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

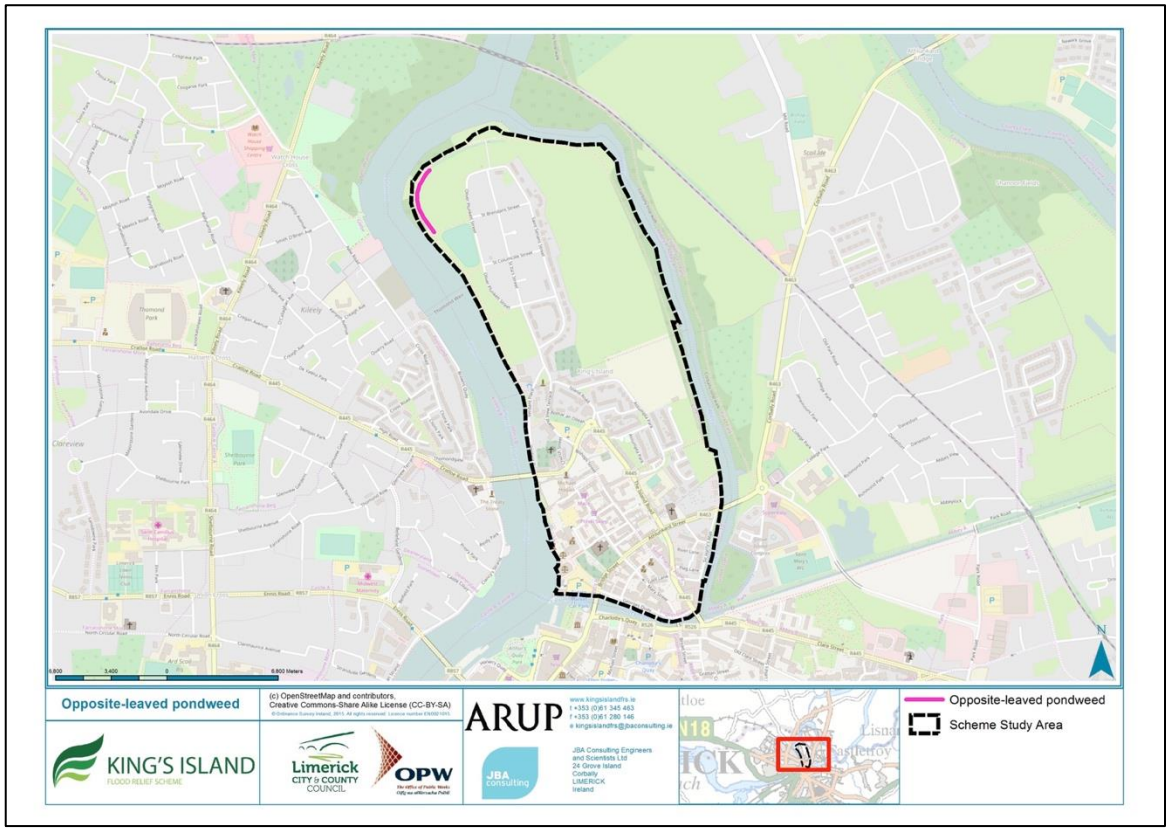
King's Island is susceptible to both coastal and fluvial flood risk and very significant flooding occurred in spring 2014 when existing defences failed locally, both overtopping the through breaching. A proposed flood relief scheme at King's Island will construct an embankment on the western side of 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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