Appendix 5C
Invasive Plant Survey

OFFICE OF PUBLIC WORKS

Lower Lee (Cork City) Drainage Scheme

INVASIVE PLANT SURVEY

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Table of Contents

1. Introduction

Triturus Environmental consultants were appointed by Ryan Hanley to undertake an invasive plant survey along the corridor of the Lower River Lee and major tributaries (namely the Curragheen, Glasheen, Bride [North] and Glenamought) in Co. Cork (see Fig 2.1). The work was commissioned in order to establish the distribution of invasive plants overlapping proposed infrastructural flood relief works forming part of the Lower Lee (Cork City) Drainage Scheme. The scheme is required to prevent or minimise flood events damaging urban infrastructure. Severe flood events have become increasingly frequent in Cork City, the most significant being those occurring in November and December 2009.

The River Lee (river code: IE_SW_19_1663) runs for some 65km, with the catchment draining an area of approx. 1250km^2. According to O' Mahony (2009) the flora of the River Lee is 'varied and interesting, containing a range of wetland habitats and a wide mix of native and naturalised plants'. Given that the Lee has an important botanical diversity it is important to prevent the spread of invasive plants. This can be first achieved by identifying their distribution and then by removing them from affected areas.

Prior to the walkover survey component of this report, a number of terrestrial invasive species were identified from the survey area (NBDC, 2014), notably Himalayan Balsam (*Impatiens glandulifera*), Japanese Knotweed (*Fallopia japonica*) and Giant rhubarb (*Gunnera tinctoria*). Water fern (*Azolla filiculoides*) and Nuttall's Pondweed (*Elodea nuttallii*) are the two notable aquatic invasive species on the River Lee, both of which have been expanding their distribution more recently (pers. obs.). All of the above species were prioritised as target species to be recorded during the survey given that they are considered as having potential to become highly invasive.

Other non-native species which are considered less invasive included Buddleia (*Buddleia davidii*), Winter Heliotrope (*Petasites fragrans*), Snowberry (*Symphoricarpos albus*), Cherry Laurel (*Prunus laurocerasus*) and Montbretia (*Monbretia x crocosmiiflora*) were not recorded during the current survey. Additionally, O' Mahony (2009) also records Travellers Joy (*Clematis vitalba*) and Prickly lettuce (*Lactuca serriola*) as alien threats to the lower Lee. The former is very widespread in the urban hedgerows of Cork City (pers. obs.). However, none of the above mentioned species were appraised during the current survey as they are not subject to restrictions under sections 49 and 50 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477/2011), i.e. not listed on the 3rd schedule.

The primary purpose of this report was therefore to record noxious invasive plant species in order to identify the extent of overlap between them and the proposed flood relief works areas. The noxious invasive species are those which have the greatest risk of reducing riparian diversity, damaging ecosystem functioning or damaging infrastructure (e.g. Japanese Knotweed). On the River Lee the most prominent noxious invasive plants would include Himalayan Balsam, Japanese Knotweed and Giant rhubarb. By identifying where invasive plants overlap with works areas, mitigation can be recommended to prevent their spread due to mechanical disturbance or transfer to other areas off-site by machinery.

In addition to collation of field records, this report provides a contemporary baseline GIS database of noxious invasive species along the River Lee and tributaries Curragheen, Bride and Glenamought river corridors. The records of these species will assist their future management and help inform strategies for control over time by interpolating changes in patterns of spread.

Invasive species

An invasive species can be defined as one who's introduction and/or spread outside their natural past or present distribution threatens biological diversity (Convention on Biological Diversity). A wider definition includes the characteristic of causing economic or environmental detriment or harm to human health. The damage to native species and ecosystems worldwide caused by invasive non-native species is estimated to be as serious as the loss and degradation of habitats (IUCN, 2000).

Aside from environmental impacts, the economic costs associated with the control and management of invasive species are also cause for serious concern. Invasive species can, and do, negatively affect many sectors including tourism, recreation, agriculture, horticulture and construction. In Ireland alone the most recent estimate of economic impact caused by invasive species stands at over €202 million annually (Kelly *et al.*, 2013).

Notably, not all non-native (alien) species have the potential to become invasive (Richardson *et al.*, 2000) and their potential threat is determined by a number of inter-related factors (Williamson & Fitter, 1996; Stokes *et al.*, 2006). For a species to become invasive it must successfully out-compete native organisms, spread through its new environment, increase in population density and harm ecosystems in its introduced range (Keller *et al.*, 2011).

Incidentally, for the purposes of this report, it should be clarified that a non-native species does not automatically convey invasive properties. Whilst many species in Ireland, such as sycamore (*Acer psuedoplanatus*), beech (*Fagus sylvatica*) and fuschia (*Fuschia magellanica*) are indeed (established) non-native, their overall ecological impact on biodiversity is considered low or benign (Stout, 2011; O Flynn *et al.*, 2014). In fact, a recent estimate is that only 19% of non-native plants with well-established populations are considered invasive in Ireland (Milbau & Stout, 2008). Certain non-native plant species, such as Buddleia and Montbretia are typically only recorded on a local scale and have not been shown to have any wide reaching negative implications on biodiversity in Ireland. Nevertheless, whilst some non-native species may have little impact on a national scale they can be associated with severe impacts on a local scale and should not be ignored (Milbau & Stout, 2008).

Therefore, the focus of this report is to assess those non-native plants which are deemed noxious invasive species. In accordance with both the Draft Cork County Development Plan 2013 and the Cork City Development Plan 2015-2021, the principal invasive species within the study area are considered to be Japanese Knotweed and Himalayan Balsam. Others terrestrial invasive species such as Giant Rhubarb were also surveyed for. Nuttall's Pondweed and *Azolla* Water fern were recorded in aquatic habitats bordering the flood relief infrastructure.

Invasive species legislation in Ireland

Invasive species present a serious threat to native biodiversity and failure to address the issues of non-native or invasive species may contravene Ireland's obligations under a number of conventions and the EU Habitats Directive (NRA, 2010). For example, among the worst invasive plants in Ireland are Japanese and Giant Knotweed (*Fallopia sachalinensis*), which are now listed under the 3rd Schedule: Part 1 of Birds and Habitats Directive S.I 477 of 2011 as non-native (plant) species subject to restrictions under Regulations 49 & 50. Regulation 49 deals with the "Prohibition on introduction and dispersal" of listed species such as Japanese knotweed; while Regulation 24 seeks to "to prevent the dispersal, establishment or spread of an animal or plant to which Regulation 49 or 50 applies". Additionally, the Wildlife (Amendment) Act 1976 - 2000 states that "anyone who plants or otherwise causes to grow in a wild state in any place in the State any species of (exotic) flora, or the flowers, roots, seeds or spores of (exotic) flora shall be guilty of an offence".

2. Methods

Desktop review

Prior to field survey commencement, an in depth review of literature relating to invasive species and any previous ecological studies of the study areas were carried out. Relevant published and un-published reports and literature were consulted.

Study Sites

The survey focused on the defined proposed works areas as opposed to the entire length of river channels. Works areas were present along the Lee (both North and South channels), Curragheen, Bride (North) and Glenamought river's. The assessment of the distribution of invasive plants within the proposed works zones incorporated the rivers listed in Table 2.1 and illustrated on Figure 2.1 below.

Table 2.1- River channels surveyed for invasive species as part of the Lower Lee Flood Relief scheme

River	Survey area	Length of channel to be surveyed (approx.)
River Lee (lower)	Innishcarra Hydroelectric Dam d/s to the Port of Cork, Cork City (including both the North and South channels of the river flowing through Cork City & the secondary channel flowing through Ballincollig Park)	25.3km
Curragheen River	150m u/s Carrigrohane Bridge, d/s to confluence with River Lee South channel	3km
Glasheen River	R608 road bridge (Glasheen) d/s to confluence with Curragheen River	0.5km
River Bride (North)	150m u/s Blackstone Bridge d/s to Blackpool, Cork City (where river is culverted underground until River Lee confluence)	3.4km
Glenamought River	300m u/s Kilcully Bridge d/s to confluence with River Bride at North Point Business Park	0.57km

Mapping Invasive Species

A key objective of the project was to store and manage all invasive species data recorded during the field surveys on a GIS database, for ease of dissemination and assimilation between relevant stakeholders and authorities. The GIS database was constructed using a combination of MS Excel 2016 and the open-source Quantum GIS v2.18. At the commencement of the field survey period a joint training day with all surveyors was undertaken to ensure consistency of field procedures and data recording. Features of interest were recorded in the field using a GLONASS-supported Garmin eTrex 30 handheld GPS unit. Each individual feature of interest (i.e. invasive and non-native species) was assigned a unique identifier code for each of the five rivers surveyed, as well as each defined proposed works area. This information included species name (common and scientific), GPS coordinates (ITM), surrounding habitat type and land use, details on

physical attributes (such as dimensions of stand, other species associations) and details on the location of the feature within the site. Additionally, this information was correlated, through the same unique identifier code, to individual photographic images, as well as annotated maps. Invasive species were mapped within a 50m buffer of the river channels. Any further distance from the channels was considered outside the zone of influence of any proposed works. Three individual datasets were constructed, with invasive species recorded and annotated as either a polygon (≥100m^2 in area), polyline (≥10m in length and ≤2m in width) or a single point (≥1m in are / length or ≤100m^2). The survey concentrated on the riparian zone either side of the main watercourses, however systematic checks were also carried out of the aquatic zone to determine the presence of aquatic invasive species, such as Nuttall's Pondweed (*Elodea nuttalii*) and Azolla Waterfern (*Azolla filiculoides*).

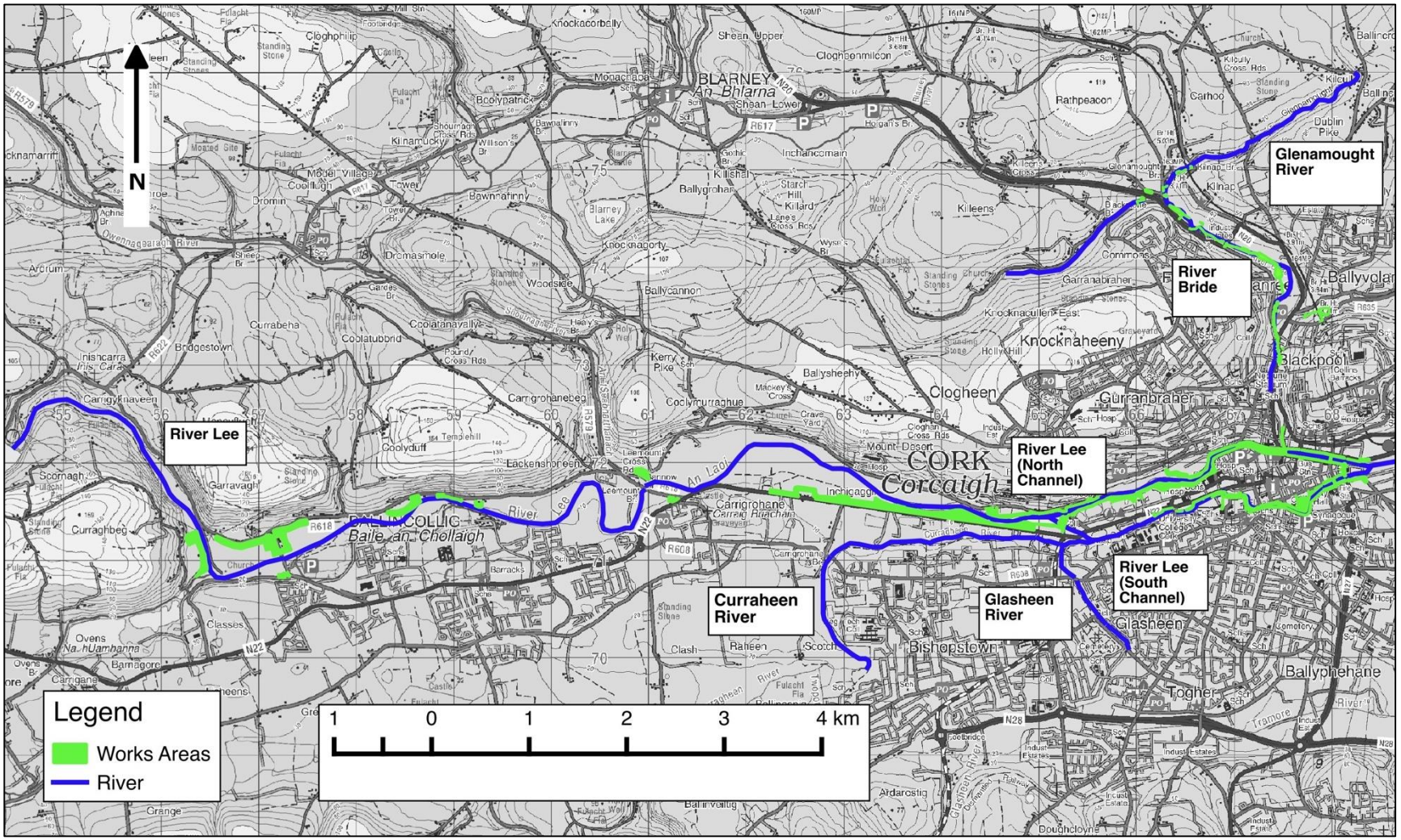

Figure: 2.1 - Overview of the Lower Lee (Cork City) Drainage Scheme study area

Optimum Survey Period

Walkover surveys for invasive species were carried out during optimum periods when plants were still vegetated and/or in flower. In practice this was the August to September period, prior to the autumn die-back. This timing was vital and aided in correct species identification and also facilitated a more accurate appraisal of the true density and distribution of invasive plant species along the River Lee and selected tributaries. Aquatic species surveys were also conducted during this period where good water clarity allowed.

3. Results

General overview

Field work was undertaken during August and September 2014, while a small section of river on the north bank of the River Lee, adjoining the Innishcarra Road was surveyed during 2016. A total of 95 individual records of invasive species were documented during the course of the study, within the proposed works areas on five rivers (Lee, Curragheen, Bride [North] & Glenamought). Summary data of each individual record is presented in Appendix 1. Maps showing the distribution of records for each river channel are outlined in the proceeding sections of this report.

Overall, the most commonly recorded species was Japanese Knotweed, being observed at 54 locations within the proposed works areas. This was followed by Himalayan Balsam, which was recorded in 21 separate locations. Broadly speaking, Himalayan Balsam was most frequent along the River Lee, particularly in the sections from Lee Road downstream to Fitzgerald's Park (Cork City). Japanese Knotweed was especially frequent within Cork City boundaries, on the Lee, Curragheen and Bride (North) rivers. Notably, none was recorded downstream of Clarkes Bridge, Cork City centre. However, the Mardyke walkway (i.e. UCC North Mall Campus) had very dense stands of knotweed behind areas enclosed by fencing.

Fig 3.1 - Himalayan Balsam growing in shade along the Lee Fields, River Lee (North bank)

A new invasive species record for the survey area (according to the data of O' Mahony (2010); NBDC, 2014), for Nuttall's Pondweed (River Lee) was documented. Nuttall's Pondweed was especially prominent in the Lee Fields stretch of the River Lee. These records are detailed in Appendix I. The findings for each river surveyed are presented below in specific relation to overlaps with proposed works area boundaries.

River Lee - invasive species overlaps with proposed works areas

Within the works areas along the River Lee (both north and south channels), a total of 5 noxious invasive plant species were recorded (three terrestrial & two aquatic). Japanese Knotweed was the most frequently recorded invasive, occurring at 30 different locations within the works areas. This species was particularly abundant within the Cork City boundaries. Himalayan Balsam was recorded at 21 locations along the River

Lee works areas. Giant rhubarb was locally frequent in Fitzgerald's Park and on the north bank of the River Lee opposite the park. Nuttall's Pondweed, a submerged aquatic macrophyte previously unrecorded downstream of Innishcarra Reservoir (Caffrey et al., 2006), was recorded at 8 locations. It was widespread on the north bank on the River Lee in the Lee Fields in slack areas of water. Its distribution was localised and no extensive stands were observed. The water fern, *Azolla filiculoides* was recorded at a single small, wetland location at Hollymount, on the north bank of the Lee Fields. No other aquatic invasive species were recorded. The overall distribution of invasive species along the lower River Lee proposed works areas are shown in Figures 3.1, 3.2, 3.3 and 3.4. One invasive plant species was recorded along the works areas on the north and south banks of the Curragheen River, tributary of the River Lee – namely Japanese Knotweed. The species occurred at 6 locations within these areas (four points and one linear strip). No aquatic invasive species were recorded along the Curragheen. The distribution of invasive species along the Curragheen River is shown in Fig 3.2 below.

River Bride-invasive species overlaps with proposed works area

Two invasive species, Japanese Knotweed and Giant rhubarb, were recorded along the proposed works areas on the River Bride channel. All told, Japanese Knotweed was recorded at 12 locations within these areas, whilst Giant rhubarb was present as a single plant in the amenity park adjacent to Blackpool Retail Park. No aquatic invasive species were recorded in the River Bride. It should be noted that approx. 1.5km of the existing channel is culverted underground from Blackpool, Cork City to its confluence with the River Lee at Popes Quay and thus it was not possible or pertinent to survey this section. The distribution of invasive species along the River Bride is shown in Fig 3.4. Japanese Knotweed was the only invasive species recorded along Glenamought River channel. It was recorded at four locations. The distribution of invasive species along the Glenamought River proposed works area is shown in Fig 3.4 (below).

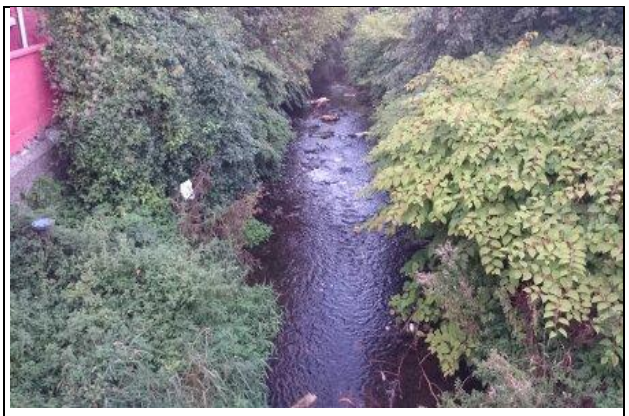

Fig 3.4 - Japanese Knotweed on the River Bride at Orchard Court, Blackpool, Cork City

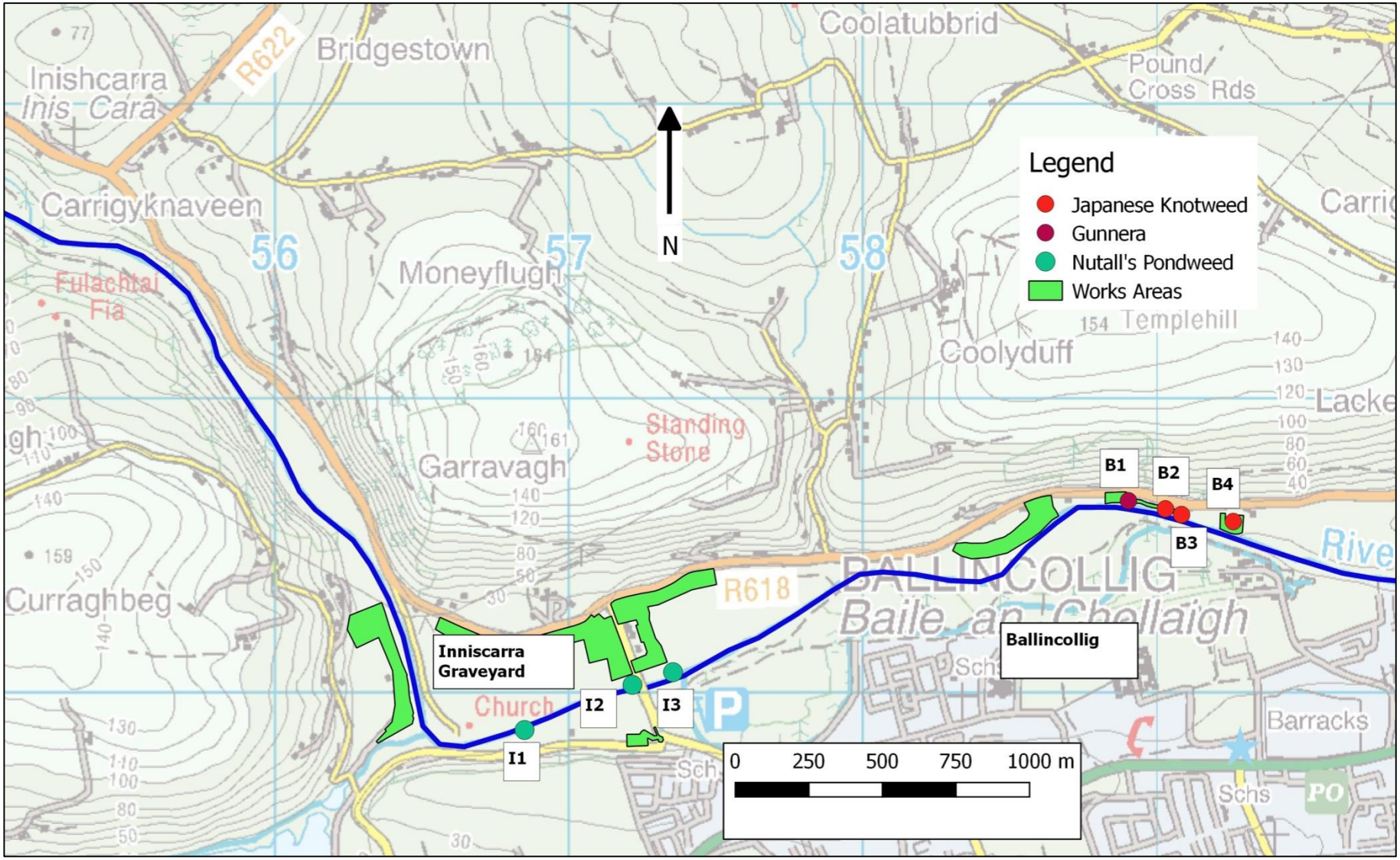

Figure 3.1 - Map showing invasive species recorded within the proposed works areas along the River Lee (Innishcarra & Ballincollig) – see corresponding database in Appendix I

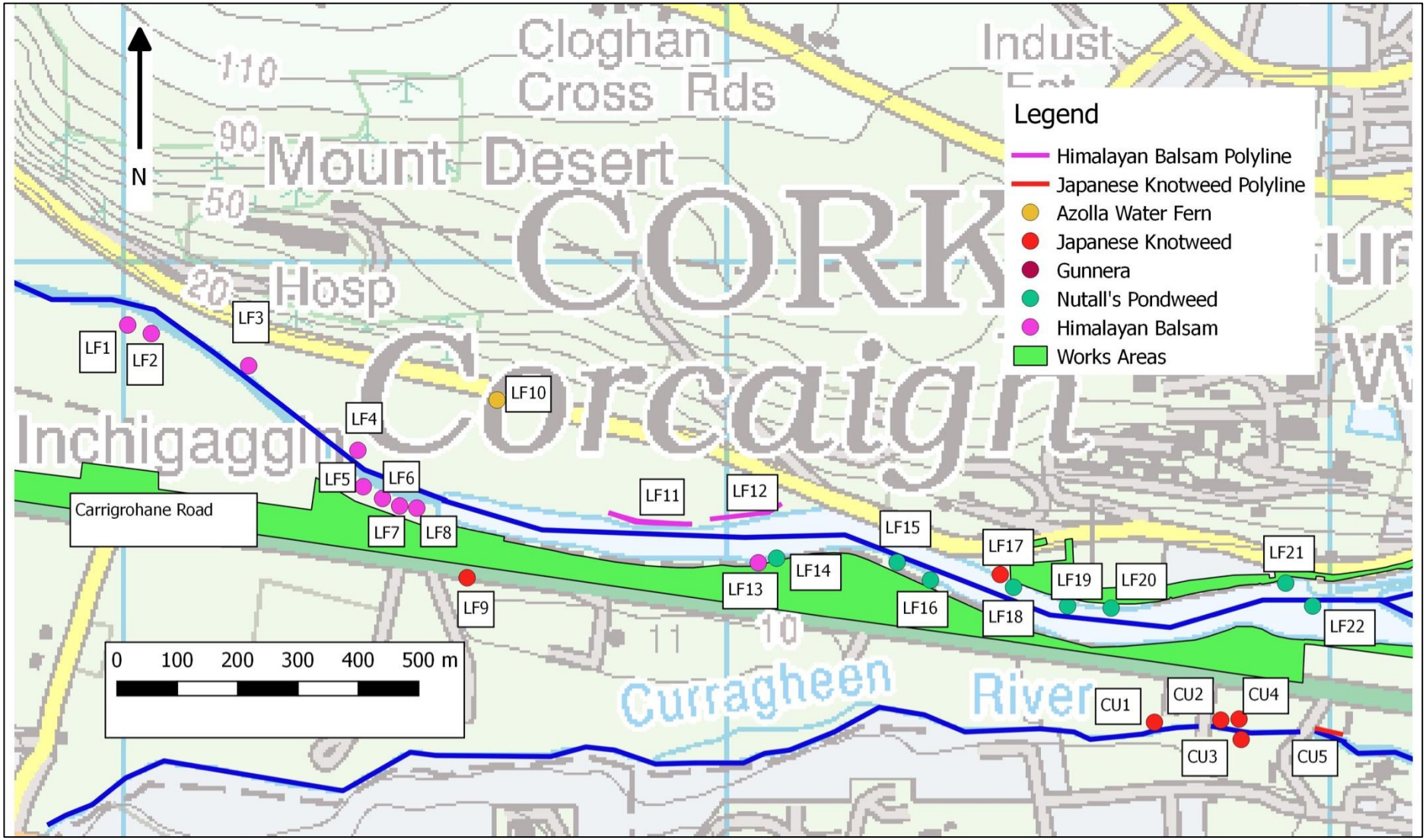

Figure 3.2 - Map showing invasive species recorded within the proposed works areas along the River Lee (Lee Fields area) – see corresponding database in Appendix I

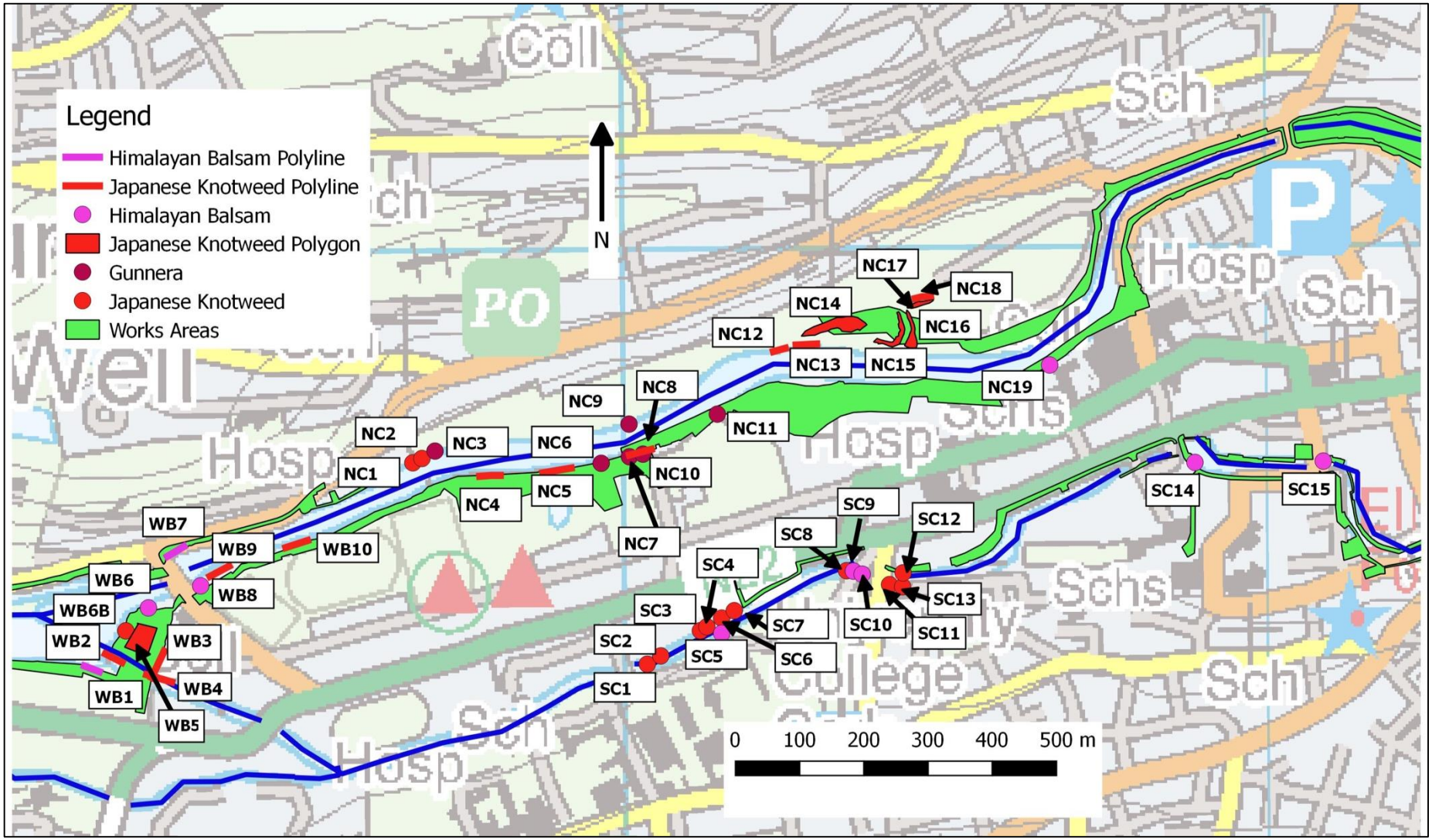

Figure 3.3 - Map showing invasive species recorded within the proposed works areas on the north and south channel of the River Lee (Cork City) – see corresponding database in Appendix I

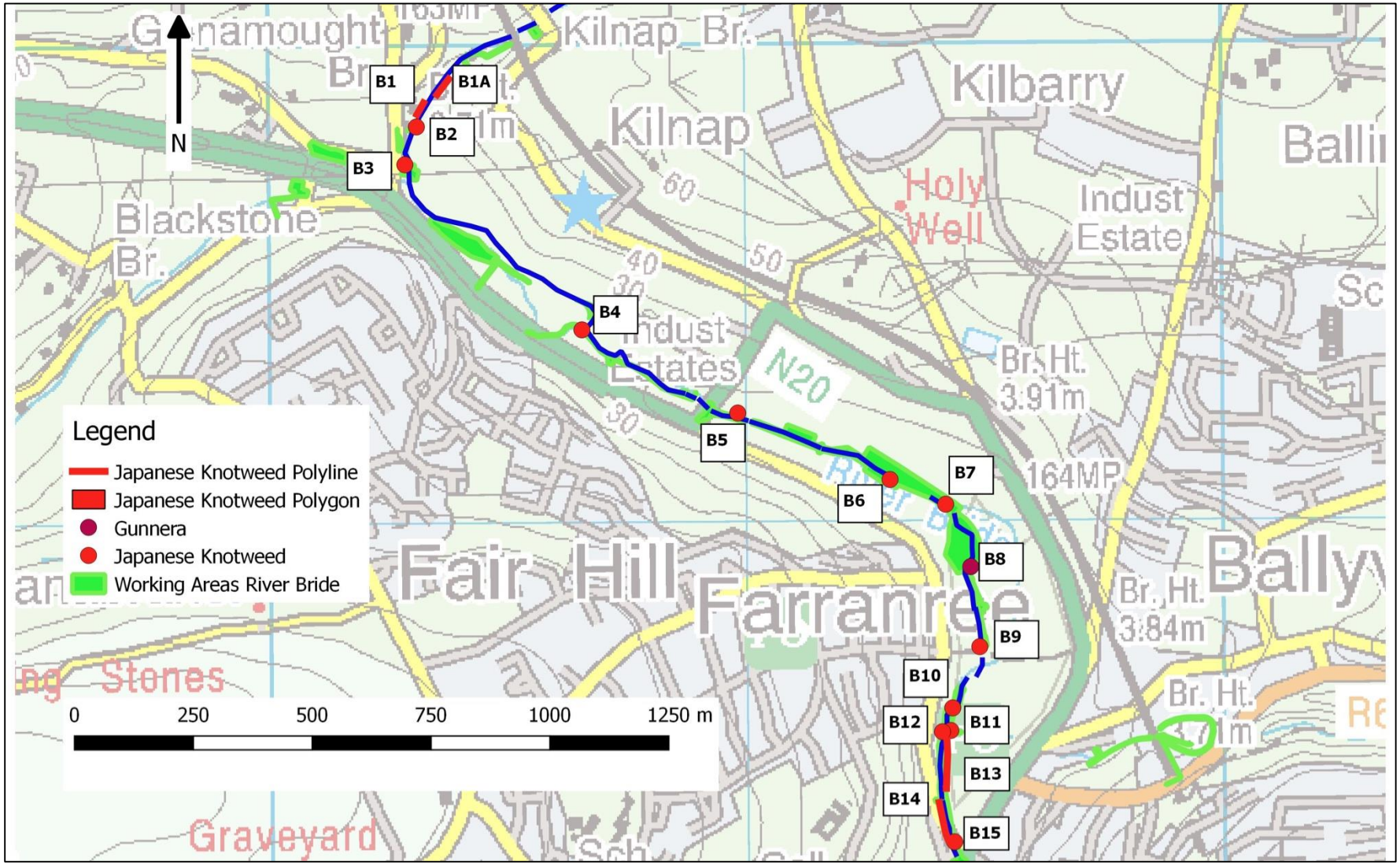

Figure 3.4 - Map showing invasive species recorded within the proposed works areas along the Rivers Bride & Glenamought – see corresponding database in Appendix I

4. Discussion

General findings

Evidently, the two most prevalent and potentially problematic invasive species within the proposed works areas of the Lee, Curragheen, Bride (North) and Glenamought Rivers, comprising the Lower Lee (Cork City) Drainage Scheme area, are Japanese Knotweed (*Fallopia japonica*) and, to a lesser extent, Himalayan Balsam (*Impatiens glandulifera*). These findings are in agreement with existing literature (Draft Cork County Development Plan 2013; Cork City Development Plan 2015-2021).

In addition, three other invasive species were recorded from the survey area, namely Giant Rhubarb (*Gunnera tinctoria*), Azolla Water Fern (*Azolla filiculoides*) and Nuttall's Pondweed (*Elodea nuttallii*). However, these invasive plants were only locally frequent rather than colonising large corridors of river as observed with Japanese Knotweed and Himalayan Balsam. As previously stated a number of non-native species, not typically classed as invasive, such as Travellers Joy (*Clematis vitalba*) and Buddleia (*Buddleia davidii*), were especially widespread and abundant along the surveyed channels in the vicinity of Cork City but were not appraised during this study.

Detailed information on invasive species distribution and occurrence are provided in the results section and Appendix I. This baseline information will prove valuable to local stakeholders and will be crucial in informing mitigation for the proposed Lower Lee (Cork City) Drainage Scheme. Collated data will also enable the future assessment of the spread and potential impact of invasive species along the selected channels which this survey evaluated.

Recommended Invasive Species Management (Works Areas)

Japanese Knotweed control and management

As the most abundant invasive species recorded, Japanese Knotweed is of primary concern in relation to the proposed works areas. This is particularly so along the sections of the rivers Lee such as near Wellington Bridge, and Fitzgerald's Park. The highest concentration of Japanese Knotweed recorded was on the UCC North Mall campus. The plant was also prevalent in areas along the Curragheen and Bride (North) in the vicinity of Cork City. Whilst the species currently shows a relatively intermittent distribution in most of these areas, it is likely to spread further over time especially where the soil layer is disturbed during construction activities. Flood events and mismanagement are perhaps the two major threats in expanding its distribution, as this species can regenerate from very small fragments of rhizome which may become waterborne during flood events or through ill-informed management measures such as cutting or pruning and incorrect disposal. The root system of Japanese Knotweed is typically extensive and thus traditional removal techniques often prove unsuccessful.

Japanese Knotweed occurring within or immediately adjacent to the proposed works areas should be treated as specified below according to current best practice. All works which may impact on invasive species are to be undertaken in compliance with best practice and national legislation, including best practice management guidelines such as Japanese Knotweed *Fallopia japonica* Invasive Species Ireland (Kelly *et al.,* 2008a) (Appendix A) and The Management of Noxious Weeds and Non-Native Invasive Plant Species on National Roads (NRA, 2010).

Chemical control of Japanese Knotweed is considered suitable as there is sufficient time to implement effective measures (due to localised distribution). Several different herbicides can be used to eradicate Japanese knotweed, with glyphosate, triclopyr, picloram and 2,4-D amine among the most effective during the growing season, where foliar uptake spreads the herbicide throughout the plant. However, where stands occur adjacent to water, Department of Food Agriculture & Marine (DAFM) herbicides approved for use next to water should be used. As most of the stands of Japanese Knotweed are growing close to (riparian zone of) the river channels in question, only those herbicides approved for use near water should be utilised, i.e. the less persistent glyphosates or the more broad leaved-plant-selective 2-4D amine). Also consideration must be given to constraints imposed by chemicals that are persistent in the soil which may delay the planting of replacement (often native) species. It is important not to apply herbicide during wet weather when the real target (i.e. plant) is missed and the nearby watercourse receives the chemical.

To reduce the risk of Knotweed spread to uncontaminated (i.e. Knotweed-free) areas of channel and to limit future control and management costs, herbicide treatment should be applied at the earliest opportunity to the areas of Japanese knotweed, given that in-situ herbicide treatment may take between 3-5 years to be effective (Kelly *et al.*, 2008a).

Herbicide control of Japanese knotweed should follow the advice below (as per Kelly *et al.*, 2008a): -

- Herbicide treatment must be undertaken by a qualified operator, and in line with relevant health and safety guidance, including that from Cork City/County Council, and appropriate regulations;
- It is imperative that the manufacturer's guidelines for the chosen herbicide are adhered to;
- Two foliar applications of herbicide to leaves are recommended, once in May/June (summer growth period) and a follow-up application in September/October (pre-autumn die-back).
- Should a herbicide be utilised in the late spring/early summer (>May) period, it should be noted that the removal of Japanese Knotweed from an area may simply facilitate the colonisation by Himalayan Balsam, which produces seeds at this time. Vigilant management is required where Japanese Knotweed and Himalayan Balsam occur in close proximity (such as the River Lee) to avoid such issues;
- Herbicide can be target-sprayed onto leaves avoiding non-target vegetation and minimising herbicide drift. Herbicide can also be applied directly to target plants using a weed-wiper or herbicide glove. The application rate should follow the manufacturer's guidance;
- Operator to ensure equipment used in treatment is cleaned prior to use elsewhere to ensure no spread of Japanese Knotweed
- Repeated herbicide treatments over several years (3-5 years) are normally recommended for complete control of Japanese Knotweed
- Continued monitoring of the treated areas post herbicide application should also be carried out to ensure that no new shoots appear. Any new shoots should be treated with herbicide as detailed above
- Post-control, native tree or shrub planting should be considered to stabilise soils and provide riparian cover
- Japanese Knotweed can regenerate from very small fragments of rhizome (as little as 0.7g; Brock & Wade, 1992).
- Equipment that is likely to result in further spread of Japanese knotweed, such as mowers, trimmers or strimmers should not be used on or near identified stands. Any soil, mud on boots, plant cutting and waste material containing Japanese knotweed could facilitate the further spread this species

Himalayan Balsam control and management

After Japanese Knotweed, the most potentially threatening invasive species present in or adjacent to the proposed works areas is Himalayan Balsam. Again, although its current distribution is localised (along the River Lee), there is a high potential for the plant to spread as a result of the proposed works for the Lower Lee Flood Relief Scheme if best practice is not first adhered to. This species reproduces through seeds which become airborne and can easily travel downstream in water. However, importantly, unlike Japanese Knotweed, Himalayan Balsam can often be successfully removed without the use of herbicides; always the ideal scenario in invasive plant species management. The root system of Himalayan Balsam is shallow in comparison to knotweeds and other species and can be removed by hand-pulling or cutting techniques. This is the recommended course of action for the purposes of the Lower Lee Flood Relief Scheme. Herbicidal treatment (again with glyphospahte or 2-4D amine) should only be considered where large, dense stands of Himalayan Balsam reduce the feasibility of manual removal.

The removal of Himalayan Balsam typically results in the re-establishment of native riparian plant species. However, studies have shown that other invasive plant species can be more responsive in this scenario (e.g. Hulme & Bremner, 2006) which highlights the importance of a river-specific or catchment-wide invasive management plan; one that targets all invasive plant species (at least) for control.

Herbicide control of Himalayan Balsam should follow the advice below (as per Kelly *et al.*, 2008b):-

- Manual removal (hand-pulling, hand cutting) is a viable and successful removal method. Cut at ground level (the plant must be cut below the lowest node to stop regeneration) using a scythe, flail or strimmer before the flowering stage in June. Cutting earlier than this will promote greater seed production from plants that regrow. Cutting should be repeated annually until no more growth occurs.
- Control should be undertaken working from the upstream end to prevent seed recolonization. To avoid additional spread do not disturb plants if seed pods are visible. Programmes should be undertaken initially from April to mid-June prior to seed pods forming
- For larger, denser stands a herbicide treatment can be used for Himalayan Balsam. Herbicide treatment must be undertaken by a qualified operator and in line with relevant health and safety guidance, including that from Cork City/County Council, and appropriate regulations
- It is imperative that the manufacturer's guidelines for the chosen herbicide are adhered to
- Plants should be sprayed in the spring before flowering but late enough to ensure that germinating seedlings have grown up sufficiently to be adequately covered by the herbicide spray
- Herbicide can be target sprayed onto leaves avoiding non-target vegetation and minimising herbicide drift. Herbicide can also be applied directly to target plants using a weed-wiper or herbicide glove. The application rate should follow the manufacturer's guidance
- The operator will ensure equipment used in treatment is cleaned prior to use elsewhere to ensure no spread of Himalayan Balsam seeds
- Repeat checks will be required on a monthly basis for any late germinating seeds. Repeat checks should be carried out each year throughout the growing season to prevent any new plants from setting seed until no further growth is found. Any new shoots should be treated with herbicide as detailed above
- Post-control, native tree or shrub planting should be considered to stabilise soils and provide riparian cover and also to minimise the risk of colonisation by other invasive plants

Potential impacts on habitats and/or species of conservation importance

Whilst none of the rivers within the Lee catchment are designated as Special Areas of Conservation (SAC), Cork Harbour, to which the River Lee and its tributaries discharge, is a Special Protection Area (SPA) under

the EU Birds Directive (site code: 004030). It supports internationally important numbers of resident and wintering birds such as Wigeon (*Anas penelope*), Black-tailed Godwit (*Limosa limosa*) and Golden Plover (*Pluvialis apricaria*) (NPWS, 2008). Due to direct downstream connectivity, any work related activities carried out as part of the Lower Lee Flood Relief Scheme must consider the threat of spreading invasive plant species to the SPA. Studies have suggested that Japanese Knotweed has a broad salinity tolerance and may be capable of colonising estuarine and saltmarsh habitats (Richards *et al.*, 2008).

5. Further Work

Although this study focused on proposed flood relief areas on the river corridors of the Lee, Curragheen, Bride (North) and tributary Glenamought, it is important that the potential impacts of invasive species are also assessed further up the catchment, i.e. from the sources of these rivers downstream. These areas could act as dispersal zones for seeds moving downstream and as such the full upstream extent from source areas should be established. For example, the Gearagh area of the River Lee (near Macroom) has abundant Himalayan Balsam indicating that invasive plants occur high up in the catchment (pers. obs.). Pro-active management from the top of the catchment downstream will prevent invasive spread through means of containment and control. The effectiveness of follow-up control can then be appraised over time once good baseline mapping of distributions and later patterns of change have been monitored. The evidence of successful treatment would be no re-establishment of invasive species over time following the removal of stands/plants from upstream. While other means of introduction i.e. vectors are also possible the presence of invasive plants on river corridors is primarily by means of water seed dispersal and as such upstream control should prove successful.

Species such as Japanese Knotweed and Himalayan Balsam have repeatedly been proven to negatively impact and alter the riparian species assemblages and the ecology, and even hydrology, of watercourses (Lecerf *et al.*, 2007; Gerber *et al.*, 2008). Without appropriate control and management, these invasive species could have wide-reaching, long terms impacts on protected Annex I birds such as Kingfisher (*Alcedo atthis*), Annex II fish species such as Atlantic salmon (*Salmo salar*) and lamprey species, and biodiversity in general within the entire catchment. Invasive plants can also cause indirect impacts through bank destabilisation and increased flooding or leaf deposition and localised siltation of fish spawning areas. As such it is important to map the distribution of invasive plants on river corridors and systematically remove from upstream to downstream contaminated areas.

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Appendix I

Database of Invasive Records

Database of Invasive Records Corresponding to GIS Mapping

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	5m²	I1	Point	556815 , 570930
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	10m²	I2	Point	557183, 571098
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	5m²	I3	Point	557306, 571156
Lee	Innishcarra Road	North bank of Lee adjoining residential properties	Gunnera	5m²	B1	Point	559225, 571635
Lee	Innishcarra Road	North bank of Lee adjoining residential properties	Japanese Knotweed	10m²	B2	Point	5592864, 571664
Lee	Innishcarra Road	North bank of Lee adjoining residential properties	Japanese Knotweed	10m²	B3	Point	558995, 571681
Lee	Innishcarra Road	North bank of Lee adjoining residential properties	Japanese Knotweed	10m²	B4	Point	558860, 571712
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m²	SC1	Point	565992, 571417
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m²	SC2	Point	566013, 571430
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m²	SC3	Point	566076, 571468
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m²	SC4	Point	566108, 571466
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m²	SC5	Point	566086, 571475
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m²	SC6	Point	566109, 571489
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	10m²	SC7	Point	566129, 571501
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	Single Plant	SC8	Point	566306, 571563
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m²	SC9	Point	566314, 571561
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m²	SC10	Point	566328, 571557
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	5m²	SC11	Point	566371, 571542
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	10m²	SC12	Point	566391, 571557
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	5m²	SC13	Point	566390, 571536
Lee	South Channel	St. Finbarrs Road (Wandsford Quay)	Himalayan Balsam	5m²	SC14	Point	566847, 571725
Lee	South Channel	Clarkes Bridge (City Centre)	Himalayan Balsam	5m²	SC15	Point	567048, 571728
Lee	North Channel	Shakey Bridge	Japanese Knotweed	50m²	NC01	Point	565629, 571734
Lee	North Channel	Shakey Bridge	Japanese Knotweed	20m²	NC02	Point	565644, 571740

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	North Channel	Fitzgerald's Park (North Bank)	Gunnera	10m²	NC03	Point	565665, 571751
Lee	North Channel	Fitzgerald's Park (North Bank)	Japanese Knotweed	10m	NC04	Line	565670, 571753
Lee	North Channel	Fitzgerald's Park	Japanese Knotweed	30m	NC05	Line	565720, 571717
Lee	North Channel	Fitzgerald's Park	Gunnera	10m²	NC06	Point	565744, 571714
Lee	North Channel	Fitzgerald's Park	Gunnera	10m²	NC07	Point	565838, 571718
Lee	North Channel	Fitzgerald's Park	Japanese Knotweed	15m	NC08	Point	565858, 571767
Lee	North Channel	Fitzgerald's Park (North bank)	Gunnera	10m²	NC09	Point	565922, 571731
Lee	North Channel	Fitzgerald's Park	Gunnera	5m²	NC10	Line	565967, 571740
Lee	North Channel	Fitzgerald's Park	Gunnera	10m²	NC11	Point	565967, 571794
Lee	North Channel	Mardyke Walk (North Mall)	Japanese Knotweed	15m	NC12	Line	566201, 571907
Lee	North Channel	Mardyke Walk (North Mall)	Japanese Knotweed	10m	NC13	Line	566233, 571913
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	1464m²	NC14	Polygon	556294, 571945
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	534m²	NC15	Polygon	556388, 571924
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	622m²	NC16	Polygon	556408, 571925
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	272m²	NC17	Polygon	556417, 571975
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	20m	NC18	Line	566423, 571986
Lee	North Channel	Presentation Brothers	Himalayan Balsam	<5m²	NC19	Point	566622, 571878
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	<5m²	LF1	Point	562966, 571955
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	<5m²	LF2	Point	563003, 571934
Lee	Lee Fields	North Bank	Himalayan Balsam	10m²	LF3	Point	563169, 571894
Lee	Lee Fields	North Bank	Himalayan Balsam	Single Plant	LF4	Point	563352, 571750
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF5	Point	563352, 571674
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF6	Point	563388, 571659
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF7	Point	563418, 571645
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF8	Point	563446, 571640
Lee	Lee Fields	Carrigrohane Road	Japanese Knotweed	15m²	LF9	Point	563533, 571542
Lee	Lee Fields	North Bank - Hollymount Wetlands	Azolla Water fern	25m²	LF10	Point	563582, 571834

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	Lee Fields	North Bank – Hollymount	Himalayan Balsam	140m	LF11	Line	564020, 571563
Lee	Lee Fields	North Bank – Hollymount	Himalayan Balsam	130m	LF12	Line	563808, 571638
Lee	Lee Fields	South Bank - Lee Fields	Himalayan Balsam	<5m²	LF13	Point	564021, 571563
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	<5m²	LF14	Point	564048, 571572
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	90m²	LF15	Point	564244, 571564
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	50m²	LF16	Point	564301, 571533
Lee	Lee Fields	North Bank - ERI building	Japanese Knotweed	15m²	LF17	Point	564428, 571543
Lee	Lee Fields	North Bank - ERI building	Nuttall's Pondweed	10m²	LF18	Point	564440, 571524
Lee	Lee Fields	North Bank - Water Treatment Plant	Nuttall's Pondweed	30m²	LF19	Point	564532, 571491
Lee	Lee Fields	North Bank - Water Treatment Plant	Nuttall's Pondweed	50m²	LF20	Point	564599, 571488
Lee	Lee Fields	Turbines	Nuttall's Pondweed	50m²	LF21	Point	564895, 571531
Lee	Lee Fields	County Hall Weir	Nuttall's Pondweed	50m²	LF22	Point	564930, 571491
Lee	Wellington Bridge	South Channel (u/s footbridge)	Himalayan Balsam	15m	WB1	Line	565114, 571425
Lee	Wellington Bridge	South Channel (u/s footbridge)	Japanese Knotweed	10m	WB2	Line	565164, 571434
Lee	Wellington Bridge	Wall bordering Park	Japanese Knotweed	30m	WB3	Line	565227, 571419
Lee	Wellington Bridge	South Channel (d/s footbridge)	Japanese Knotweed	10m	WB4	Line	565225, 571401
Lee	Wellington Bridge	Square of Japanese Knotweed	Japanese Knotweed	1557m²	WB5	Polygon	565205, 571455
Lee	Wellington Bridge	North Channel u/s Wellington Bridge	Himalayan Balsam	20m	WB6	Line	565215, 571512
Lee	Wellington Bridge	North Channel u/s Wellington Bridge	Japanese Knotweed	10m²	WB6b	Point	565178, 571478
Lee	Wellington Bridge	Sundays Well Road	Himalayan Balsam	Single Plant	WB7	Point	565249, 571598
Lee	Wellington Bridge	Mardyke	Himalayan Balsam	Single Plant	WB8	Point	565296, 571543
Lee	Wellington Bridge	Mardyke	Japanese Knotweed	10m	WB9	Line	565363, 571573
Lee	Wellington Bridge	Mardyke	Japanese Knotweed	10m	WB10	Line	565451, 571606
Curragheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	5m²	CU01	Point	564673, 571286
Curagheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	10m²	CU02	Point	564787, 571287
Curragheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	5m²	CU03	Point	564810, 571281
Curragheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	10m²	CU04	Point	564812, 571289

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Curragheen	Curragheen	County Hall	Japanese Knotweed	40m	CU05	Line	564946, 571276
Bride	Blackpool	Commons Road	Japanese Knotweed	<5m^2	B04	Point	566368, 574410
Bride	Blackpool	Commons Road	Japanese Knotweed	<5m^2	B05	Point	567004, 574317
Bride	Blackpool	Commons Road	Japanese Knotweed	7m	B06	Point	567271, 574145
Bride	Blackpool	Commons Road	Japanese Knotweed	Single Plant	B07	Point	567375, 574108
Bride	Blackpool	Commons Road	Gunnera	Single Plant	B08	Point	567434, 573979
Bride	Blackpool	Commons Road	Japanese Knotweed	Single Plant	B09	Point	567466, 573804
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B10	Point	567396, 573668
Bride	Blackpool	Orchard Court	Japanese Knotweed	<5m^2	B11	Point	567391, 573628
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B12	Point	567369, 573620
Bride	Blackpool	Orchard Court	Japanese Knotweed	40m	B13	Line	567376, 573553
Bride	Blackpool	Orchard Court	Japanese Knotweed	20m	B14	Line	567366, 573439
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B15	Point	567394, 573401
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	30m	B01A	Line	0566311, 0574970
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m^2	B01	Point	566296, 574936
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m^2	B02	Point	566273, 574898
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m^2	B03	Point	566248, 574813

Appendix II

Invasive Species Information Sheets

1.3 Description of particularly problematic invasive species

Detailed below are species-specific accounts of the biology and ecology of selected invasive species, as taken from Kelly *et al.,* 2008a (Japanese Knotweed), Kelly *et al.,* 2008b (Himalayan Balsam), Armstrong *et al*., 2009 (Giant rhubarb) and Invasive Species Ireland (all accessed at http://invasivespeciesireland.com)

1.3.1 Japanese Knotweed (*Fallopia japonica*)

Habitat type: Terrestrial

Threat: Reduction of species diversity.

Habitat: Can tolerate wide range of conditions, including full shade, high temperatures, high salinity and drought. It is found near water sources, such as along river banks, low-lying and disturbed areas. It can colonize coastal shores and islands.

Description: This is a relatively large plant that can grow up to 2 – 3 m in height and can dominate an area to the exclusion of most other plants. It can form an extensive network of rhizomes (roots) which cause problems when managing this species. Small pieces of rhizomes are capable of rejuvenating the plant. The rhizomes also allow the plant to survive over winter when the over ground conspicuous leafy part of the plant dies back to a brown wasted stem. The leaves are shield or heart shaped usually with a pale stripe down the middle. Flowers are creamy and arise from the tips of stems.

Japanese Knotweed growing along the River Lee corridor, Co. Cork

Origin and Distribution: A native of Japan, Korea, Taiwan and China where both male and female plants are known. This species is now widespread in continental Europe and Britain but only female plants have been recorded to date, including in Ireland.

Impacts: *F. japonica* is a threat in open and riparian areas where it spreads rapidly to form dense stands, excluding native vegetation and prohibiting regeneration. This reduces species diversity and alters habitat for wildlife. Once stands become established, they are extremely persistent and difficult to remove. Japanese Knotweed is also of concern to developers and private citizens. This plant has the ability to grow through tarmac and concrete (in some cases within dwellings) and therefore must be cleared completely before starting to build or lay roads.

How did it arrive in Ireland? The date of first introduction to Ireland is not know for certain. It is believed that this plant arrived in the mid to late 1800s. Regardless of the date of introduction, this plant has spread from gardens into the environment and is now a pest species.

Where is it found in Ireland? Japanese Knotweed is very common right across Ireland. It occurs in numerous different types of habitats from road sides to river corridors to waste ground in urban areas.

1.3.2 Himalayan Balsam (*Impatiens glandulifera*)

Habitat type: Terrestrial

Threat: Competition with native plants.

Habitat: riverbanks and areas of damp ground

Description: It can form dense mono-specific stands where individual plants can reach 2 – 3 m in height (one of the tallest annual plants in Ireland). The stem of the plant is smooth, hairless and hollow. They grow upright, easily broken and are usually purple in colour with many large oval shaped pointed leaves bearing teeth around the edges. The flowers of this plant can vary in colour but are usually shades of white, pink or purple. Flowering usually takes place from June to October. Seed capsules arise where the flowers were and when mature and dry, the slightest touch causes these fruits to split open explosively dispersing seeds up to 20 feet from the parent plant. Seeds are capable of further dispersal by water and animal and human aid.

Himalayan Balsam growing along the River Lee in front of the Kingsley Hotel, Cork City

Origin and Distribution: The plant is native to the western Himalayas but is now invasive in many parts of continental Europe. In Britain, Himalayan balsam is regarded as one of the top-ten most wanted species that have caused significant environmental impact.

Impacts: This species grows in thick mono-specific stands, shading out native plants such as grasses. From October onwards, the plants die back leaving the soil more exposed to erosion because of the loss of native plants earlier in the year. It has also been shown to produce more nectar in its flowers than native species making the plant more attractive to bumblebees resulting in less pollination of our native species.

How did it arrive in Ireland? It is thought to have originally arrived as an ornamental garden plant. According to O' Mahoney (2009), the plant became prominent in Ireland during the 1930's and has spread widely in Cork River systems.

Where is it found in Ireland? The species is now found throughout the island of Ireland suitable habitats. Particularly favours wetter areas with partial shading.

1.3.3 Giant rhubarb (*Gunnera tinctoria*)

Status: Established

Habitat: Terrestrial

Threat: Competition with native plants.

Habitat: coastal cliffs, waterways, roadsides, wet meadows and derelict gardens and fields.

Description: *Gunnera tinctoria* or giant rhubarb is not related to rhubarb, but as its name implies it is similar in appearance. This is a much larger plant with thorny leaves and stems. This is a large herbaceous plant that forms dense colonies and shades out other plants. This plant is most conspicuous in spring and summer when it can grow up to 2 m tall with large 'umbrella' shaped leaves that arise from sturdy stalks or petioles. *Gunnera* over-winters as large buds accumulating on the rhizomes (roots) above the surface, while the leaves die back, exposing these buds.

Giant rhubarb growing in Fitzgerald's Park, Cork City

Origin and Distribution: Native to South America but is now invasive in Europe, North America, New Zealand and Australia.

Impacts: *Gunnera* reduces the biodiversity value of infested sites. It can lead to the local extinction of some species with the formation of almost mono-specific stands of *Gunnera*. Elsewhere, this species has also caused problems by blocking drainage ditches and also access ways for people.

How did it get here? The plant arrived in Ireland as an ornamental plant for gardens.

Where is it found in Ireland? The species is currently considered invasive on the west coast of

Ireland, although it is also found on the east coast to date it is not considered invasive. It is considered to be having a significant impact on Achill Island, County Mayo, where is has spread throughout.

1.3.4 Nuttall's Pondweed (*Elodea nuttalii*)

Habitat type: Aquatic (freshwater)

Threat: Negative impacts on native macrophytes and invertebrates

Habitat: most common in calcareous waters and eutrophic waters because it has a high tissue demand for both phosphorus and nitrogen

Description: *Elodea nuttallii* originated from North America. This species is very similar to another invasive species know as *Elodea canadensis* (Canadian waterweed). Both species grow in still or slow flowing eutrophic waters but *Elodea nuttallii* has replaced *E. canadensis* at many sites possibly due to increased eutrophication. This is an aquatic weed that grows rapidly towards the surface of eutrophic freshwater systems without branching where they form a densely branched canopy. *E. nuttallii* is perennial and over winters in Ireland as horizontal shoots which regenerate new lateral shoots as the temperature reaches 6-8°C.

Nuttall's Pondweed growing along the margins of the River Lee, Co. Cork

Origin and Distribution: This species is native to North America but is now invasive in Britain where it is common.

Impacts: *E. nuttallii* tends to dominate native macrophyte communities which may lead to their local extinction. Impacts have also been recorded on invertebrate communities. This species may also have a significant impact on protected sites. *E. nuttallii* is also known to replace other invasive species as the dominant species in an impacted ecosystem. More recently data from Britain suggests that this species is now becoming replaced by *Largarosiphon major*

How did it get here? Traded as a garden plant

Where is it found in Ireland? This species now occurs at a number of sites spread right across the island. Notably, the species is known to occur in the Lee system (Carrigadrohid and Innishcarra Reservoirs; Caffrey *et al*., 2006).

Database of Invasive Records Corresponding to GIS Mapping

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	5m^2	I1	Point	556815 , 570930
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	10m^2	I2	Point	557183, 571098
Lee	Innishcarra	Innishcarra Graveyard	Nuttall's Pondweed	5m^2	I3	Point	557306, 571156
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m^2	SC1	Point	565992, 571417
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m^2	SC2	Point	566013, 571430
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m^2	SC3	Point	566076, 571468
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m^2	SC4	Point	566108, 571466
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m^2	SC5	Point	566086, 571475
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	5m^2	SC6	Point	566109, 571489
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	10m^2	SC7	Point	566129, 571501
Lee	South Channel	U.C.C. Main Campus	Japanese Knotweed	Single Plant	SC8	Point	566306, 571563
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m^2	SC9	Point	566314, 571561
Lee	South Channel	U.C.C. Main Campus	Himalayan Balsam	<5m^2	SC10	Point	566328, 571557
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	5m^2	SC11	Point	566371, 571542
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	10m^2	SC12	Point	566391, 571557
Lee	South Channel	O' Donovan Rossa Road	Japanese Knotweed	5m^2	SC13	Point	566390, 571536
Lee	South Channel	St. Finbarrs Road (Wandsford Quay)	Himalayan Balsam	5m^2	SC14	Point	566847, 571725
Lee	South Channel	Clarkes Bridge (City Centre)	Himalayan Balsam	5m^2	SC15	Point	567048, 571728
Lee	North Channel	Shakey Bridge	Japanese Knotweed	50m^2	NC01	Point	565629, 571734
Lee	North Channel	Shakey Bridge	Japanese Knotweed	20m^2	NC02	Point	565644, 571740
Lee	North Channel	Fitzgerald's Park (North Bank)	Gunnera	10m^2	NC03	Point	565665, 571751
Lee	North Channel	Fitzgerald's Park (North Bank)	Japanese Knotweed	10m	NC04	Line	565670, 571753
Lee	North Channel	Fitzgerald's Park	Japanese Knotweed	30m	NC05	Line	565720, 571717
Lee	North Channel	Fitzgerald's Park	Gunnera	10m^2	NC06	Point	565744, 571714
Lee	North Channel	Fitzgerald's Park	Gunnera	10m^2	NC07	Point	565838, 571718
Lee	North Channel	Fitzgerald's Park	Japanese Knotweed	15m	NC08	Point	565858, 571767

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	North Channel	Fitzgerald's Park (North bank)	Gunnera	10m²	NC09	Point	565922, 571731
Lee	North Channel	Fitzgerald's Park	Gunnera	5m²	NC10	Line	565967, 571740
Lee	North Channel	Fitzgerald's Park	Gunnera	10m²	NC11	Point	565967, 571794
Lee	North Channel	Mardyke Walk (North Mall)	Japanese Knotweed	15m	NC12	Line	566201, 571907
Lee	North Channel	Mardyke Walk (North Mall)	Japanese Knotweed	10m	NC13	Line	566233, 571913
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	1464m²	NC14	Polygon	556294, 571945
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	534m²	NC15	Polygon	556388, 571924
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	622m²	NC16	Polygon	556408, 571925
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	272m²	NC17	Polygon	556417, 571975
Lee	North Channel	UCC North Mall Campus	Japanese Knotweed	20m	NC18	Line	566423, 571986
Lee	North Channel	Presentation Brothers	Himalayan Balsam	<5m²	NC19	Point	566622, 571878
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	<5m²	LF1	Point	562966, 571955
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	<5m²	LF2	Point	563003, 571934
Lee	Lee Fields	North Bank	Himalayan Balsam	10m²	LF3	Point	563169, 571894
Lee	Lee Fields	North Bank	Himalayan Balsam	Single Plant	LF4	Point	563352, 571750
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF5	Point	563352, 571674
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF6	Point	563388, 571659
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF7	Point	563418, 571645
Lee	Lee Fields	South Bank (Woods Farm)	Himalayan Balsam	Single Plant	LF8	Point	563446, 571640
Lee	Lee Fields	Carrigrohane Road	Japanese Knotweed	15m²	LF9	Point	563533, 571542
Lee	Lee Fields	North Bank - Hollymount Wetlands	Azolla Water fern	25m²	LF10	Point	563582, 571834
Lee	Lee Fields	North Bank – Hollymount	Himalayan Balsam	140m	LF11	Line	564020, 571563
Lee	Lee Fields	North Bank – Hollymount	Himalayan Balsam	130m	LF12	Line	563808, 571638
Lee	Lee Fields	South Bank - Lee Fields	Himalayan Balsam	<5m²	LF13	Point	564021, 571563
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	<5m²	LF14	Point	564048, 571572
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	90m²	LF15	Point	564244, 571564
Lee	Lee Fields	South Bank - Lee Fields	Nuttall's Pondweed	50m²	LF16	Point	564301, 571533

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Lee	Lee Fields	North Bank - ERI building	Japanese Knotweed	15m^2	LF17	Point	564428, 571543
Lee	Lee Fields	North Bank - ERI building	Nuttall's Pondweed	10m^2	LF18	Point	564440, 571524
Lee	Lee Fields	North Bank - Water Treatment Plant	Nuttall's Pondweed	30m^2	LF19	Point	564532, 571491
Lee	Lee Fields	North Bank - Water Treatment Plant	Nuttall's Pondweed	50m^2	LF20	Point	564599, 571488
Lee	Lee Fields	Turbines	Nuttall's Pondweed	50m^2	LF21	Point	564895, 571531
Lee	Lee Fields	County Hall Weir	Nuttall's Pondweed	50m^2	LF22	Point	564930, 571491
Lee	Wellington Bridge	South Channel (u/s footbridge)	Himalayan Balsam	15m	WB1	Line	565114, 571425
Lee	Wellington Bridge	South Channel (u/s footbridge)	Japanese Knotweed	10m	WB2	Line	565164, 571434
Lee	Wellington Bridge	Wall bordering Park	Japanese Knotweed	30m	WB3	Line	565227, 571419
Lee	Wellington Bridge	South Channel (d/s footbridge)	Japanese Knotweed	10m	WB4	Line	565225, 571401
Lee	Wellington Bridge	Square of Japanese Knotweed	Japanese Knotweed	1557m^2	WB5	Polygon	565205, 571455
Lee	Wellington Bridge	North Channel u/s Wellington Bridge	Himalayan Balsam	20m	WB6	Line	565215, 571512
Lee	Wellington Bridge	North Channel u/s Wellington Bridge	Japanese Knotweed	10m^2	WB6b	Point	565178, 571478
Lee	Wellington Bridge	Sundays Well Road	Himalayan Balsam	Single Plant	WB7	Point	565249, 571598
Lee	Wellington Bridge	Mardyke	Himalayan Balsam	Single Plant	WB8	Point	565296, 571543
Lee	Wellington Bridge	Mardyke	Japanese Knotweed	10m	WB9	Line	565363, 571573
Lee	Wellington Bridge	Mardyke	Japanese Knotweed	10m	WB10	Line	565451, 571606
Curragheen	Curagheen	Atkins Farm Machinery	Japanese Knotweed	5m^2	CU01	Point	564673, 571286
Curagheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	10m^2	CU02	Point	564787, 571287
Curragheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	5m^2	CU03	Point	564810, 571281
Curragheen	Curragheen	Atkins Farm Machinery	Japanese Knotweed	10m^2	CU04	Point	564812, 571289
Curragheen	Curragheen	County Hall	Japanese Knotweed	40m	CU05	Line	564946, 571276
Bride	Blackpool	Commons Road	Japanese Knotweed	<5m^2	B04	Point	566368, 574410
Bride	Blackpool	Commons Road	Japanese Knotweed	<5m^2	B05	Point	567004, 574317
Bride	Blackpool	Commons Road	Japanese Knotweed	7m	B06	Point	567271, 574145
Bride	Blackpool	Commons Road	Japanese Knotweed	Single Plant	B07	Point	567375, 574108
Bride	Blackpool	Commons Road	Gunnera	Single Plant	B08	Point	567434, 573979

River	Map Tile Area	Specific Area	Invasive Plant	Size/Area	Unique Identifier	Type	GPS Co-ordinates
Bride	Blackpool	Commons Road	Japanese Knotweed	Single Plant	B09	Point	567466, 573804
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B10	Point	567396, 573668
Bride	Blackpool	Orchard Court	Japanese Knotweed	<5m²	B11	Point	567391, 573628
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B12	Point	567369, 573620
Bride	Blackpool	Orchard Court	Japanese Knotweed	40m	B13	Line	567376, 573553
Bride	Blackpool	Orchard Court	Japanese Knotweed	20m	B14	Line	567366, 573439
Bride	Blackpool	Orchard Court	Japanese Knotweed	Single Plant	B15	Point	567394, 573401
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	30m	B01A	Line	0566311, 0574970
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m²	B01	Point	566296, 574936
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m²	B02	Point	566273, 574898
Glenamought	Blackpool	u/s North Point Business Park	Japanese Knotweed	<5m²	B03	Point	566248, 574813

Appendix II

Invasive Species Information Sheets

1.3 Description of particularly problematic invasive species

Detailed below are species-specific accounts of the biology and ecology of selected invasive species, as taken from Kelly *et al.,* 2008a (Japanese Knotweed), Kelly *et al.,* 2008b (Himalayan Balsam), Armstrong *et al*., 2009 (Giant rhubarb) and Invasive Species Ireland (all accessed at http://invasivespeciesireland.com)

1.3.1 Japanese Knotweed (*Fallopia japonica*)

Habitat type: Terrestrial

Threat: Reduction of species diversity.

Habitat: Can tolerate wide range of conditions, including full shade, high temperatures, high salinity and drought. It is found near water sources, such as along river banks, low-lying and disturbed areas. It can colonize coastal shores and islands.

Description: This is a relatively large plant that can grow up to 2 – 3 m in height and can dominate an area to the exclusion of most other plants. It can form an extensive network of rhizomes (roots) which cause problems when managing this species. Small pieces of rhizomes are capable of rejuvenating the plant. The rhizomes also allow the plant to survive over winter when the over ground conspicuous leafy part of the plant dies back to a brown wasted stem. The leaves are shield or heart shaped usually with a pale stripe down the middle. Flowers are creamy and arise from the tips of stems.

Japanese Knotweed growing along the River Lee corridor, Co. Cork

Origin and Distribution: A native of Japan, Korea, Taiwan and China where both male and female plants are known. This species is now widespread in continental Europe and Britain but only female plants have been recorded to date, including in Ireland.

Impacts: *F. japonica* is a threat in open and riparian areas where it spreads rapidly to form dense stands, excluding native vegetation and prohibiting regeneration. This reduces species diversity and alters habitat for wildlife. Once stands become established, they are extremely persistent and difficult to remove. Japanese Knotweed is also of concern to developers and private citizens. This plant has the ability to grow through tarmac and concrete (in some cases within dwellings) and therefore must be cleared completely before starting to build or lay roads.

How did it arrive in Ireland? The date of first introduction to Ireland is not know for certain. It is believed that this plant arrived in the mid to late 1800s. Regardless of the date of introduction, this plant has spread from gardens into the environment and is now a pest species.

Where is it found in Ireland? Japanese Knotweed is very common right across Ireland. It occurs in numerous different types of habitats from road sides to river corridors to waste ground in urban areas.

1.3.2 Himalayan Balsam (*Impatiens glandulifera*)

Habitat type: Terrestrial

Threat: Competition with native plants.

Habitat: riverbanks and areas of damp ground

Description: It can form dense mono-specific stands where individual plants can reach 2 – 3 m in height (one of the tallest annual plants in Ireland). The stem of the plant is smooth, hairless and hollow. They grow upright, easily broken and are usually purple in colour with many large oval shaped pointed leaves bearing teeth around the edges. The flowers of this plant can vary in colour but are usually shades of white, pink or purple. Flowering usually takes place from June to October. Seed capsules arise where the flowers were and when mature and dry, the slightest touch causes these fruits to split open explosively dispersing seeds up to 20 feet from the parent plant. Seeds are capable of further dispersal by water and animal and human aid.

Himalayan Balsam growing along the River Lee in front of the Kingsley Hotel, Cork City

Origin and Distribution: The plant is native to the western Himalayas but is now invasive in many parts of continental Europe. In Britain, Himalayan balsam is regarded as one of the top-ten most wanted species that have caused significant environmental impact.

Impacts: This species grows in thick mono-specific stands, shading out native plants such as grasses. From October onwards, the plants die back leaving the soil more exposed to erosion because of the loss of native plants earlier in the year. It has also been shown to produce more nectar in its flowers than native species making the plant more attractive to bumblebees resulting in less pollination of our native species.

How did it arrive in Ireland? It is thought to have originally arrived as an ornamental garden plant. According to O' Mahoney (2009), the plant became prominent in Ireland during the 1930's and has spread widely in Cork River systems.

Where is it found in Ireland? The species is now found throughout the island of Ireland suitable habitats. Particularly favours wetter areas with partial shading.

1.3.3 Giant rhubarb (*Gunnera tinctoria*)

Status: Established

Habitat: Terrestrial

Threat: Competition with native plants.

Habitat: coastal cliffs, waterways, roadsides, wet meadows and derelict gardens and fields.

Description: *Gunnera tinctoria* or giant rhubarb is not related to rhubarb, but as its name implies it is similar in appearance. This is a much larger plant with thorny leaves and stems. This is a large herbaceous plant that forms dense colonies and shades out other plants. This plant is most conspicuous in spring and summer when it can grow up to 2 m tall with large 'umbrella' shaped leaves that arise from sturdy stalks or petioles. *Gunnera* over-winters as large buds accumulating on the rhizomes (roots) above the surface, while the leaves die back, exposing these buds.

Giant rhubarb growing in Fitzgerald's Park, Cork City

Origin and Distribution: Native to South America but is now invasive in Europe, North America, New Zealand and Australia.

Impacts: *Gunnera* reduces the biodiversity value of infested sites. It can lead to the local extinction of some species with the formation of almost mono-specific stands of *Gunnera*. Elsewhere, this species has also caused problems by blocking drainage ditches and also access ways for people.

How did it get here? The plant arrived in Ireland as an ornamental plant for gardens.

Where is it found in Ireland? The species is currently considered invasive on the west coast of

Ireland, although it is also found on the east coast to date it is not considered invasive. It is considered to be having a significant impact on Achill Island, County Mayo, where is has spread throughout.

1.3.4 Nuttall's Pondweed (*Elodea nuttalii*)

Habitat type: Aquatic (freshwater)

Threat: Negative impacts on native macrophytes and invertebrates

Habitat: most common in calcareous waters and eutrophic waters because it has a high tissue demand for both phosphorus and nitrogen

Description: *Elodea nuttallii* originated from North America. This species is very similar to another invasive species know as *Elodea canadensis* (Canadian waterweed). Both species grow in still or slow flowing eutrophic waters but *Elodea nuttallii* has replaced *E. canadensis* at many sites possibly due to increased eutrophication. This is an aquatic weed that grows rapidly towards the surface of eutrophic freshwater systems without branching where they form a densely branched canopy. *E. nuttallii* is perennial and over winters in Ireland as horizontal shoots which regenerate new lateral shoots as the temperature reaches 6-8°C.

Nuttall's Pondweed growing along the margins of the River Lee, Co. Cork

Origin and Distribution: This species is native to North America but is now invasive in Britain where it is common.

Impacts: *E. nuttallii* tends to dominate native macrophyte communities which may lead to their local extinction. Impacts have also been recorded on invertebrate communities. This species may also have a significant impact on protected sites. *E. nuttallii* is also known to replace other invasive species as the dominant species in an impacted ecosystem. More recently data from Britain suggests that this species is now becoming replaced by *Largarosiphon major*

How did it get here? Traded as a garden plant

Where is it found in Ireland? This species now occurs at a number of sites spread right across the island. Notably, the species is known to occur in the Lee system (Carrigadrohid and Innishcarra Reservoirs; Caffrey *et al*., 2006).