried over this angle on a round arch c.4m high. Opening off this doorway are, to the south, the main first floor chamber and to the west a spiral stair located at the junction of the tower with the west curtain wall and giving access to the ground and second floors levels. At the base of the stairs is a blocked, pointed doorway, with dressed limestone jambs,which presumably gave access to the ground floor chamber. This chamber is not accessible, but is also evidenced by a small, narrow loop with limestone jambs, facing north-west and visible externally. The first-floor chamber is circular and had at least three embrasures facing east, south-east and west and possibly another facing south-west. The east embrasure has a pointed arch with traces of plank centering, although the inner part has been widened and now has a round arch. Externally a blocked rectangular doorway probably modern date is visible in a buttress-like projection. The south-east embrasure is completely blocked, while the west embrasure is largely blocked, leaving only a rectangular opening 95cm high, 80cm above ground. It has a twin-light round headed window, of which the arch heads, in sandstone are all that survive and a pointed rear arch. The chamber has a domed vault c.5.5m in overall height (walls of the chamber c.3.25m high), again probably inserted. The former existence of a

second-floor chamber is indicated by the presence of a blocked twin-light rectangular window with chamfered limestone jambs facing south-south-west and visible externally. Above first floot level at present, however, there is a flat roof with modern parapet c.2m high approached from the spiral stairs. The stairs are lit by three splayed loops facing north along the west curtain wall; the first between ground and first floor levels has sandstone jambs; the second just above first floor level had limestone jambs and is of uncertain date; the third just below roof-level is modern but beside it is a blocked rectangular opening which presumably gave access to the wall-walk of the west curtain wall.

North Curtain Wall

This wall does not run in a straight line but turns sharply to the south-east just east of the gatehouse. The angle thus formed has dressed sandstone quoins externally, as has a less pronounced angle west of the gatehouse. The wall is up to llm high externally and 3m thick, with basal batter c.3.5m high, east of the gatehouse. West of the gatehouse it is up to 9.9m high, of which the upper 1.1m is modern parapet. West of the gatehouse there is a wall-walk with access at either end from the north-west tower and gatehouse. East of the gatehouse much of the upper part of the wall is missing internally and replaced by modern stairs. Below the stairs, at ground level is a splayed loop with sandstone jambs and pointed rear arch, while three small narrow blocked loops are visible externally at c.7.5m high, two west of the gatehouse and the third east of it.

West Curtain wall

This is almost straight but is angled slightly either side of a projecting rectangular turret near the north end. It does not survive above internal ground level which is c.6.5m high higher than external ground level; thus, it is 6.5m high externally. Wall returns in the north-west and south-west towers, however, indicate that it was originally 10.4m high externally to wall-walk level, above which there was a parapet. South of the turret the wall has a basal batter 90cm high, but north of the turret the batter is much higher (2.5m) and wider (1m). At the junction of the with the north-west tower a garderobe chute in dressed limestone, has been built on. No other features are visible north of the turret, apart from a series of modern gun-loops near the top, in what is probably modern masonry. The turret itself (shown by Philips in 1685) is 5.9m wide, of masonry similar to the curtain wall but without a batter, and featureless apart from a window and gun loop in modern masonry at the top. A modern extension 5m wide, has been built onto the south side. Roughly midway between the turret and the south-west tower is a postern gate with modern arch, but some original sandstone jamb stones survive; it is approached from within the castle by a dog-leg stairs c. 2m wide, with pointed barrell vault above, the other end of which is blocked. North of the postern four rectangular windows with chamfered sandstone jambs occur at a height of c.4m externally and at intervals of c.4m; vaulted embrasures, now inaccessible, are visible inside the windows.

South Curtain Wall

A straight wall up to 7.2m high at the west end externally (but only 5.6m high at the east end, due to rising ground level) of which the upper 1.3m is modern parapet. It is topped by a wall-walk with modern parapets internally and externally. The wall is apparently of two phases. At the west end it is similar, in general features, to the west and north curtain walls, but east of a point 6.9m from the south-west tower it has a much higher (4m) and wider (1.25m) basal batter externally as well as a slight batter internally.

At the east end of the wall are the west and incomplete south walls of a quadrangular bastion which replaced the south-east tower in the early seventeenth century. At present it measures c.8.5m north-south by c.15m east-west, with walls 5.6m high of which the upper 1.3m is modern parapet, having a strong external batter 4m high, and topped by a wall-walk with modern parapets internally and externally. The masonry is of large, roughly dressed limestone blocks, with very large dressed limestone quoins.

Excavations in 1976 revealed the foundations of a thirteenth century hall-like structure and a large quantity of post-medieval pottery (Sweetman 1980)'. Further excavations were carried out in 1989 by Brian Hodkinson, Limerick Corporation, to assess the remains of the east curtain wall (Wiggins 2016, 41). In February 1990, following demolition of row 4 (Nos 22—5) and row 1 (Nos 1—6) of the Corporation terraces, excavation under licence No. E0534, was carried out

by City Archaeologist, Celie O'Rahilly, in the course of which remains of the east curtain wall and the bastion were substantially exposed (ibid.). The overall dimensions of the excavation were c. 46m (north—south), extending between the north-east tower and the standing south wall of the bastion, by c. 24m (east—west). At the beginning of March 1991 a small investigation was carried out near the northern end of the latrine block on the west curtain wall in order to determine the source of water seepage on the outside of the curtain wall. In 1993 further excavations were carried out by Kenneth Wiggins under licence No. 93E0082. Cutting 1 of this phase of the excavations was located at the rear of the gatehouse, where wall stubs indicating the presence of a demolished extension to the gate passage made this area a key one to investigate (Wiggins 2016, 46). Cutting 1 was situated adjacent to the main gate of the castle, at that time not in use for visitor access, along the northern side of the castle. Cutting 2 was established on the western side of the courtyard. Cutting 3 was located outside the south curtain wall. In January/February 1997, three large cuttings were made by mechanical excavator under the supervision of Kenneth Wiggins under licence No. 93E0082. The first two were located at the western end of the site, while cutting 3C was located in the eastern half. Cutting 3A was at the north-western corner of the site, adjacent to the south curtain wall, and measured c. 12m (east—west) by 5m. This area actually corresponded with the proposed location of Castle Lane (Wiggins 2016, 56).

Recent research carried out by Kenneth Wiggins (2016, 38-41) on the castle suggested the following phases in the development of King John's Castle:

Phase 1 (1175—6). Construction of the Anglo-Norman ringwork, an enclosure comprising a clay bank and ditch.

Phase 2 (1195—1216). The first significant masonry work is completed, within the footprint of the ringwork. Section 1 of the east curtain wall is part of this phase. This phase represents the castle as it was during the reign of King John.

Phase 3 (1216—35). The castle expands beyond the limits of the ringwork, by means of a ditch and clay bank. There is no further masonry work at this time.

Phase 4 (1235—80). The stone castle is developed by construction of the north-west tower.

Phase 5 (1280—1608). Substantial time-span, during which the masonry castle is completed. Most of the development is confined to the early years of the phase, including the building of the south-west tower and the great hall (level 1a, c. 1280; level 1b, 1280—97), and substantial improvements to the great hall and the courtyard.

Phase 6 (1608—42). The south-east corner is fortified with the construction of the bastion, and a new ditch is provided. The siege of 1642.

Phase 7 (1642-1750). Evidence for new building in the courtyard and for improved outer defences:

Phase 8 (1751—1922) - The construction of the castle barracks which is the largest building inside the castle courtyard.

Compiled by: Caimin O'Brien

Date of upload: 17 April 2018

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1. Anon. 1841 Thomond Bridge and the Castle of Limerick. The Irish Penny Journal 1, No. 39 (Mar. 27, 1841), 305-307.

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3. Cal. doc. Ire. - Calendar of documents relating to Ireland 1171-1307, ed. H.S. Sweetman (5 vols., London, 1875-86).

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5. Furnivall, F.J. (ed.) 1896 The English conquest of Ireland, A.D. 1166-1185, mainly from the "Expugnatio Hibernica" of Giraldus Cambrensis. Kegan Paul, Trench, Trubner & Co., Limited. London

6. Harbison, P. 1970 (Reprint 1992) Guide to the national monuments in the Republic of Ireland. Dublin. Gill and Macmillan.

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9. Shirley, E.P., Dineley, T., O'Brien, R. and Graves, J. 1858-67 Extracts from the Journal of Thomas Dineley, Esquire, giving some account of his visit to Ireland in the reign of Charles II. Journal of the Royal Society of Antiquaries of Ireland 6, 73-91, 176-204, 289-90.

10. Sweetman, P. D. 1980 Archaeological excavations at King John's Castle. Proceedings of the Royal Irish Academy, 80C, 207-29.

11. Todd, J. H. (ed.) 1867 Cogadh Gaedhel re Gallaibh: the war of the Gaedhil with the Gall. London.

12. Tresham, E. 1828 Rotulorum patentium et clausorum cancellariae Hiberniae calendrium Hen II - Hen VII. Dublin.

13. Wiggins, K. 2016 A Place of Great Consequence: Archaeological Excavations at King John's Castle. Wordwell. Dublin.

RMP code: LI005-017069- Class: Mill – unclassified

Grid coordinates: E 557964, N 657464

Location: 8 m north of Area B2

Description: Leask refers to Nicholas Arthur's Mill located 'about the middle of the present George's Quay' (1941, 100), which is shown on a late 16th century map of Limerick City (TCD, MS 1209/57). Also Comyn's Mills, it was demolished in 1763 (O'Flaherty 2010, 30) when George's Quay was built (Hill 1991, 82-3).

Excavations carried out in the Abbey River under licence No. 98E0581 ext. by Ed O'Donovan on behalf of Margaret Gowen & Co. Ltd were summarised as following; 'Over the past year and a half, excavations in advance of construction work associated with the Limerick Main Drainage Scheme have been carried out. The report on the first phase of these excavations (Excavations 1999, 169–71) included brief reports on excavations along George's Quay and at Broad Street. The Phase I excavations also included an account of the various artefacts recovered from the bed of the Abbey River between Matthew Bridge and Baal's Bridge. This year the excavations in the riverbed extended from Matthew Bridge to the mouth of the Abbey River, with its junction with the Shannon at Curragour Point, and from Curragour Point in the Shannon to Sarsfield Lock, and also included a short programme of excavation on George's Quay.

Town wall along George's Quay

Two further sections of the medieval town wall were uncovered along George's Quay (at Manholes E and F). Deep excavation was not required as the construction work was relatively shallow; however, the laying of new pipes along the quay at the junction of Creagh Lane and George's Quay did reveal a substantial wall running parallel to the quay. The preliminary interpretation of the structure suggested that it formed part of a bastion or building standing proud of the line of the town wall. Structures standing proud of the town wall along the Abbey River are illustrated on the early historic maps of the city (Pacata Hibernia map, Hardiman's map and Speed's map). Organic deposits of 16th-century date abutting the structure contained the grain weevil Sitophilus granarius. This insect is a pest of stored grain in particular and is

entirely dependent on humans for its dispersal (Eileen Reilly, pers. comm.). These deposits are possibly related to grain stored around Nicholas Arthur's Mill, depicted on Hardiman's map (c. 1590) (www.excavations.ie). 16th/17th-century weir in the Abbey River

The foundations of an early weir (LI005-017186) were identified in the Abbey River. The structure pre-dates Charlotte's Quay and Bank Place and is thought -to form a head-race for two mills on either side of the river, one under Bank Place (LI005-017098-) and the other at the junction of Creagh Lane and George's Quay. This again may relate to Nicholas Arthur's Mill depicted on Hardiman's map, c. 1590 (O'Donovan et. al. 2003).

Compiled by: Caimin O'Brien

Date of upload: 18 November 2019

References:

1. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

2. O'Donovan, E. et. al. 2003 Archaeological excavations on George's Quay and Broad Street: conducted as part of the Limerick Main Drainage Scheme. Unpublished excavation report 98E0581, National Monuments Service, Department of Arts, Heritage and the Gaeltacht, Dublin.

3. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Hill, J. 1991 The building of Limerick. Mercier Press

RMP code: LI005-017072- Class: Quay

Grid coordinates: E 557761, N 657536

Location: 25 m north of Area B3

Description: The potato market stands at the junction of Quay Lane [Bridge Street] and Merchant's Quay which was an important harbour or port in medieval Limerick. This merchant's harbour or port protected by a quay wall was described by Leask (1941, 101) as following; 'Where the Potato Market now is there was one of the most interesting features of ancient Limerick — the ship dock or port — enclosed by pier-like arms of the walls terminating in towers. The southern pier or wall, nearly 400 feet [122m] long, started from a tower seemingly three-sided, at the foot of the "Rue du Quay" of the French map: the modern Bridge Street, and formed the south boundary of the port. In 1500, say Fitzgerald and McGregor, "a wall and vault were built on the south side of the Quay. This vault had its entrance by a flight of steps at the end of Quay Lane, and formed a covered way to a six-gun battery at the Pierhead near the flood-gate. This is the south wall and tower shown (the former by a double line) on the French map [Lenihan 1866, 258], which also shows the entrance steps minutely. This south wall of the Quay was repaired in 1640-41, when Wm. Comyn was Mayor, and bore a long inscription to that effect which is given in Ferrar's History, 1st edition, 1767. The tower fell in 1693, the collision of the falling stones detonating the 250 barrels of gunpowder in store there, with most destructive effects: fatal casualties and much injury to persons and property houses were wrecked, many windows broken and roofs stripped. The battery at the pier-head seems to have been a successor to the tower.

The entrance to the port was bounded, on the north side also, by a wall-pier about 100 feet [30m] in length and the same distance from the south wall. It also terminated in a tower. Within the entrance lay the dock itself, an irregular piece of water surrounded by quays and projecting jetties and backed by the quay. The view in Pacata Hibernia shows a sort of half-moon quay, but the French map and that of 1590 [TCD, MS 1209/57] are more precise and detailed and

probably more accurate. The piers and terminal towers—which must have been most interesting and picturesque objects—have quite gone and so also has the whole of the river wall of the town from the dock northwards to the nearest tower of King John's Castle [LI005-017014-]. Its trace passes across the County Court House diagonally at the river end of the building, and in the same way over the yards west of the City Court House'.

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Ferrar, J. 1787 The history of Limerick. Limerick.

2. Fitzgerald, P. and McGregor, J.J. 1826 The history, topography and antiquities of the county and city of Limerick. Dublin.

3. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Lenihan, M. 1866 Limerick: its history and antiquities.

RMP code: LI005-017073- Class: Battery

Grid coordinates: E 557710, N 657515

Location: At the location of Area B3

Description: A six-gun battery on the S wall of the medieval quay (LI005-017073-) of Limerick described by Leask (1941, 101) as following; 'Where the Potato Market now is there was one of the most interesting features of ancient Limerick — the ship dock or port — enclosed by pier-like arms of the walls terminating in towers. The southern pier or wall, nearly 400 feet [122m] long, started from a tower seemingly three-sided, at the foot of the "Rue du Quay" of the French map: the modern Bridge Street, and formed the south boundary of the port. In 1500, say Fitzgerald and McGregor, "a wall and vault were built on the south side of the Quay. This vault had its entrance by a flight of steps at the end of Quay Lane [Bridge Street], and formed a covered way to a six-gun battery at the Pierhead near the flood-gate. This is the south wall and tower shown (the former by a double line) on the French map [Lenihan 1866, 258], which also shows the entrance steps minutely. This south wall of the Quay was repaired in 1640-41, when Wm. Comyn was Mayor, and bore a long inscription to that effect which is given in Ferrar's History, 1st edition, 1767. The tower fell in 1693, the collision of the falling stones detonating the 250 barrels of gunpowder in store there, with most destructive effects: fatal casualties and much injury to persons and property houses were wrecked, many windows broken and roofs stripped. The battery at the pier-head seems to have been a successor to the tower'.

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Ferrar, J. 1787 The history of Limerick. Limerick.

2. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

3. Lenihan, M. 1866 Limerick: its history and antiquities.

RMP code: LI005-017074- Class: Mill - unclassified

Grid coordinates: E 557688, N 657681

Location: At the location (4 m east) of Area B3

Description: Thomas Arthur's mill, one of a pair of mills (LI005-017075-) located between King John's Castle (LI005-017014-) and the medieval quay (LI005-017072-) (Leask 1941, 101). This is marked as 'Upper Mills' on map in O'Flaherty (2010, 3, Fig. 3) where it is described as 'Newgate Lane, W. end, in Curragour Castle. Mill 14th-15th cent.' (ibid., 30). It is very closely associated with 'Golding Mill' which is also described as 'Newgate Lane, W. end, in Curragour Castle. Mill 14th-15th cent.' (ibid., 30). The two mills were described by Leask (1941, 101) as following; 'At or near the foot of Newgate Lane—the "Rue des Moulins" of the French map [Lenihan 1866, 258] — were two water mills (J on Map). They stood out from the wall [LI005-017010-] just below the Curragower reef. These mills are specifically mentioned in the Civil Survey (Simington 1938, 442-3). There seem to have been two stone houses (36ft. by 30ft. [10.8m x 9.1m] and 45ft, by 27ft. [13.7m x 8.2m]) "with two mills (wheels?) therein seated and a thatched house. The map of 1590 [TCD, MS 1209/57] shows them as "Thos. Arthur's" [LI005-017074-] and the "Queen's Mills," and connected with the city wall (LI005-017010-) by a bridge'.

Both of these probably formed 'the King's Mills' mentioned by Hodkinson (2009, 23) who recorded that 'half of the mill building still exists within the grounds of City Hall, where two stubs of walls can be seen projecting out into the river (ibid.).

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Hodkinson, B. 2009 The medieval city of Limerick. Matthew Potter, Gearóid Ó Tuathaigh and Liam Irwin (eds.), Limerick history and society: interdisciplinary essays on the history of an Irish county, 17-40. Dublin. Geography Publications.

2. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

3. Lenihan, M. 1866 Limerick: its history and antiquities.

4. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

5. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

6. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

RMP code: LI005-017075- Class: Mill - unclassified

Grid coordinates: E 557699, N 657686

Location: 15 m east of Area B3

Description: Queen's mill, one of a pair of mills (LI005-017074-) located between King John's Castle (LI005-017014-) and the medieval quay (LI005-017072-). The two mills were described by Leask (1941, 101) as following; 'At or near the foot of Newgate Lane—the "Rue des Moulins" of the French map [Lenihan 1866, 258] — were two water mills (J on Map). They stood out from the wall just below the Curragower reef. These mills are specifically mentioned in the Civil Survey (Simington 1938, 442-3). There seem to have been two stone houses (36ft. by 30ft. [10.8m x 9.1m] and 45ft, by 27ft. [13.7m x 8.2m]) "with two mills (wheels?) therein seated and

a thatched house. The map of 1590 [TCD, MS 1209/57] shows them as "Thos. Arthur's" [LI005-017074-] and the "Queen's Mills," and connected with the city wall (LI005-017010-) by a bridge'.

Both of these probably formed 'the King's Mills' mentioned by Hodkinson (2009, 23) who recorded that 'half of the mill building still exists within the grounds of City Hall, where two stubs of walls can be seen projecting out into the river (ibid.).

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

2. Lenihan, M. 1866 Limerick: its history and antiquities.

3. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Hodkinson, B. 2009 The medieval city of Limerick. Matthew Potter, Gearóid Ó Tuathaigh and Liam Irwin (eds.), Limerick history and society: interdisciplinary essays on the history of an Irish county, 17-40. Dublin. Geography Publications.

RMP code: LI005-017101- Class: Castle - unclassified

Grid coordinates: E 557694, N 657684

Location: 10 m east of Area B3

Description: Curragower Castle described in the Urban Survey of Limerick (Bradley et. al. 1989, 259) as following; 'In 1657 this was located near the Curragour weir [LI005-110----] parish of St. Nicholas (Westropp 1906-7, 81)'.

Westropp (1906-7, 81) recorded the following details on Curragower Castle; 'The weir [LI005-110----] of Coradoguir is named in 1201 in the Inq. M. f. Henry (B.B.L., p. 15). 1577 The mills [LI005-017074-/075-] of Cordower granted to Hercules Rainsford (Fi. 3027). 1627 W. Creagh f. Martin held the C[astle]. and two mills of Carrowdarrower in the parish of St. Nicholas (Inq. Chan. 50). 1657 Curragowr stone house and C[astle] (C.S., xxviii., p. 64).

Compiled by: Caimin O'Brien

Date of upload: 21 November 2019

References:

1. Bradley, J., Halpin, A., and King, H.A. 1989 Urban archaeological survey - county Limerick (3 vols.). Unpublished report commissioned by the Office of Public Works, Dublin.

2. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

3. Westropp, T.J. 1906-7 The ancient castles of the county of Limerick. Proceedings of the Royal Irish Academy 26, 54-264.

RMP code: LI005-017115- Class: Religious house - Fratres Cruciferi

Grid coordinates: E 558079, N 657465

Location: 10 m north of Area A10

Description: Priory & Hospital of St Mary & St Edward described in the urban Survey (Bradley et. al. 1989,329-30) as following; 'PRIORY & HOSPITAL OF ST MARY & ST EDWARD, alias HOLY CROSS (FRATRES CRUCIFERI) - According to Ware, Simon Minor placed Augustinians in the priory of SS Mary & Edward before 1216. This was, in fact, a house of Augustinian Cruciferi dedicated to SS Mary, Edward and the Holy Cross (Gwynn and Hadcock 1970, 214; Begley 1906, 270-4). Described as "near the bridge" in 1321 (Westropp 1904-5, 360) it is shown on the 1590 map as situated in the angle of the town walls, south of the Franciscan Friary, at Sir Harry's Mall. In 1559 it consisted of the body of the church, a hospital, steeple and a waste garden, barns and close (Westropp 1904-5, 361). Gwynn and Hadcock (1970, 214) have suggested that there were two sets of buildings St Mary and St Edward, and Holy Cross, one the priory the other the hospital. It is possible that the references to the church of "Sancte Marie Rotunda" in the inquisition of 1201-2 (MacCaffrey 1907, 28) relates to this site. It cannot be the same, however, as the church of St Mary Magdalen listed in Bishop Donatus O'Brien's ordinance of 1204-6 (MacCaffrey 1907, 116) because the dedication of the Cruciferi house was clearly to the BVM (Gwynn and Hadcock 1970, 214)'.

Compiled by: Caimin O'Brien

Date of upload: 22 November 2019

References:

1. Bradley, J., Halpin, A., and King, H.A. 1989 Urban archaeological survey - county Limerick (3 vols.). Unpublished report commissioned by the Office of Public Works, Dublin.

2. Begley, J. 1906 The Diocese of Limerick ancient and medieval. Dublin.

3. Gwynn, A. and Hadcock, R.N. 1970 (Reprint 1988) Medieval religious houses of Ireland. Dublin. Irish Academic Press.

4. MacCaffrey, J. 1907 The black book of Limerick. Dublin.

5. Westropp, T.J. 1904-5 A survey of the ancient churches of Co. Limerick. Proceedings of the Royal Irish Academy 25C, 327-479.

RMP code: LI005-017124- Class: Castle – ringwork

Grid coordinates: E 557720, N 657809

Location: At the location of Area B3

Description: Ringwork identified during 1990-1 excavations of King John's Castle (LI005-017014-), the discovery of which was described by Wiggins (2001, 30-3) as following; 'In February 1990 two terraces of corporation houses in the castle were demolished, allowing the development of the castle as a tourist attraction to get under way. Archaeological involvement was commenced by Celie O'Rahilly of Limerick Corporation, who monitored preliminary groundwork activity by the building contractor Brian O'Connell Ltd, which quickly evolved into full-scale excavation under the direction of the writer, until work was completed in September 1991. The purpose of the investigation was to uncover the surviving remains of the eastern curtain wall of the castle, together with the northern flank and eastern face of the bastion, which had been demolished around 1800. The excavated area measured approximately 47.5m north—south, extending from the standing north-eastern tower of the castle to the standing southern wall of the bastion. The width of the excavated area east—west varied between 17m and 30.5m, covering a wide area on both sides of the eastern curtain wall, including the whole interior of the bastion, as well as an area outside the bastion to the east.

In the course of the excavation a good many structural remains other than those of the eastern curtain wall and the bastion emerged. Several features originating in the twelfth century were found, pre-dating the construction of the castle. These included part of the large-scale ringwork enclosure incorporating a stone-revetted bank and broad external ditch, originally constructed by the Anglo-Norman garrison around 1175—6. These early defences were aligned east—west, at right angles to the surviving foundations of the eastern curtain wall. The remains of both the ringwork bank behind the retaining wall and the ditch in front of it were disturbed by the digging of countermines during the siege of 1642'.

Compiled by: Caimin O'Brien

Date of upload: 26 November 2019

References:

1. Wiggins, K. 2001 Anatomy of a siege. King John's Castle, Limerick, 1642. Wordwell. Bray.

RMP code: LI005-017140- Class: House – medieval

Grid coordinates: E 557710, N 657709

Location: 18 m east of Area B3

Description: There is currently no description available for this record on the HEV.

RMP code: LI005-017153- Class: Excavation – miscellaneous

Grid coordinates: E 558058, N 657453

Location: 16 m north of Area A10

Description: This number covers the excavation by Frank Coyne (03E1610) on Mary Street/Sir Harry's Mall, except the burials which have the number LI005-017154-.

RMP code: LI005-017154- Class: Burial ground

Grid coordinates: E 558079, N 657465

Location: 20 m north of Area A10

Description: This is the burial ground represented by the burials uncovered by Frank Coyne in his excavation at Mary Street/Sir Harry's Mall (03E1610ext.) (excavation misc. LI005-017153-) which are probably associated with the nearby abbey (LI005-017115-). Further excavation by Linda G Lynch took place in 2005 uncovering 'a total of 90 human skeletons' (05E0376); see-Lynch, L.G. (2007) 'All shall forgotten lie- Archaeological Excavations at Sir Harry's Mall, Limerick City', NMAJ 47, 11-19.

RMP code: LI005-017177- Class: Burial ground

Grid coordinates: E 558090, N 657475

Location: 22 m north of Area A9

Description: There is currently no description available for this record on the HEV.

RMP code: LI005-018---- Class: Bastioned fort

Grid coordinates: E 557558, N 658574

Location: Outside of the development boundary between Areas A3 and A4.

Description: This fort was located at the northern end of King's Island outside the walled city of Limerick and dates from the period of the Cromwellian war in Ireland (1649-53). In June 1651, the Cromwellian army, under the command of Henry Ireton, came before Limerick and immediately began to invest the city with siege works (see LI005-017183-). Ireton initially set up camp to the north of the city where he erected a large fort (LI005-114----). On 19 June he attempted to storm King's Island by an assault on Thomond Bridge. This was repulsed and four days later he attempted a pre-dawn amphibious attack on the island. A small detachment arrived on the island ahead of the main body and attacked the fort but these were pushed back and a number were killed or drowned as they tried to escape. The remainder of the assault force abandoned the attack and returned to the Clare side of the Shannon. Despite a sustained bombardment Limerick managed to hold out over the following months but eventually surrendered at the end of October 1651. Without doubt the fort on King's Island continued to be garrisoned throughout this siege. The fort is represented on William Webb's map of the siege as a regular square fortification with corner bastions surrounded by a fosse forming an overall star-shaped plan: a single roofed building is shown within the interior. The fort is identified in the map index simply as 'Ye fort in ye island' (O'Flaherty 2010, map 10, no. 65).

It is evident that it was abandoned and allowed to fall into decay but was refortified again during War of the Two Kings, 1688-91. The Jacobite officer, John Stevens, records in his journal that when he arrived at Limerick after the defeat of the Boyne in July 1690 'there were only the ruins of a small fort in the island, the rest being partly a common walk for the citizens and let out for grazing' (Murray 1912, 147). William arrived with his army before Limerick on 9 August 1690 and immediately commenced a siege. At this time the Jacobites were busy strengthening the defences and Stevens remarks in his entry for 12 August that 'The unarmed men were continually kept at work, the chief part whereof was in the King's Island, where was raised a square fort with four bulwarks, on one of them a small platform for three or four guns to play over the branch of the river that makes the island, where it was thought the enemy designed to raise a battery, having made some odd shots from thence.' And again, on 16 August he noted that 'All our unarmed men were continually kept at work, some fortifying the Kings Island' (ibid., 169-70) which included 'an entrenchment or covered way was made about the King's Island to secure it from all attempts, and in the middle of it a Fort Royal with four bastions and a line of communication to the English town.' (ibid., 196). The fort is shown in the schematic panorama included by Story in his 'History' where it identified as 'A new Irish fort' (1693, facing 38; attached). The entrenchments are visible along the northern side of the island but the fort is shown as free-standing without any link to the city. The siege did not go well for William and, after suffering heavy casualties, he eventually abandoned it at the end of August.

Stevens' description of the fort is paralleled by that given by the Williamite, Colonel Michael Richards, who noted in his diary during the second siege in 1691, that it was 'well frized and palisadoed, environed with a handsome counterscarp. Several projects were conceived to attack it, it being first proposed to make a very good battery at the water's edge to cover our passage; but this ground is very low and swampy, which, I apprehend, will put an end to this new design; besides, the fort is so large that all our cannon planted on one battery on this side cannot hinder the enemies from sustaining the said fort with their whole force on the other side, having advantageous ground for it, and a double line of communication to the town' (Gilbert 1892, 288-9). And again, his account is further supported by the Williamite chronicler, George Story, who noted 'great improvements in the King's Island' which had 'a most excellent fort with a double line of communication from thence to the town, mann'd for the most part by the best of their dragoons dismounted' (Story 1693, 213, 277). As depicted on both Story's (ibid., facing 224) and Goubet's maps (O'Flaherty 2010, map 13) it is evident that, besides upgrading the existing fort's earthworks, the most significant undertaking was the addition of a substantial counterscarp and glacis. When Limerick surrendered on 3 October the fortifications were handed over to the Williamites.

The fort is depicted on the map of the city drawn by William Eyres c. 1752 and identified in the map index as the 'Fort in the King's Island; from which the Irish had a communication with the town.' (O'Flaherty 2010, map 16). The map shows that the counterscarp and glacis had been

gradually reclaimed as fields, and a small number of dwellings are depicted near the south-west corner bastion. The fort was further degraded over the ensuing decades and by the time of the OS survey of 1840-1 had been reduced to a four-pointed star with curved sides where it was named '(Site of) Cromwell's Fort'. It continued to be represented as such on subsequent surveys and revisions until it was entirely removed when St Mary's Park housing estate was built on the site by Limerick corporation in the 1930s.

LI005-018----_01 Panorama of the siege of Limerick, 1690, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 38.

LI005-018----_02 Plan of the siege of Limerick, 1691, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 224.

LI005-018----_03 Extract from the plan of the siege of Limerick, 1691, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 224.

Compiled by: Paul Walsh

Date of upload: 6 March 2018

References:

1. Gilbert, J. T. 1892 A Jacobite narrative of the war in Ireland, 1688-1691. Dublin.

2. Murray, R.H. (ed.) 1912 The journal of John Stevens: containing a brief account of the war in Ireland, 1689-1691. Oxford.

3. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

4. Story, G. 1693 An impartial history of the wars of Ireland, with a continuation thereof. London. Chiswell.

Proposed Testing Regime

In relation to the proposed King's Island Flood Relief Scheme

December 2019

Moore Group

For Arup on behalf of Limerick City and County Council

Contents

Figures

Introduction

A number of archaeologically sensitive areas have been identified in relation to the proposed construction of the King's Island Flood Relief Scheme (KIFRS) in Limerick. It is proposed to undertake archaeological testing in these areas to identify/confirm the nature and extent of archaeological features and/or deposits to clarify the upcoming detailed design phase of the proposed Project. Details of archaeological monuments in relation to the Site Boundary are presented in Appendix 1 Figures 1 and 2.

There are seven areas located in the south west of King's Island where it is proposed to undertake archaeological testing (Appendix 1 3). Proposed constructions work in these areas including flood defences, inter-tidal surface water storage tanks, surface water drainage and a proposed gravity sewer. The works proposed in each area are discussed in more detail below.

It is noted that all of the proposed archaeological testing areas are located within the Record of Monuments and Place Zones of Notification for Limerick City and that much of the work is to take place in the vicinity of the alignment of the City Walls which are designated as National Monuments. The testing in many of the proposed areas is to confirm the presence or absence of the City Walls and, if present, their nature and extent. As such the proposed archaeological testing will take place under Ministerial Consent. Construction of the final designed works will also require Ministerial Consent. Appendix 1 Figure 3 includes the proposed testing Areas overlaid with the alignment of the City Wall from the Limerick City Wall Conservation Management Plan. The alignment of the city wall and its relevant features are discussed in more detail in the relevant sections below.

Archaeological Testing

The definition cited below is that published by the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (now the DCHG) in 1999.

'Test excavation is that form of archaeological excavation where the purpose is to establish the nature and extent of archaeological deposits and features present in a location which it is proposed to develop (though not normally to fully investigate those deposits or features) and allow an assessment to be made of the archaeological impact of the proposed development. It may also be referred to as archaeological testing' (DAHGI 1999a, 27).

It is proposed that the applicant machine excavate the trenches using an excavator fitted with a grading bucket to natural subsoil or to the top of archaeological levels if encountered.

Should archaeological material/levels be encountered further cleaning will be carried out by hand in line with best practise and a full photographic and written survey will be completed.

On site recording will be carried out using the single context recording system. Any evident cuts and fills will be recorded using context sheets and if required a mid-excavation plan will be drawn at a scale of 1:10 using a 1m planning grid. Levels will be taken and any cuts photographed. All material will be taken into the curation of the site director and provision will be made for their secure and appropriate treatment. Digital camera equipment will be used and any feature encountered will be recorded three dimensionally using a combination of scale drawings and surveying equipment. A post excavation plan would be drawn at a scale of 1:20 and levels taken and marked onto the plan. The spoil will be metal detected.

Finds Retrieval

Temporary finds storage facilities will be available on-site and more long-term facilities are available in our offices.

All clearing back to investigate potential features will be done by hand and finds from all contexts will be recorded, bagged and numbered in accordance with best practice and in keeping with the special needs and preservation of each find.

All finds and ecofact samples will be kept and submitted to the National Museum as required. If any artefacts require conservation, the relevant licence (Licence to Alter) will be sought from the NMI and professional conservator employed to deal with the material. Osteological remains will be treated per the NMI policy on Human Remains, the Garda Síochána will be notified and an osteoarchaeologist (Linda Lynch) will be available to assist if required. Where a particularly important object is found during testing, the National Museum will be informed immediately.

Environmental Sampling

In the event that sampling is possible without compromising secure contexts, samples for radiocarbon dating would be taken. Advice from environmental specialists would be sought immediately if sensitive bioarchaeological material is encountered (particularly poorly preserved or waterlogged material), to advise on the particular needs of the materials in question. There are no on-site facilities for conservation. Finds or materials requiring conservation would be sent to conservation specialists in that field.

Specialists

No consultations have been undertaken between the applicant and specific specialists, but the following specialists are available for consultation as required.

- Osteologist: Linda Lynch
- Archaeozoologist: Fiona Beglane
- Pottery specialist: Rosanne Meenan
- Conservation specialist: Susannah Kelly.

Additional specialists as required will be contacted.

Reporting

After completion of the testing all records will be indexed, ordered, quantified and checked for consistency. Context, finds, sample and other paper-based records will be transferred to an integrated computer-based system. The drawn record will be digitised in an appropriate format that will permit the output of standard GIS Shapefiles. The Test Excavation Report shall describe the location, nature, date, character, extent, stratigraphy and significance of each archaeological feature or deposit or object discovered or confirmed by Test Excavations. Photographs, plans and sectional drawings of individual trenches, features and deposits (at an appropriate scale) shall be included as appropriate, as well as more general photographs of the work in progress.

Dissemination of the results will take the form of a stratigraphic report and full report to publishable standard lodged with the licensing section (NMS) and the Planning Section (NMS) and the National Museum of Ireland. The report will include the archaeological and historical background of the area, fieldwork procedure, the results of the excavation, the results of the specialist assessment, interpretation and phasing, illustrations (photographs, plans and sections) and assessment, and conclusions.

The final report will comprise an illustrated report on the investigation including all specialist analyses and dating evidence. A summary of the report will also be submitted to the Excavations Bulletin within six weeks of the end of fieldwork. Should results warrant it, wider dissemination in the form of a full publication may be recommended.

Archive and finds deposition

The site archive and any finds will be examined and processed by a professional conservator, pending deposition with the National Museum of Ireland. In the intervening time they would be stored in a safe, secure and suitable location by Moore Group.

Team

The excavation will be conducted by Declan Moore, assisted by Billy Quinn and Willl Anderson. Additional assistance will be available as required.

Summary of Proposed Project

The KIFRS involves the construction of flood defences to protect Kings Island.

There are extensive works proposed in the north of King's Island relating to the construction of an embankment and associated drainage internal to the flood defences. The construction site compound is also proposed in the north of the Island. There is little in the way of known archaeology in the north of King's Island, only a single recoded monument for Cromwell's Fort (SMR No. LI005-018), a bastioned fort dating from c. 1650. The remains of the fort lie beneath what is now St. Mary's Park estate. The nearest works to the fort are approximately 40 m to the west of its associated Zone of Notification. and, following consultation with Sarah McCutcheon (Executive Archaeologist Limerick City and County Council), it is proposed that archaeological mitigation in this area will take the form of archaeological monitoring of topsoil stripping of all greenfield areas that are to be affected by the proposed KIFRS.

Flood defences for the southern half of the Island are more varied, including new concrete flood defence walls, flood defence glass panelling, and new surface water drainage. It is also proposed to lay a new gravity foul sewer pipe from an existing foul sewer pumping station at the rear (north) of Civic Offices to Limerick's Main Drainage manhole on George's Quay. There are two existing foul sewer-pumping stations at the Courthouse and the Civic Offices. It is proposed to decommission these pumping stations and connect directly to this new gravity foul sewer.

There is an intertidal storage tank proposed at the rear of the Civic Offices and a second intertidal storage tank proposed between the Courthouse and the Potato Market at Merchant's Quay. These intertidal storage tanks are designed to cater for 1 in 30-year rainfall event during a high tide event. It is proposed to provide overflows from these intertidal storage tanks to the gravity foul sewer as an emergency overflow, in the event that a high tide and rainfall event greater than the storage volume in the tanks coincide, to prevent surface water ponding at Merchant's Quay.

The greatest threat to archaeology in the south of the Island is dig-out that is required to anchor the proposed flood defences with mass concrete backing to quay walls (Figure 2) and dig-out required to facilitate construction of the gravity sewer.

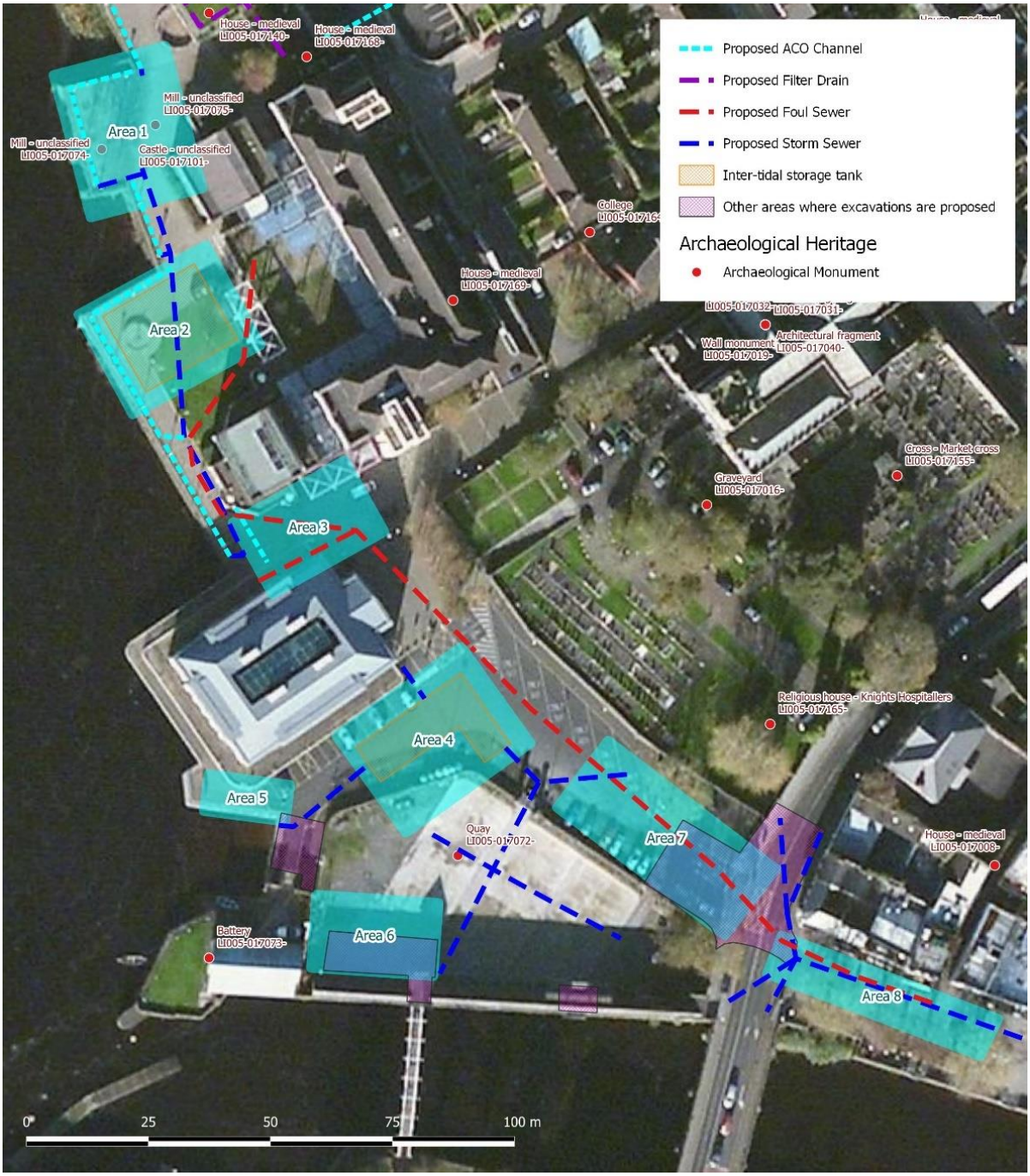


Figure 1. Overview of proposed Project and Archaeological Testing Areas.

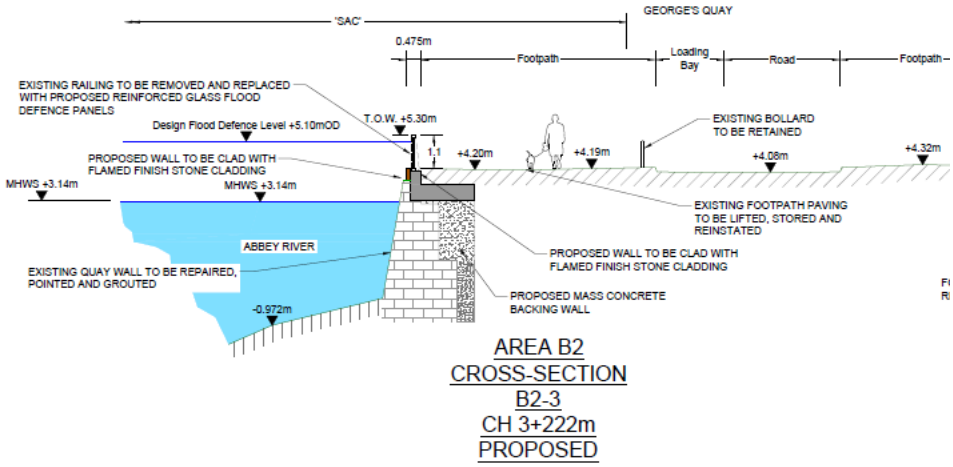


Figure 2. Section showing mass concrete backing to quay wall to support proposed flood defence.

Archaeological Testing Areas

Test trenches will be approximately 1.5 m wide but may be widened to allow for the use of trench boxes or if necessary, for health and safety purposes.

Area 1

Archaeological Potential

The proposed Project design in this area is sensitive to the fact that there are known archaeological deposits in this area that are associated with the City Wall. These include a bridge and the remains of mills, which were accessed through a gate in the City Wall. This is evidenced in numerous historic maps dating from the 16th Century (Figure 3) to the 19th Century, Thomas Phillips' prospect of Limerick from 1685 (Figure 4) and the results of archaeological excavations undertaken by Celie O'Rahilly (1987) (Figure 6) prior to the construction of the Council's Offices. O'Rahilly also noted the presence of a later tunnel which directed water under the western arch of the bridge. Tunnels appear to be indicated in William Eyres' map of 1752 (Figure 5).

Protrusions of stone wall to the west of the quay wall in this area, visible in Figure 6, at the western end of the bridge, would appear to be remnants of one of the mill buildings.

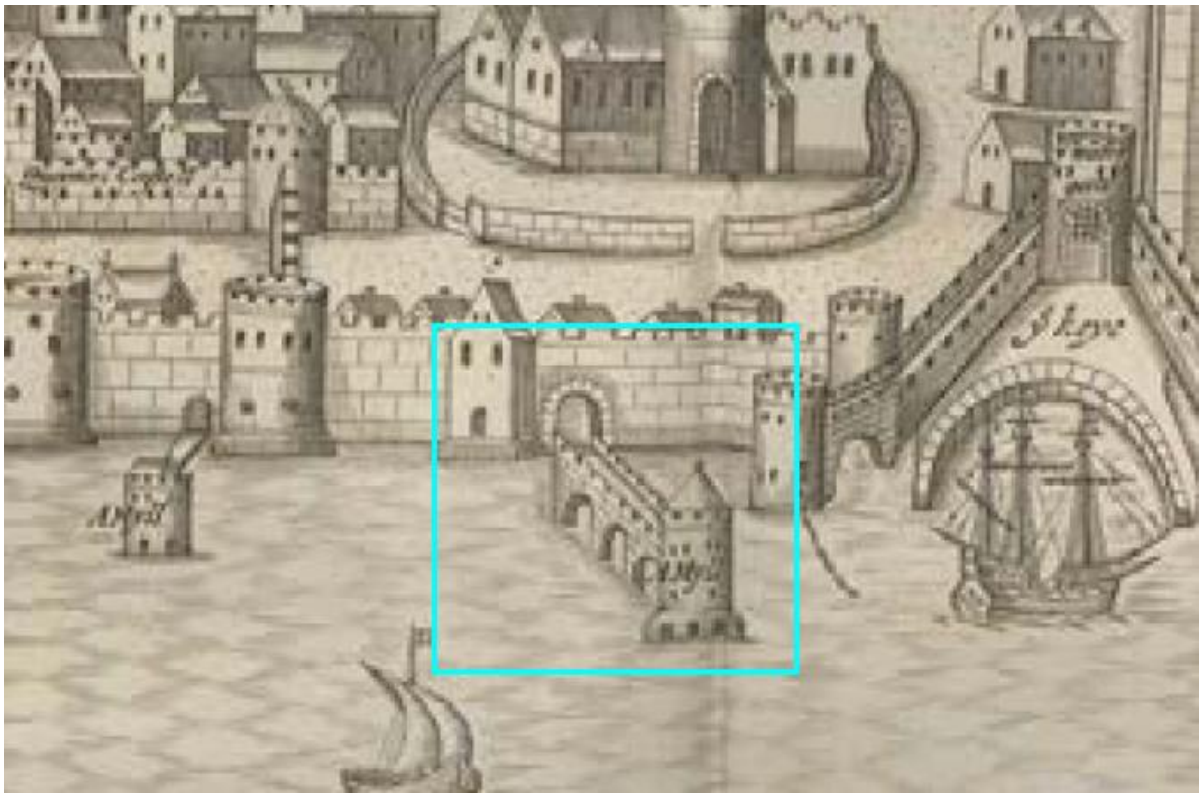


Figure 3. Extract from Limerick, 1633, (Pacata Hibernia 2) (Irish Historic Towns Atlas No. 21 Limerick, Map 9) with location of gate, bridge and mill indicated.

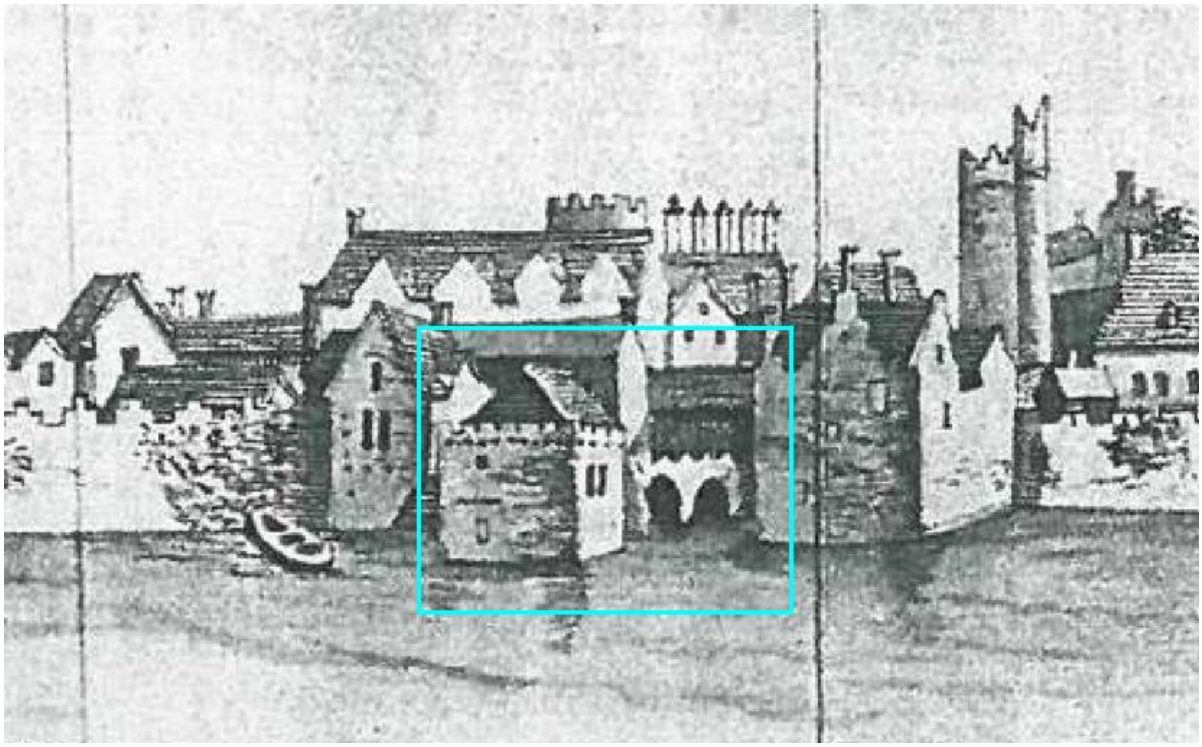


Figure 4. Extract from Limerick, looking north east, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Plate 2) with Bridge and Mill indicated.

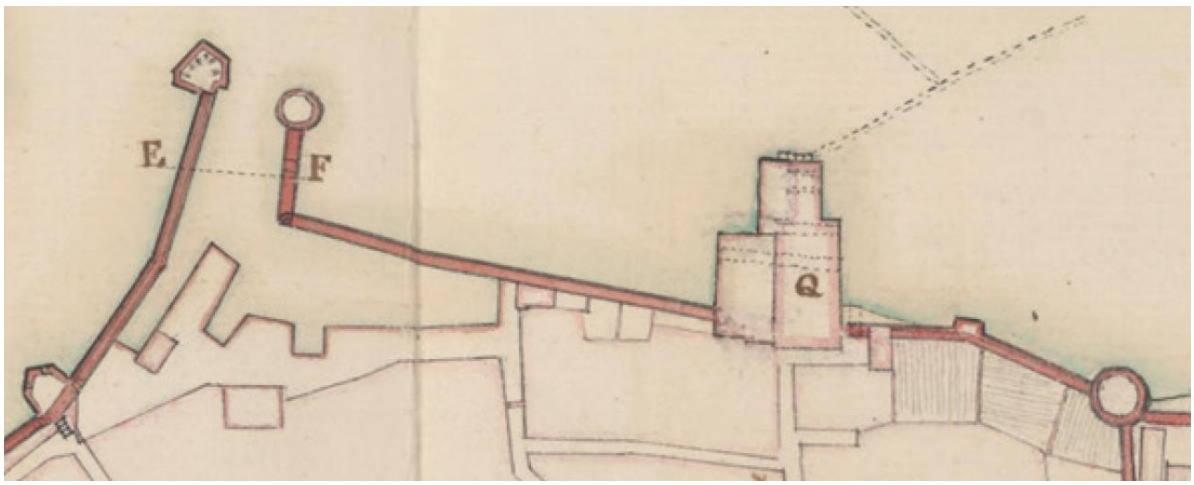


Figure 5. Extract from Willian Eyres' map, 1752, (British Library) (Irish Historic Towns Atlas 21 Limerick, Map 15) with what appear to be tunnels at 'Q Mills and Breweries'.

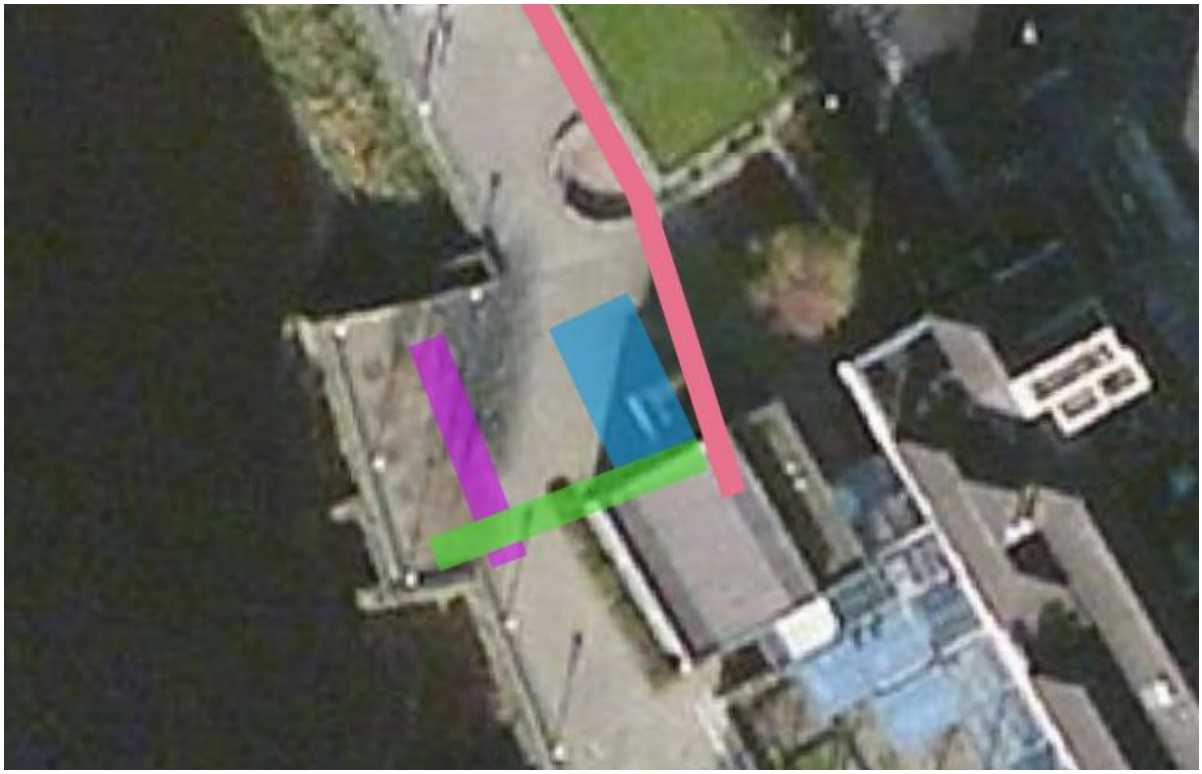


Figure 6. Possible location of tunnel (magenta), bridge (green), quay area (blue) and City Wall (Red).

Proposed Works

Area 1 is situated to the north west of the Limerick City and County Council's Offices at Merchant's Quay. Flood defences are proposed along the coastal margins consisting of reinforced concrete walls clad in stone with stone copings and glass panelling (Figure 7).

The proposed works avoid the remains of the bridge, mill and tunnel, which will remain in situ. The proposed concrete flood defence wall will cross over the bridge and tunnel from south to north supported on a raft foundation above the level of the bridge and tunnel. The raft foundation is to be supported on piles to prevent any loads on the bridge or tunnel. The wall will continue to a point to the north of the remains of the mill, before turning to the west and joining with the quay wall. Dig-out to the rear of the quay wall, to the west, will facilitate the construction of a concrete backing wall of mass concrete that will act as a support for cantilevered glass panels which will be situated above the quay. The northern flood defence wall is to be constructed of reinforced concrete and will bridge the tunnel on a raft foundation supported on piles.

Proposed dig-out for the glass panelling is approx. 3 m wide by 4 m deep. For the piled raft foundations, the proposed dig-out is approximately 1.5 m. Proposed test excavations for the raft foundation areas are deeper to ascertain the extent of the features that are to be preserved in situ.

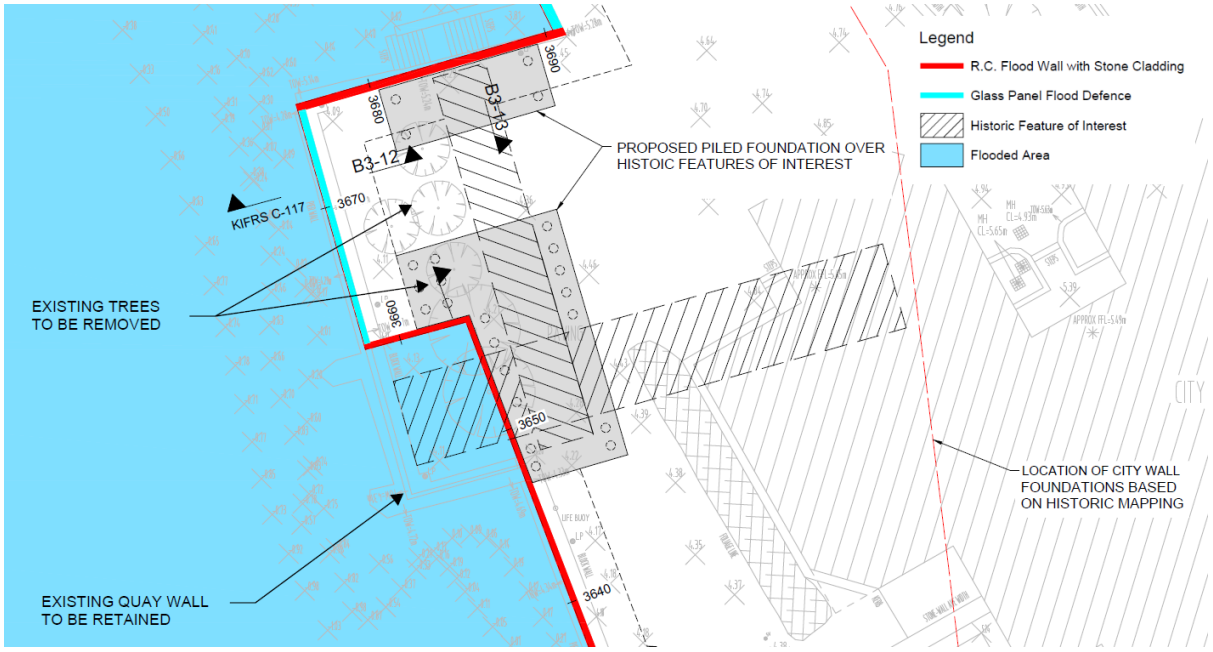


Figure 7. Proposed development in Area 1.

Proposed Testing

Four test trenches are proposed in Area 1 (Figure 8). Given the location of the trenches to the rear of quay walls only one trench will be open at any one time. Trenching will be undertaken to coincide with low tide.

Archaeological testing to the rear of quay walls will also help to identify the condition of the rear of the quay walls and the nature of the substrate to the rear of the quay walls. This information will inform the methodologies for the consolidation of the quay walls for their long-term preservation.

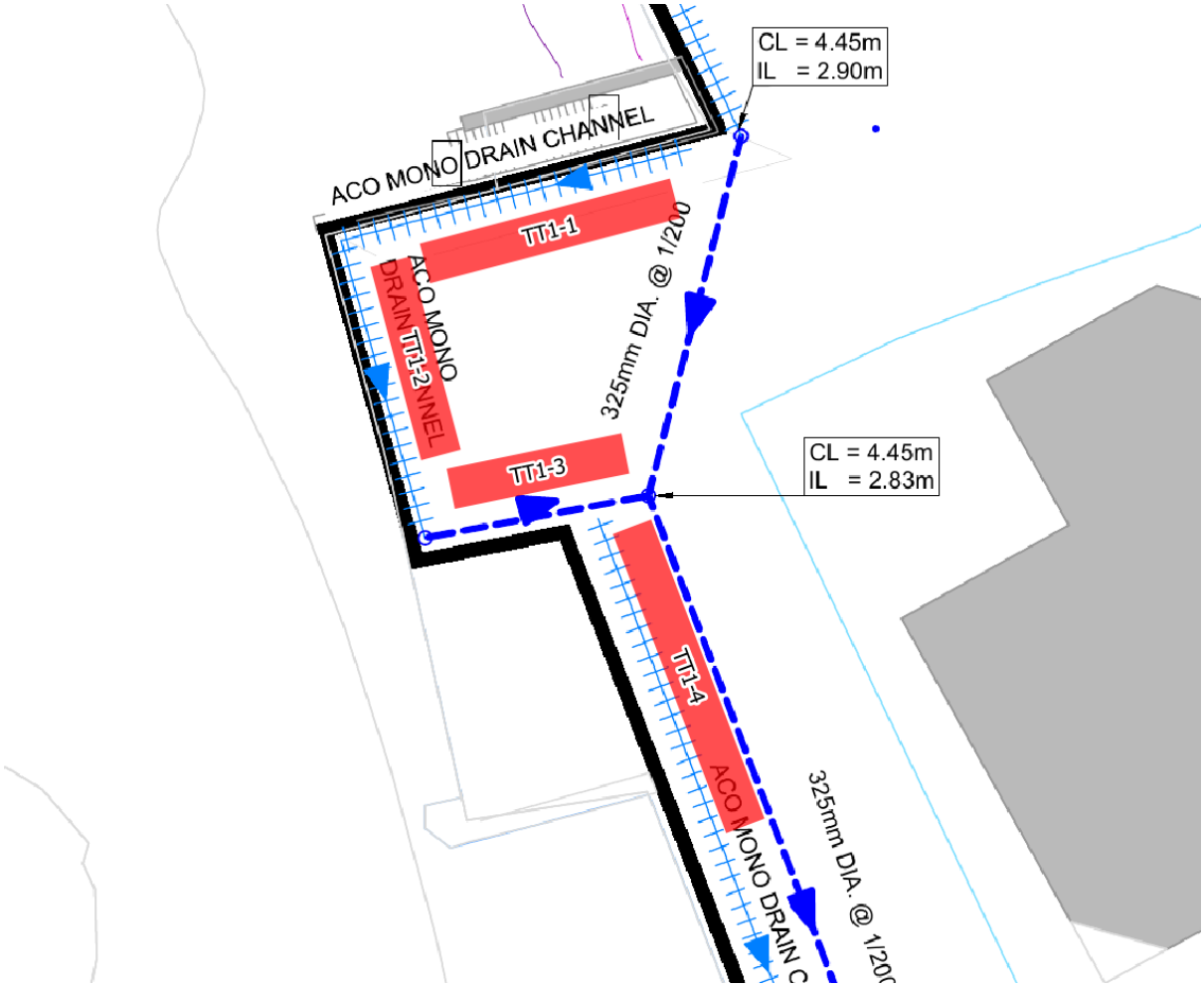


Figure 8. Proposed test trenches in Area 1.

TT1-1

Approx. 1.5 m x 9 m, depth approx. 4 m

The purpose of TT1-1 is identify the northern extent of the tunnel noted by O'Rahilly. The dimensions for the length of the tunnel recorded by O'Rahilly appear to coincide with OSI 1870 mapping of mill walls in the area (Figure 9). To the north of the mill is what appears to be a slipway into the river.

Figure 9. Extract from OSI 1870 mapping[1].

TT1-2

Approx. 1.5 m x 7 m, depth approx. 4 m

The purpose of TT1-2 is to identify the nature of the rear of the quay wall to the west and ascertain whether the distance between the quay and tunnel will influence the design of the mass concrete backing in this area.

TT1-3

Approx. 1.5 m x 7 m, depth approx. 4 m

The purpose of TT1-3 is to identify the dimension of the tunnel for the design of the raft foundation and associated piling.

TT1-4

Approx. 1.5 m x 10 m, depth approx. 4 m

The purpose of TT1-4 is to identify the location of the bridge and southern extent of the tunnel.

[1] "Ordnance Survey Ireland (OSi) 19th Century Historical Maps," held by Ordnance Survey Ireland. © Public domain. Digital content: © Ordnance Survey Ireland, published by UCD Library, University College Dublin <http://digital.ucd.ie/view/ucdlib:40377>

Area 2

Archaeological Potential

Early mapping such as Thomas Phillips' map of 1685 indicates a narrow entrance into the harbour at the south western corner of King's Island (Figure 10). William Eyres' later map of 1752 indicates a similar entrance into the harbour (Figure 5) but shows more detail in a section (E-F) through the entrance into the harbour which indicates the width of the opening to be approximately 90 feet (Figure 12).

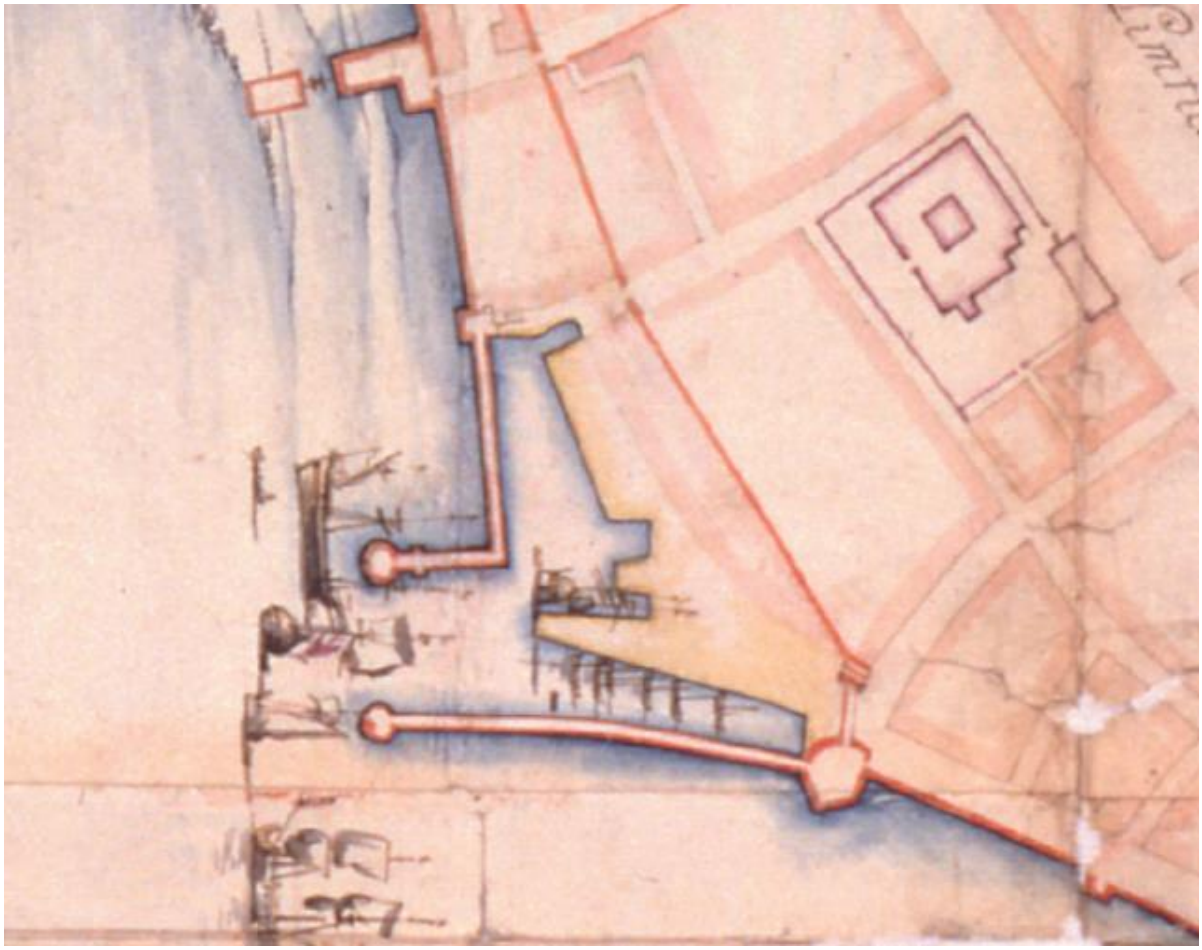


Figure 10. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) showing a single entrance into the harbour.

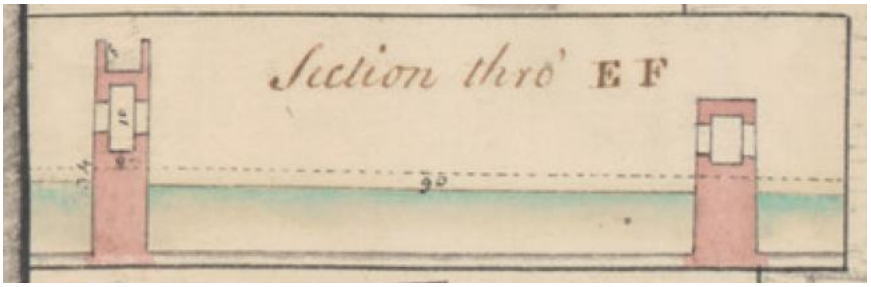


Figure 11. Section E-F from Eyres Map through the entrance into the Harbour (British Library – Irish Historic Towns Atlas 21 Limerick Map 15).

It is clear from mapping by Colles and Sauthier that the layout of the harbour and quays saw significant changes during the latter half of the 18th Century. Whereas previously there had

been a single narrow entrance into the harbour at King's Island a second, new entrance to a quay area was opened to the north (Figure 11).

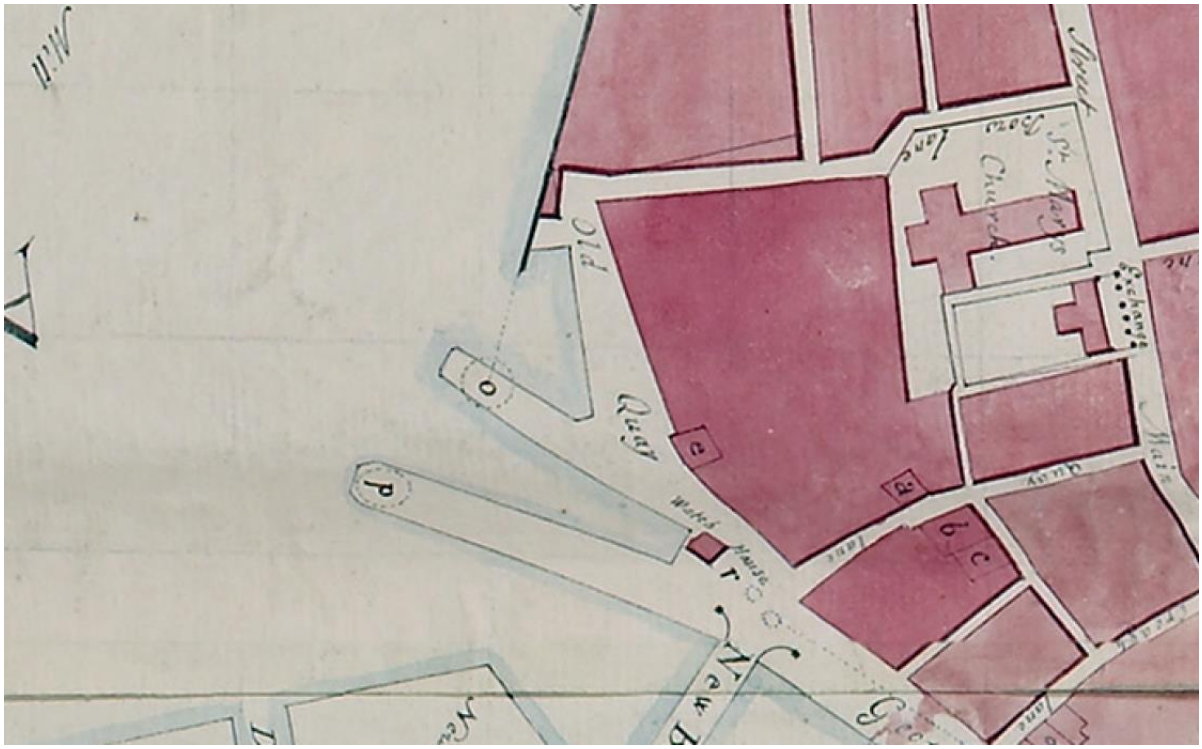


Figure 12. Extract from Limerick, 1769 by Christopher Colles (British Library) (Irish Historic Towns Atlas No. 21 Limerick, Map 18) showing second entrance to a quay to the north.

This quay was later filled in and the Court House constructed in the area during the early 19th Century. It is evident from an overlay of modern surveys that a section of City Wall may still be extant in the area between the Court House and the Council's Offices (Figure 13).

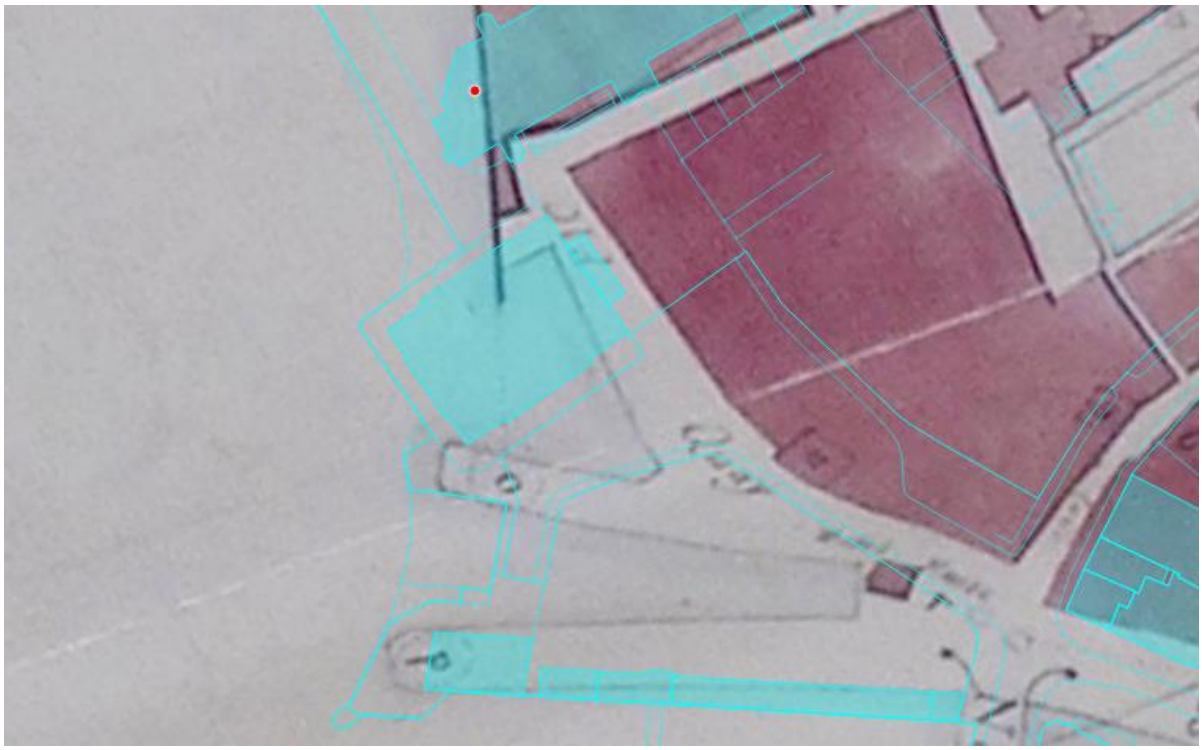


Figure 13. Extract from Limerick, 1769 by Christopher Colles (British Library) (Irish Historic Towns Atlas No. 21 Limerick, Map 18) overlaid with recent OSI Survey.

Celie O'Rahilly did place a trench in this area during archaeological excavations associated with the construction of the new Council Offices, however it appears that the trench may have been slightly to the east of this location and may have missed the City Wall if it was still in situ.

Proposed Works

It is proposed to construct a new gravity sewer between the Council's Offices and the Court House. The invert level of the sewer in this area is approximately 3 m and the ground level is approximately 4.2 m.

Proposed Testing

TT2-1

Approx. 1.5 m x 10 m, depth approx. 1.5 m

A single test trench is proposed in Area 2 along the alignment of the proposed gravity sewer (Figure 14). The purpose of the test trench is to identify if there are any extant remains of the City Wall in this area that may be affected by the proposed construction of the sewer.

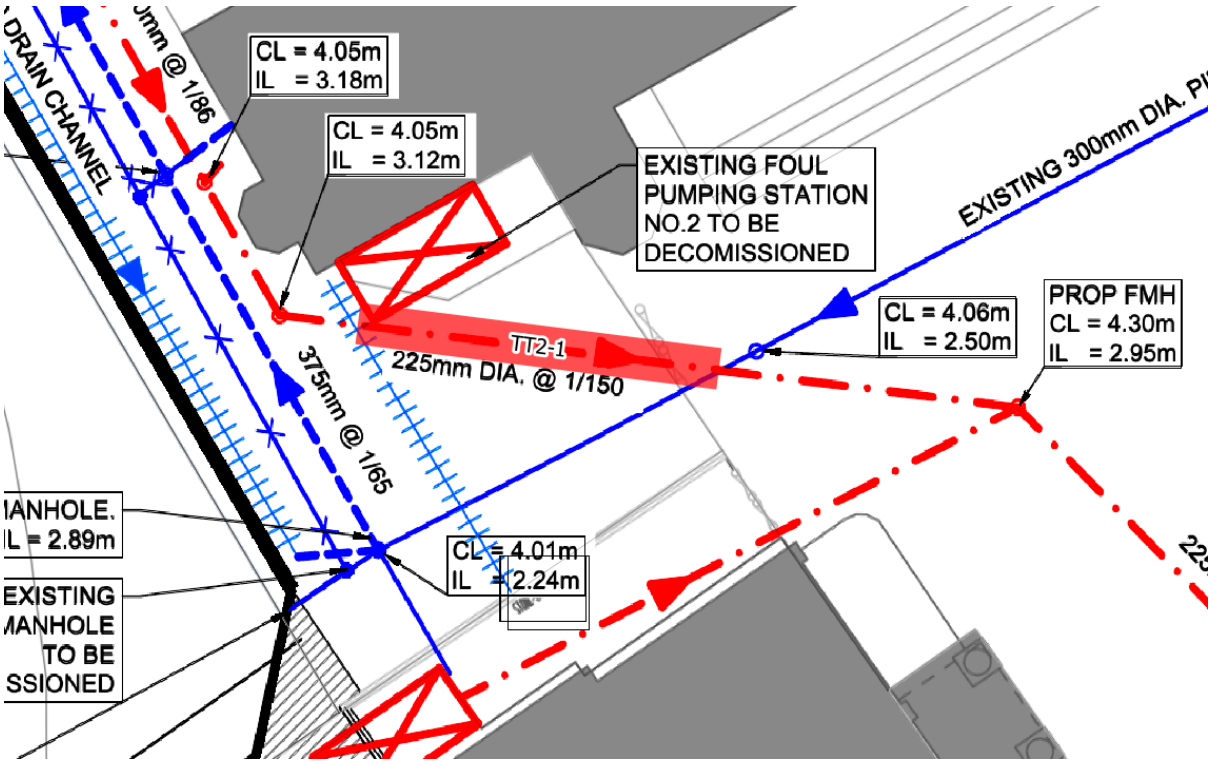


Figure 14. Proposed TT2-1 in Area 2.

Area 3

Archaeological Potential

Based on Colles' map the central quay associated with the harbour during the late 18th Century was located in the vicinity of the southern corner of the Court House (Figure 13). It is possible that there is material that dates from the earlier entrance into harbour as is evident when OSI's recent survey is overlaid on Phillips' map of 1685.

Given the extensive work that took place in the area at the time when the new entrance to quay to the north was constructed, during the late 18th Century, and the work to construct the Court House itself, it is unlikely that there are any remnants of the City Wall still extant. However, given the protection afforded to the City Wall through the National Monuments Act and the recognition of the status of town walls in the National Policy on Town Defences (2008), it is important to confirm whether there are any remains present.

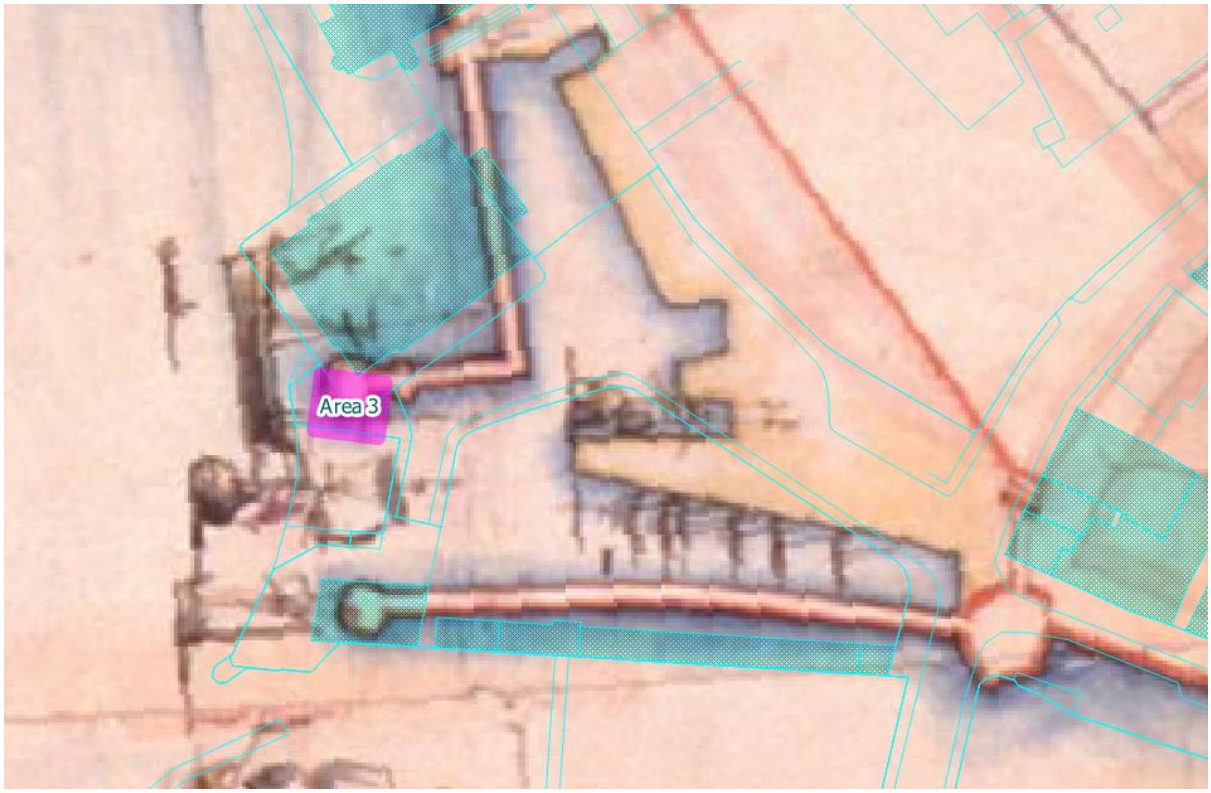


Figure 15. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) showing entrance to the harbour.

Proposed Works

Area 3 is situated to the south of the southern corner of the Court House. Flood defences are proposed along the coastal margins in the area. To support the flood defences, dig-out is to take place behind the quay walls to construct concrete foundations to a depth of approximately 4 m.

Proposed Testing

TT3-1 Approx. 1.5 m x 8 m, depth approx. 4m

TT3-2 Approx. 1.5 m x 6 m, depth approx. 4m

Two test trenches are proposed in Area 3, TT3-1 and TT3-2. Their extent is constrained by iron rail fencing around the Court House and a bench seat which is located parallel with the western face of the quay. The purpose of the test trenches (TT3-1 and TT3-2) is to ascertain whether there are any remains of the City Wall still extant.

Figure 16. Proposed test trench in Area 3 – TT3-1 and TT3-2.

Area 4

Archaeological potential

Early mapping, such as Colles' map from 1685, indicates that the southern range of the City Wall at the entrance into the harbour was located within the Potato Market (Figure 17). It would also appear that this area changed significantly towards the end of the 18th Century, with the construction of the new quays as indicated on Colles' Map (Figure 13).

Figure 17. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) with Area 4 indicated.

Proposed Works

A new flood defence wall is proposed between the Potato Market and the Boat Club to the west. To support the flood defences, dig-out is to take place to pour concrete foundations.

There is also a ramp to be constructed to allow access to the pedestrian bridge which extends south from the Potato Market, crossing the mouth of the Abbey River. The foundation for this ramp is to be relatively shallow (~0.5 m), however historic features associated with the previous quay and harbour walls would have been above high tide level and may, therefore, be located just below the surface. Proposed dig out for the flood wall between the Potato Market and the Boat Club is approximately 4 to 5 m depth.

Proposed Testing

TT4-1 to TT4-3

TT4-1 Approx. 1.5 m x 15 m depth approx. 4-5 m

The purpose of the test trench TT4-1 is to ascertain the nature and extent of any historic quay walls in the area of the proposed flood defence wall to the west of the Potato Market and to confirm whether or not there are any remnants of earlier quays in the area that may have been associated with the City Walls.

TT4-2 to TT4-3

TT4-2 Approx. 1.5 m x 20 m, depth approx. 0.75 m

TT4-3 Approx. 1.5 m x 6 m, depth approx. 0.75 m

The purpose of the test trenches TT4-2 and TT4-3 is to ascertain the nature and extent of any historic quay walls in the area of the proposed ramp and to confirm whether or not there are any remnants of earlier quays in the area that may have been associated with the City Walls.

TT4-4

TT4-4 Approx. 1.5 m x 10 m depth approx. 2 m

The purpose of the test trench TT4-4 is to ascertain the nature and extent of any historic quay walls in the area of the proposed surface water drainage and to confirm whether or not there are any remnants of earlier quays in the area that may have been associated with the City Walls.

Figure 18. Proposed test trenches in Area 4 – TT4-1 to TT4-4.

Area 5

Archaeological Potential

As has been noted in the discussion regarding Area 2, there were significant changes to the Merchant's Quay area in the late 18th Century, with the opening of a new entrance into a quay area in the vicinity of what is now the Court House.

Area 3, to the south of the Court House, is indicated as having been a quay area on Phillips' map of 1685 (Figure 19). Phillips' map is a good guide as it is spatially the most accurate of the 17th Century maps. However, even earlier maps, such as Hardiman's from 1590 (Figure 20), shows an extensive quays area to the east of the City Wall and north of the harbour entrance. It is interesting to note that Phillips indicates a second bounding wall further to the east that appears to enclose the quays area. This is likely a further layer of defence that may be part of the City's defences.

Figure 19. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) with approx. location of Area 5 indicated.

Figure 20. Extract from Limerick c.1590 by Hardiman (Trinity College Dublin) (Irish Historic Towns Atlas No. 21 Limerick, Map 6) show the quays area.

Figure 21. Extract from Limerick, 1769 by Christopher Colles (British Library) (Irish Historic Towns Atlas No. 21 Limerick, Map 18) overlaid with recent OSI Survey, showing Area 5.

Proposed Works

In Area 5 it is proposed to construct an inter-tidal surface water storage tank. This will consist of a large underground surface water storage tank. Proposed depth of dig-out for the tank is approximately 3.5 m deep. There is an outfall from the storage tank to the south west which will include oil interception. The dig-out for the outfall will be to a similar depth as the inter-tidal storage tank. It is evident that the outlet for the outfall is located in a relative recent quay wall to the west that was constructed when the harbour was filled in the mid-19th Century.

Proposed Testing

TT5-1 to TT5-4

TT5-1 Approx. 1.5 m x 9 m, depth approx. 3.5 m

TT5-2 Approx. 1.5 m x 20 m, depth approx. 3.5 m

TT5-3 Approx. 1.5 m x 10 m, depth approx. 3.5 m

TT5-4 Approx. 1.5 m x 7 m, depth approx. 3.5 m

There are four test trenches associated with the inter-tidal storage tank proposed in Area 5. Their purpose is to identify the extent of quay walls and any other associated structure that may be present.

TT5-5

TT5-5 Approx. 1.5m x 10 m, depth approx. 3.5 m

The purpose of TT5-1 is to investigate the archaeological potential of the proposed outfall and oil interceptor.

Figure 22. Proposed test trenches in Area 5 – TT5-1 to TT5-5.

Area 6

Archaeological Potential

Area 6 is located in Merchant's Quay, to the west of Bridge Street. A review of early mapping indicates that this area has been associated with the harbour and quays since at least the 16th Century. It is clear from this early mapping that there was a gate to the east in this area that provided access to the quays from the east and that there was a substantial tower at the approximately location of the intersection of Bridge Street, Merchant's and George's Quay (Figure 23 and Figure 24). This tower was likely associated with manning the access to the quays but was also likely a defensive structure overlooking the Abbey River.

The tower was located at the bottom of Bridge Street, prior to the construction of Mathew Bridge, and historic maps indicate that Bridge Street turned to the east at its southern extent and continued as George's Quay. Based on this it appears likely that the towers and gate were located to the east of Bridge Street.

Figure 23. Extract from Limerick c.1590 by Hardiman (Trinity College Dublin) (Irish Historic Towns Atlas No. 21 Limerick, Map 6) showing the quays area, with gated entrance from the east evident.

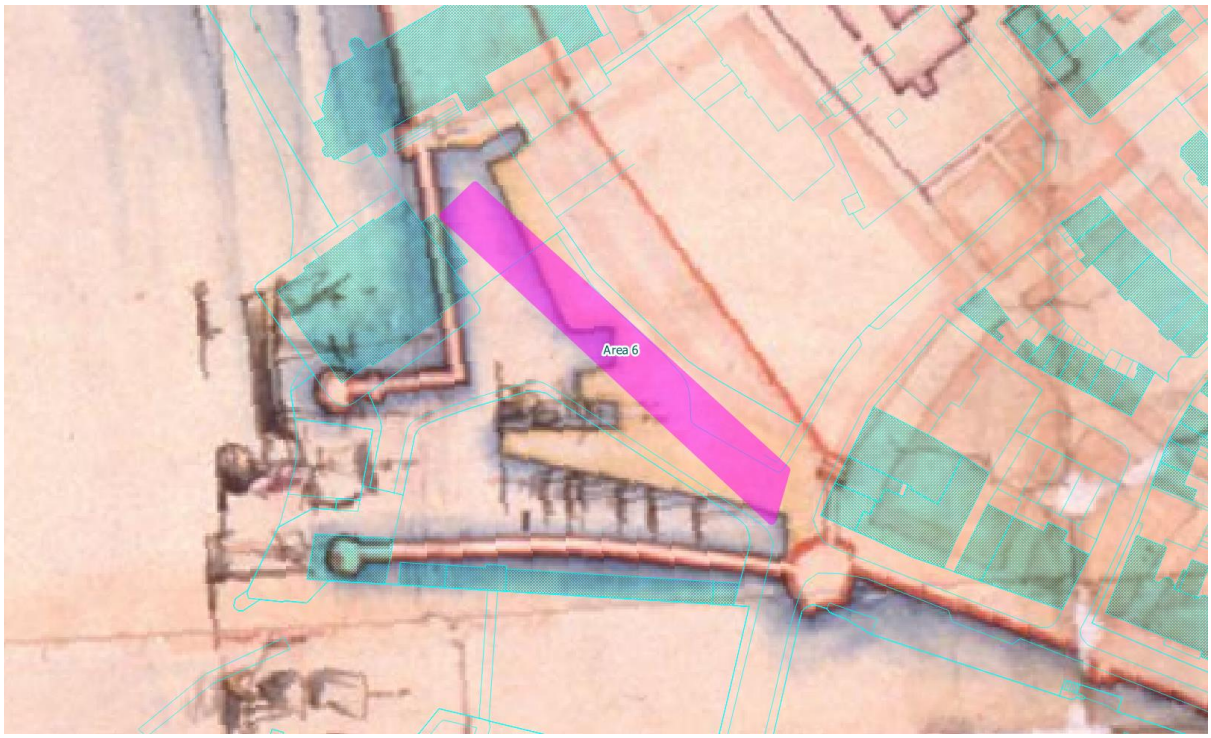


Figure 24. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) with area 6 indicated.

Proposed Works

It is proposed that the gravity sewer will be constructed along an alignment from Merchant's Quay to Georges Quay (red dashed line in Figure 25). There are also regrading works proposed at the intersection, which will involve the removal of the road surface and a shallow

ground reduction (~0.5 m) of the shaded area indicated in Figure 25. New surface water drainage is also proposed, but this is to follow existing drains and no new excavation is envisaged to facilitate this.

It is noted that the gravity sewer increases in depth along its length and that at the point at which it crosses Bridge Street it will be required to be at a depth of approximately 2.5m and will amount to a substantial dig-out.

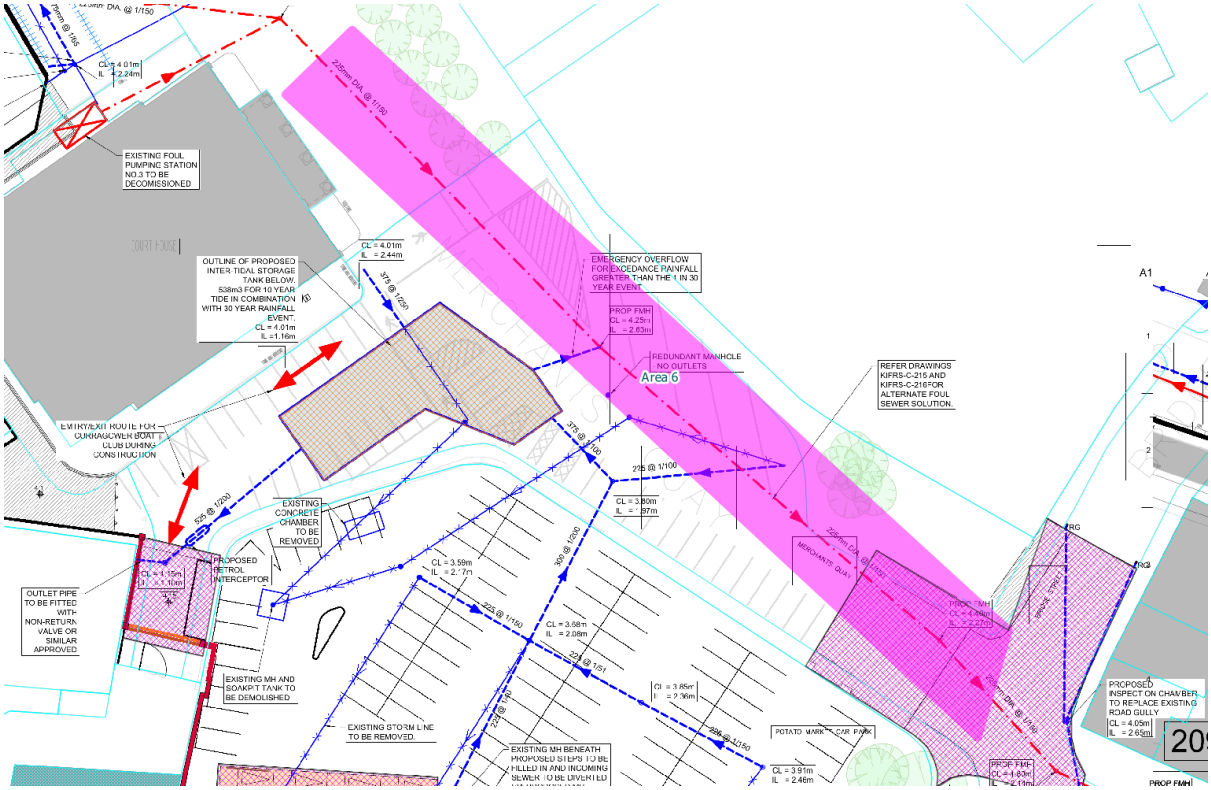


Figure 25. Proposed works at the intersection of Bridge Street, Merchant's Quay and George's Quay.

Proposed Testing

TT6-1 & TT6-4

TT6-1 1.5 m x 12 m, depth approx. 3 m

TT6-2 1.5 m x 6 m, depth approx. 3 m

TT6-3 1.5 m x 6 m, depth approx. 3 m

TT6-4 1.5 m x 6 m, depth approx. 3 m

There are four test trenches proposed in Area 6 (Figure 26), these are orientated roughly north south along the alignment of the proposed gravity sewer. The purpose of these test trenches is to try and ascertain whether there are any features associated with the City Wall located along the proposed route of the sewer and in the vicinity of Bridge Street.

The purpose of test trench TT6-1 is also to try and ascertain whether there are any remnants of the City Wall to the west of Bridge Street and, if so, whether there is a break in the wall at a sufficient depth to facilitate the proposed gravity sewer without impacting on the City Wall.

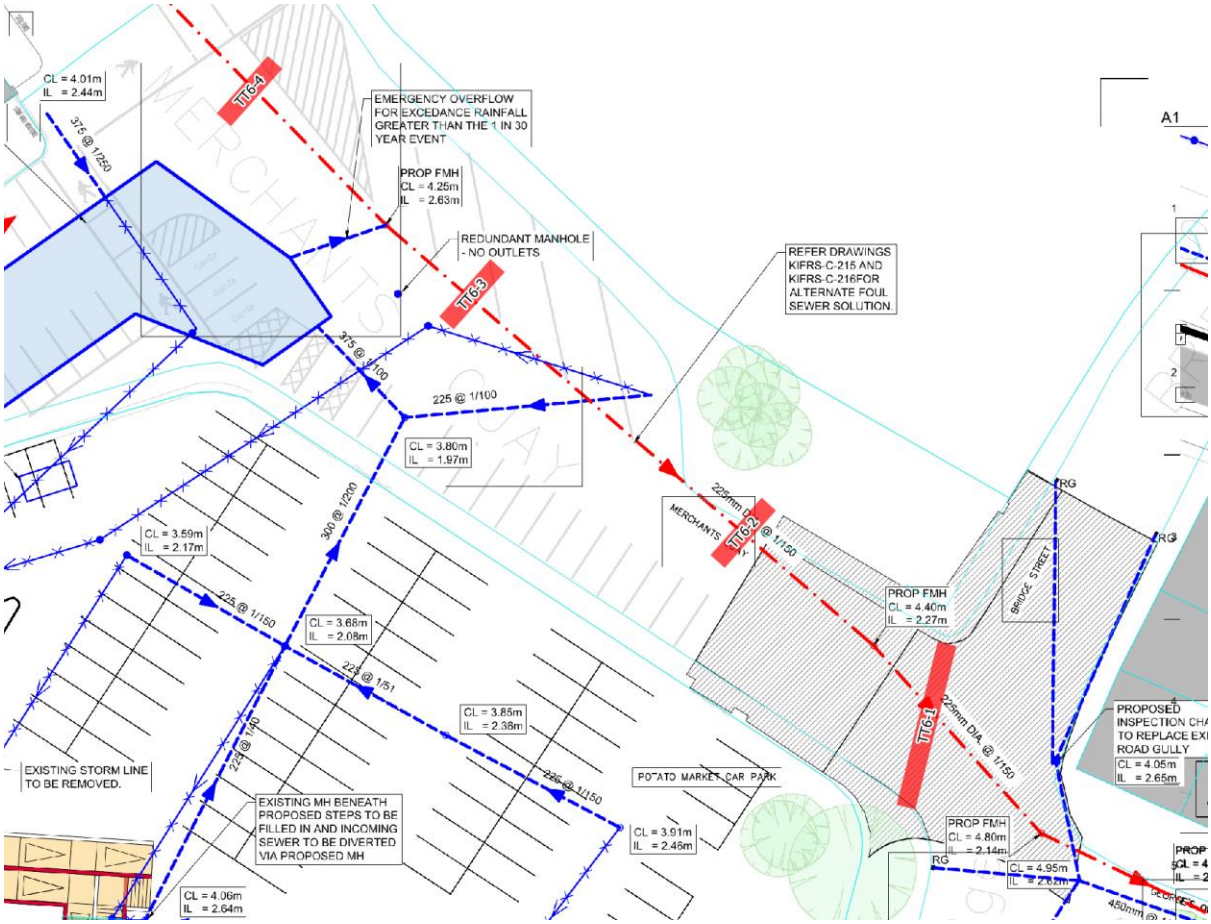


Figure 26. Proposed testing in Area 6 – TT6-1 & TT6-4.

Area 7

Archaeological Potential

Area 7 is located along George's Quay roadway immediately to the east of Bridge Street. Similarly to Area 6, this area is in the vicinity of the City Walls and tower and gateway associated with access into the quays area. However, as is noted in the archaeological potential discussion of Area 6, it is likely that the towers and gate were located to the west of Bridge Street.

Proposed Works

Similarly to Area 6 the main works in this area relate to the installation of the proposed gravity sewer, which given its distance from the Council's Offices is to be installed at over 2 m depth and will include substantial ground disturbance.

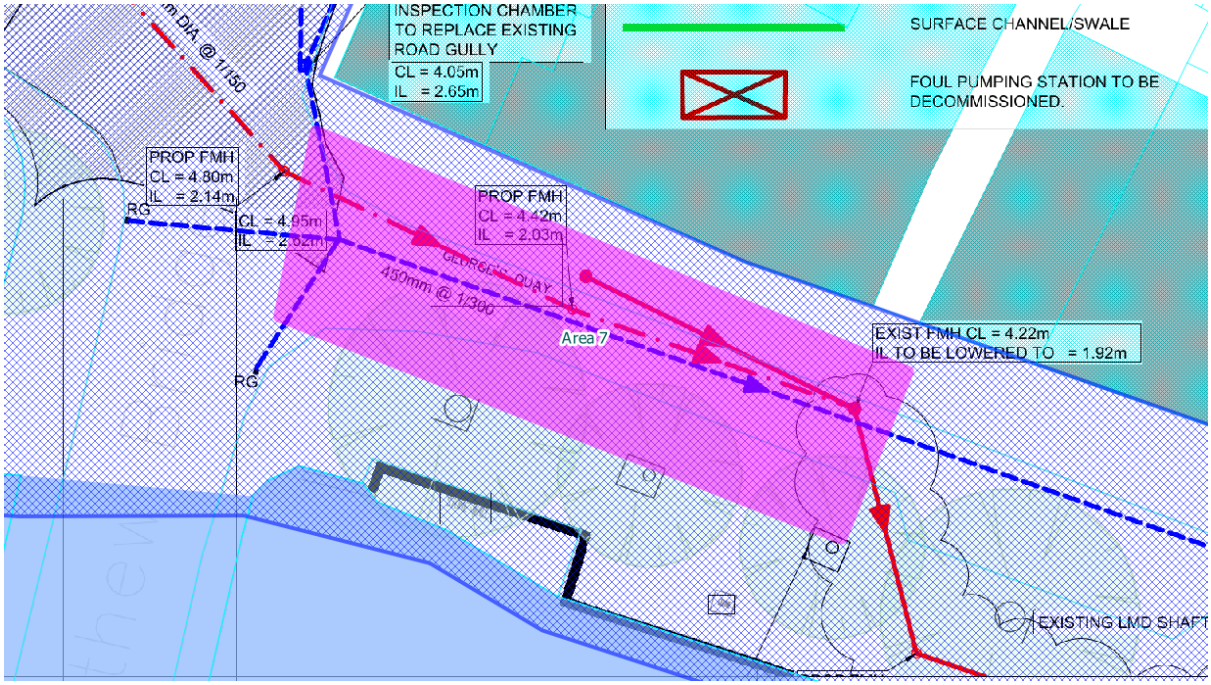


Figure 27. Proposed works at the western end of George's Quay with Area 7 indicated.

Proposed Testing

TT7-1 & TT7-2

TT7-1 1.5 m x 6 m, depth approx. 3m

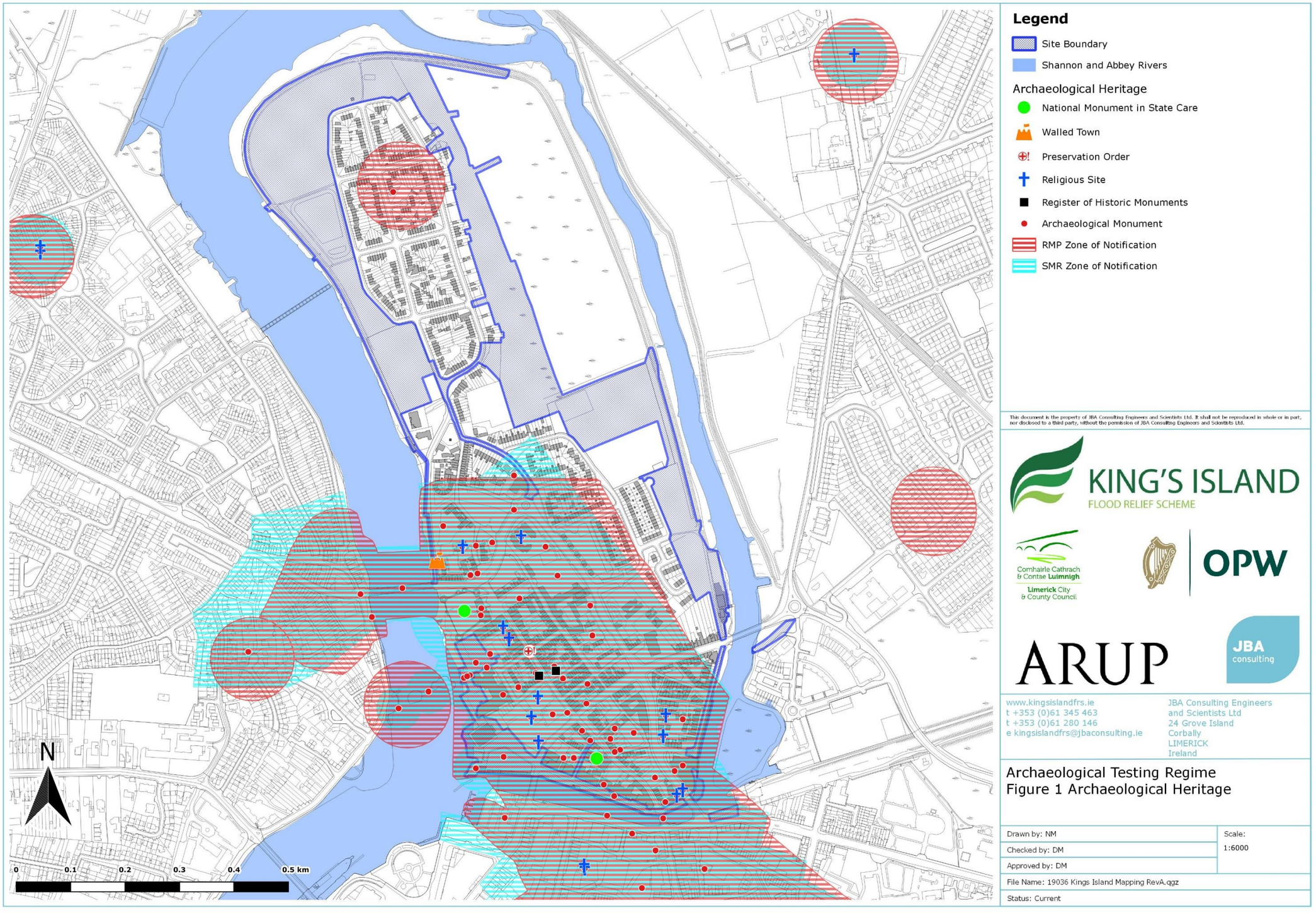
TT7-2 1.5 m x 6 m, depth approx. 3m

There are two test trenches proposed in Area 7 (Figure 28), these are orientated roughly north south along the alignment of the proposed gravity sewer. The purposed of these test trenches is to try and ascertain whether there are any features associated with the City Wall located along the proposed route of the sewer and in the vicinity of Bridge Street.

Figure 28. Proposed testing in Area 7 – TT7-1 and TT7-2.

Appendix 1

A3 Figures


Legend
Site Boundary
Shannon and Abbey Rivers
Archaeological Heritage
National Monument in State Care
Walled Town
Preservation Order
Religious Site
Register of Historic Monuments
Archaeological Monument
RMP Zone of Notification
SMR Zone of Notification
N
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0.1
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0.3
0.4
0.5 km
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Figure 1 Archaeological Heritage
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Scale:
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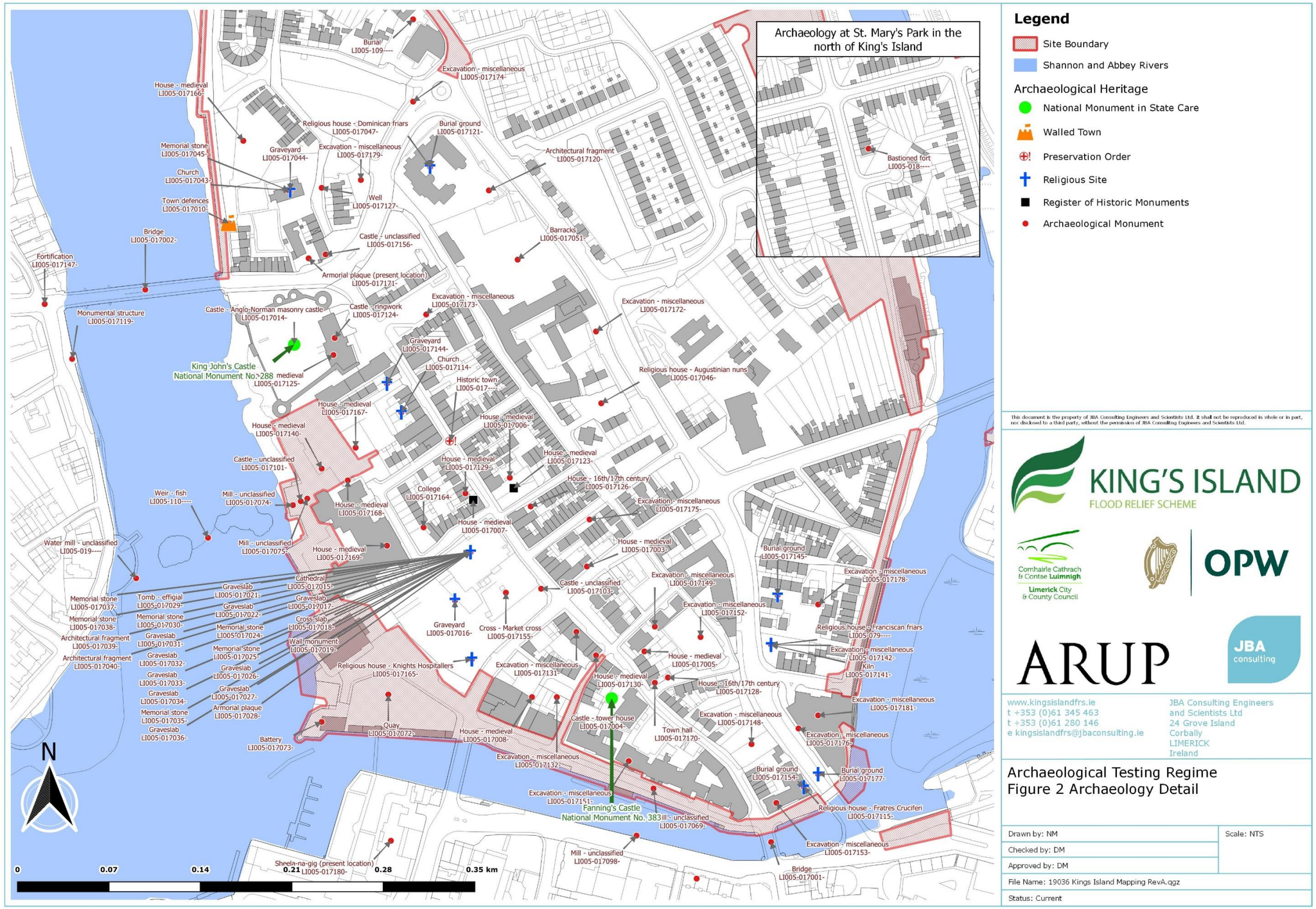
Status: Current


Archaeology at St. Mary's Park in the north of King's Island
Bastioned fort LI005-018----
Legend
Site Boundary
Shannon and Abbey Rivers
Archaeological Heritage
National Monument in State Care
Walled Town
Preservation Order
Religious Site
Register of Historic Monuments
Archaeological Monument
Burial LI005-109----
Excavation - miscellaneous LI005-017174-
House - medieval LI005-017166-
Religious house - Dominican friars LI005-017047-
Burial ground LI005-017121-
Memorial stone LI005-017045-
Graveyard LI005-017044-
Excavation - miscellaneous LI005-017179-
Architectural fragment LI005-017120-
Church LI005-017043-
Well LI005-017127-
Town defences LI005-017010-
Bridge LI005-017002-
Castle - unclassified LI005-017156-
Barracks LI005-017051-
Fortification LI005-017147-
Armorial plaque (present location) LI005-017171-
Excavation - miscellaneous LI005-017173-
Monumental structure LI005-017119-
Castle - Anglo-Norman masonry castle LI005-017014-
Castle - ringwork LI005-017124-
Excavation - miscellaneous LI005-017172-
Graveyard LI005-017144-
King John's Castle National Monument No.288 medieval LI005-017125-
Church LI005-017114-
Religious house - Augustinian nuns LI005-017046-
Historic town LI005-017---
House - medieval LI005-017167-
House - medieval LI005-017006-
House - medieval LI005-017140-
House - medieval LI005-017123-
Castle - unclassified LI005-017101-
House - medieval LI005-017129-
House - 16th/17th century LI005-017126-
College LI005-017164-
Weir - fish LI005-110----
Mill - unclassified LI005-017074-
House - medieval LI005-017168-
Excavation - miscellaneous LI005-017175-
House - medieval LI005-017007-
Water mill - unclassified LI005-019----
Mill - unclassified LI005-017075-
House - medieval LI005-017169-
House - medieval LI005-017003-
Burial ground LI005-017145-
Cathedral LI005-017015-
Castle - unclassified LI005-017103-
Excavation - miscellaneous LI005-017149-
Excavation - miscellaneous LI005-017178-
Graveslab LI005-017021-
Graveslab LI005-017017-
Memorial stone LI005-017037-
Tomb - effigial LI005-017029-
Graveslab LI005-017022-
Excavation - miscellaneous LI005-017152-
Memorial stone LI005-017038-
Memorial stone LI005-017030-
Cross-slab LI005-017018-
Graveyard LI005-017016-
Cross - Market cross LI005-017155-
Religious house - Franciscan friars LI005-079----
Architectural fragment LI005-017039-
Graveslab LI005-017031-
Memorial stone LI005-017024-
Wall monument LI005-017019-
Excavation - miscellaneous LI005-017142-
Architectural fragment LI005-017040-
Graveslab LI005-017032-
Memorial stone LI005-017025-
Religious house - Knights Hospitallers LI005-017165-
Excavation - miscellaneous LI005-017131-
House - medieval LI005-017005-
Kiln LI005-017141-
Graveslab LI005-017033-
Graveslab LI005-017026-
House - medieval LI005-017130-
House - 16th/17th century LI005-017128-
Graveslab LI005-017034-
Graveslab LI005-017027-
Excavation - miscellaneous LI005-017181-
Armorial plaque LI005-017028-
Memorial stone LI005-017035-
Castle - tower house LI005-017004-
Excavation - miscellaneous LI005-017148-
Graveslab LI005-017036-
Quay LI005-017072-
Town hall LI005-017170-
Excavation - miscellaneous LI005-017176-
Battery LI005-017073-
House - medieval LI005-017008-
Excavation - miscellaneous LI005-017132-
Burial ground LI005-017154-
Burial ground LI005-017177-
Excavation - miscellaneous LI005-017151-
Fanning's Castle National Monument No. 383
Mill - unclassified LI005-017069-
Religious house - Fratres Cruciferi LI005-017115-
Excavation - miscellaneous LI005-017153-
Mill - unclassified LI005-017098-
Sheela-na-gig (present location) LI005-017180-
Bridge LI005-017001-
N
0
0.07
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0.21
0.28
0.35 km
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Archaeological Testing Regime
Figure 2 Archaeology Detail
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Scale: NTS
Checked by: DM
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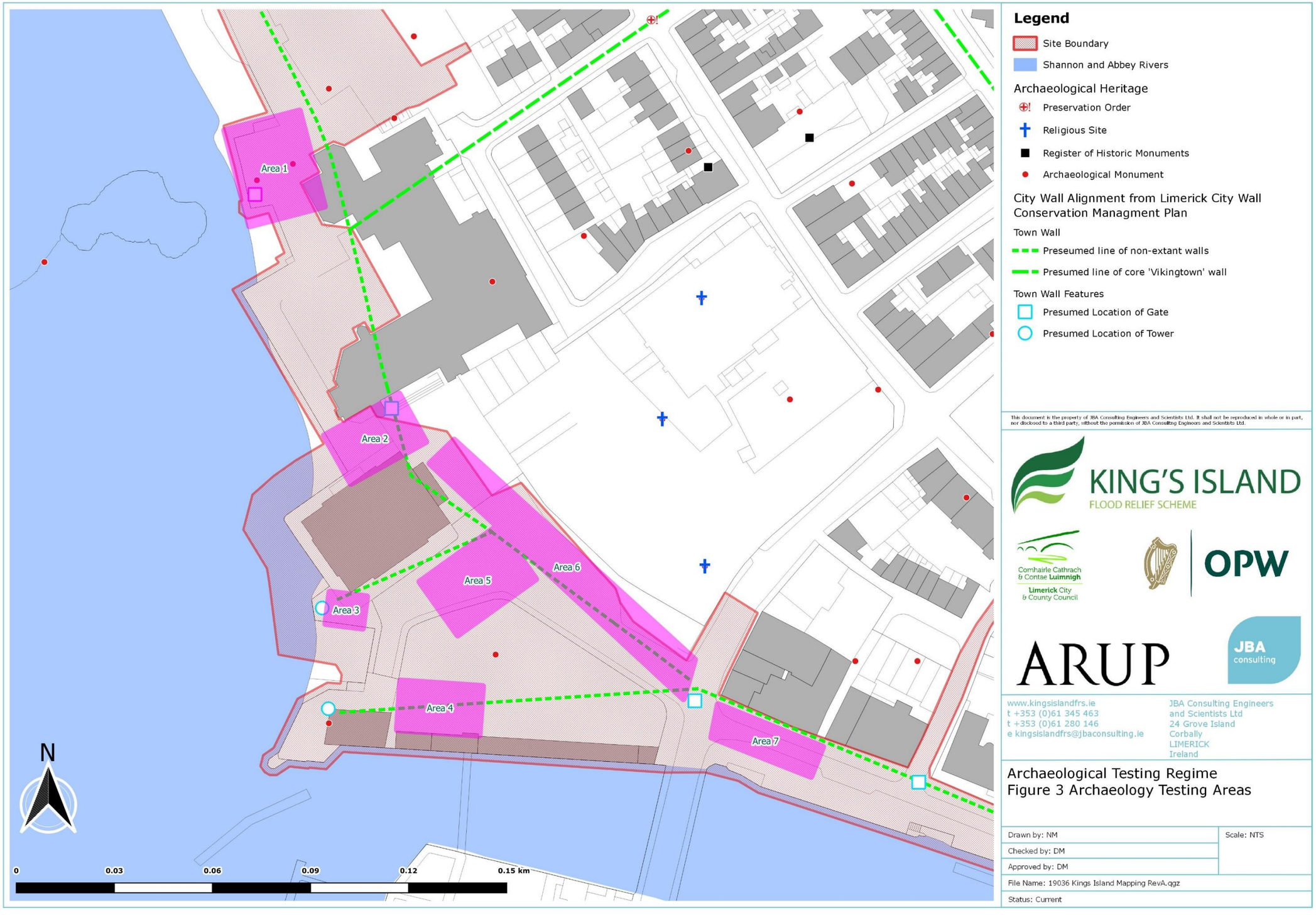
Area 1
Area 2
Area 3
Area 4
Area 5
Area 6
Area 7
N
0
0.03
0.06
0.09
0.12
0.15 km
Legend
Site Boundary
Shannon and Abbey Rivers
Archaeological Heritage
Preservation Order
Religious Site
Register of Historic Monuments
Archaeological Monument
City Wall Alignment from Limerick City Wall Conservation Managment Plan
Town Wall
Preseumed line of non-extant walls
Presumed line of core 'Vikingtown' wall
Town Wall Features
Presumed Location of Gate
Presumed Location of Tower
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Archaeological Testing Regime
Figure 3 Archaeology Testing Areas
Drawn by: NM
Scale: NTS
Checked by: DM
Approved by: DM
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