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Aquatic and Fisheries Assessment Report

Aquatic and fisheries assessment of watercourses associated with the MetroLink project, Co. Dublin

Prepared by Triturus Environmental Ltd. for Scott Cawley

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1. Introduction

Project background

Triturus Environmental Ltd. (formerly Triturus Environmental Services) were contracted by Scott Cawley Ltd. to conduct aquatic and fisheries assessments of numerous watercourses within the footprint of the proposed MetroLink project (Figure 2.1).

The survey was required to establish baseline ecological data in light of the proposed MetroLink alignment from Charlemont to Lissenhall, north of Swords. The proposed works cross or adjoin several watercourses along the proposed alignment (see Table 2.1), including the River Dodder, River Tolka, Santry River, Broadmeadow River, Grand Canal, Royal Canal and River Liffey. By undertaking electro-fishing and aquatic surveys in conjunction with an assessment of fisheries habitat, a robust assessment can be undertaken to evaluate the fisheries value of each riverine location, which will help inform any mitigation required for the proposed MetroLink project.

The primary aim of this survey was therefore to assess the habitat suitability and presence or absence of various fish species including salmonids (Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*)), lamprey species (*Lampetra fluviatilis* and *L. planeri*) and others including European eel (*Anguilla anguilla*). The survey would also provide additional data on general fish stock assemblages and the overall local ecological health of the often heavily urbanised watercourses by analysing water samples through both macro-invertebrate Q-sampling and water chemistry analysis.

Additionally, a dedicated white-clawed crayfish (*Austropotamobius pallipes*) survey (under national licence no. C82/2018) was carried out alongside electro-fishing efforts across nine rivers and two canal sites (excluding the tidal River Liffey). The findings of the baseline surveys would inform recommendations to minimise general fisheries related impacts as a result of the proposed MetroLink works.

Triturus Environmental Services made an application under Section 14 of the Fisheries (Consolidation) Act, 1959 as substituted by Section 4 of the Fisheries (Amendment) Act, 1962, to undertake an electro-fishing surveys of the Slang, Dodder, Tolka, Santry, Mayne, Sluice, Ward, Broadmeadow and Staffordstown Rivers. Triturus were successfully granted the Section 14 Authorisation on the 20th September 2018. Following notification to Inland Fisheries Ireland (Blackrock), the survey was conducted on the 28th and 29th September 2018. The crayfish surveys were undertaken under sections 23 and 34 of the Wildlife Acts 1976 to 2012 using national license no. C82/2018 as issued by the NPWS.

2. Methodology

Desktop review

A desktop review of the available fisheries-related data was undertaken for the ten rivers and two canals associated with the proposed MetroLink project. Additionally, local stakeholders and anglers were consulted. Data records held by the National Biodiversity data Centre (NBDC) and National Parks & Wildlife Service (NPWS) were also reviewed.

Fish stock assessment (electro-fishing)

A single anode Smith-Root LR24 backpack (12V DC input; 300V, 100W DC output) was used to electro-fish *n*=10 riverine sites on Friday 28th and Saturday 29th September 2018 under the conditions of the Department of Communications, Climate Action & Environment (DCCAE) license (Appendix I). Both river and holding water temperature was monitored before and during each survey effort to ensure temperatures of 20°C were not exceeded, thus minimising stress to the captured fish due to low dissolved oxygen levels. The electro-fishing survey was undertaken across ten sites on nine separate watercourses in the footprint of the proposed MetroLink North works (see Figures 2.1, 2.2 and 2.3 above).

2.1.1 Salmonids and European eel

For salmonid species (i.e. brown trout, Atlantic salmon) and European eel, as well as other incidental fish species, electro-fishing was carried out in an upstream direction for a 10-minute CPUE, an increasingly common standard approach for wadable streams (e.g. Matson et al., 2018; Delanty et al., 2017). A total of *n*=10 sites were surveyed via electro-fishing to provide a better representation of the overall fisheries habitat in the vicinity of the proposed crossing points.

Relative conductivity of the water was checked in-situ with a conductivity meter and the backpack energised with the appropriate voltage and frequency to provide enough draw to attract salmonids and European eel to the anode without harm. For the relatively high conductivity waters of the survey sites (due to local geology and general pollution gradients) a voltage of 200-225V, frequency of 40Hz and pulse duration of 4ms was utilised to draw fish to the anode without causing physical damage.

2.1.2 Lamprey

Electro-fishing for lamprey ammocoetes across the ten riverine sites were conducted using targeted $1m^2$ box quadrat-based electro-fishing (as per Harvey & Cowx, 2003) in areas of subjectively suitable marginal sand/silt (i.e. Type 1 and Type 2 substrate; Applegate 1950; Slade et al., 2003), where encountered.

As lamprey ammocoetes take longer to emerge from silts than other species they were targeted at low frequency (20-30Hz) settings that also allowed detection of European eel, if present. Settings for lamprey followed those recommended and used by Harvey & Cowx (2003), APEM (2004) and Niven & McAuley (2013). Using this approach, the anode was placed under the water surface, approx. 10-15 cm above the sediment, to prevent immobilising lamprey ammocoetes within the sediment. The anode was energised with 100V of pulsed DC for 15-20 seconds and then turned off for approximately five seconds to allow ammocoetes to emerge from their burrows. The anode was switched on and off in this way for approximately two minutes. Immobilised ammocoetes (if captured, as with other fish) were collected in a secondary fine-mesh, fish-friendly hand net. All fish species were transferred to a container with oxygenated river water following capture.

Fish were anaesthetised using 0.5ml/l clove oil solution (emulsified in ethanol at a ratio of 1:9) and measured to the nearest millimetre. Lamprey species would be identified to species level, where possible, with the assistance of a hand lens, through external pigmentation patterns and trunk myomere counts as described by Potter & Osborne (1975) and Gardiner (2003). Following measurement, lamprey and other species incidentally captured were released following a suitable recovery period in oxygenated containers of fresh river water.

Table 2.1 Survey site locations in the footprint of the proposed MetroLink project, September 2018

Site no.	Watercourse	EPA code	Location	ITM (x)	ITM (y)
1	Slang River	09S04	Dundrum	716879	728481
2	River Dodder	09D01	Patrick Doyle Road	716523	730009
3	River Tolka	09T01	Dean Swift Bridge	715400	737218
4	River Santry	09S01	Old Ballymun Road	715543	741035
5	River Mayne	09M03	Dardistown, 0.5km south of Dublin Airport	716156	741827
6	Cuckoo Stream	09C07	Swords Road, Dublin Airport	717462	742618
7	Sluice Stream	09S07	Naul Road, north of Dublin Airport	717395	744441
8	Ward River	08W01	Ballyheary Park, Swords	718665	748165
9	Broadmeadow River	08B02	Lissenhall Bridge, Swords	718686	748268
10	Staffordstown River	08S15	Lissenhall, Swords	718906	748895
A	Grand Canal	n/a	Charlemont	716056	732610
B	River Liffey	19W01	Rosie Hackett Bridge	716114	734478
C	Royal Canal	n/a	Cross Gun’s Quay	714986	736317

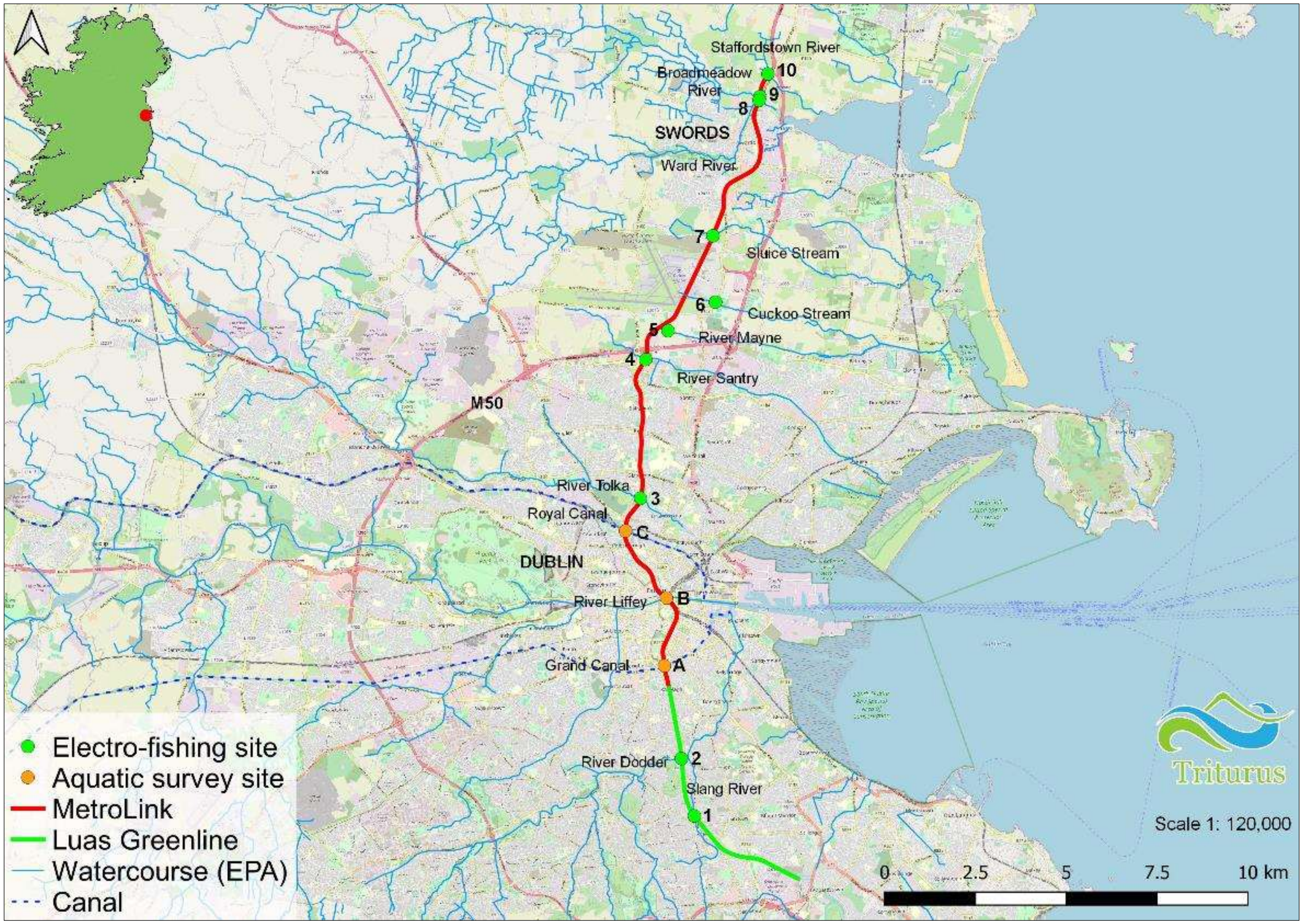

Figure 2.1 Location of electro-fishing and aquatic survey sites in the footprint of the proposed MetroLink project, September 2018

Fisheries habitat reporting

2.1.3 Salmonid habitat

Fisheries habitat for salmonids was assessed using the Life Cycle Unit method (Kennedy, 1984; O'Connor & Kennedy, 2002) to map the ten riverine survey sites as nursery, spawning and holding water, by assigning quality scores to each type of habitat. Those habitats with poor quality substrata, shallow depth and a poorly defined river profile receive a higher score. Higher scores in the Life Cycle Unit method of fisheries quantification are representative of poorer value, with lower scores being more optimal despite this appearing counter-intuitive.

Table 2.1 Life Cycle Unit scoring system for salmonid nursery, spawning and holding habitat value (as per Kennedy, 1984 & O'Connor & Kennedy, 2002)

Habitat quality	Habitat score	Total score (three components)
Poor	4	12
Moderate	3	9-11
Good	2	6-8
Excellent	1	3-5

2.1.4 Lamprey habitat

The evaluation of the lamprey importance of the ten riverine sites surveyed is provided below and follows the novel Lamprey Habitat Quality Index (LHQI) scoring system as devised by the authors of this report. In the absence of a universally accepted lamprey-specific scoring system for overall habitat quality, the LHQI loosely follows the same rationale as the Life Cycle Unit score for salmonids above (Kennedy, 1984; O'Connor & Kennedy, 2002). Those habitats with a lack of soft, largely organic sediment areas for ammocoete burrowing, shallow sediment depth (<10cm) or compacted sediment nature receive a higher score. Higher scores in our improvised method of lamprey fisheries quantification are thus of poorer value (in a similar fashion to the salmonid Life Cycle Unit Index), with lower scores being more optimal despite this appearing counter intuitive. Larval lamprey habitat quality as well as the suitability of adult spawning habitat is assessed based on the information provided in Maitland (2003) and other relevant literature. Unlike the salmonid Life Cycle Unit index, holding habitat for adult lamprey is not assessed owing to their different migratory and life history strategies, and that surveys such as this one routinely only sample larval lamprey.

Incidentally, the LHQI scoring system provides additional information compared to the habitat classification based on the observations of Applegate (1950) and Slade et al. (2003), which deals specifically with larval (sea) lamprey settlement habitat. Under this scheme, habitat is classified into three different types: preferred (Type 1), acceptable (Type 2), and not acceptable for larvae (Type 3) (Slade et al. 2003). Type 1 habitat is characterised by soft substrate materials usually consisting of a mixture of sand and fine organic matter, often with some cover over the top such as detritus or twigs in areas of deposition. Type 2 habitat is characterized by substrates consisting of shifting sand with little if any organic matter and may also contain some gravel and cobble (lamprey may be present but at much lower densities than Type 1). Type 3 habitat consists of materials too hard for larvae to burrow including bedrock and overly-compacted sediment. This classification can also be broadly applied to other lamprey species ammocoetes.

Table 2.2 Lamprey Habitat Quality Index (LHQI) scoring system for lamprey spawning and nursery habitat value (Macklin et al., 2018).

Habitat quality	Habitat score	Total score (two components)
Poor	4	8
Moderate	3	6-7
Good	2	3-5
Excellent	1	2

2.1.5 General fisheries habitat

All lamprey species present in Ireland are listed on Annex II of the EU Habitats Directive (92/42/EEC), with River Lamprey also being listed on Annex V. Atlantic salmon are listed on both Annex II and V of the EU Habitats Directive (92/42/EEC), while European eel are a national red listed species (King et al. 2011). The surveys were undertaken to establish the fisheries importance of each site for all fish species of conservation value. This included a broad appraisal/overview of the upstream and downstream habitat at each electro-fishing site was also undertaken to evaluate their importance for salmonid and lamprey spawning etc. Additionally, a single site on the Grand Canal (Charlemont), Royal Canal (5th level, Gun's Cross Quay, Cabra) and the River Liffey (Rosie Hackett bridge), respectively, were also assessed for their fisheries habitat and value given that standard electro-fishing methodologies were not feasible at these locations. River habitat surveys and fisheries assessments were also carried out utilising elements of the approaches in the River Habitat Survey Methodology (Environment Agency, 2003) and Fishery Assessment Methodology (O'Grady, 2006) to broadly characterise the river sites (i.e. channel profiles, substrata etc.).

Macro-invertebrates

The Environmental Protection Agency (EPA) group invertebrates into classes whereby pollution intolerant species are denoted class A, and species with greater pollution tolerance fall into successive classes (B through E, respectively) (Toner et al., 2005). As such, the presence or absence of these groups and their relative abundance facilitates an assessment of biological river health.

All Q-samples were taken with a standard kick sampling net (250mm width, 500µm mesh size) from areas of riffle/glide utilising a three-minute sample. At sites not suitable for Q-sampling (i.e. canals), macro-invertebrate samples were taken with a standard kick sampling hand net (250mm width, 500µm mesh size) which was used to sweep macrophytes. The net was also moved along the benthos to collect epibenthic and epiphytic invertebrates from the substratum (as per Cheal et al., 1993). A 3-minute sampling period was divided amongst the range of meso-habitats present to get a representative sample for sub-habitats. Large cobble was also washed at each site where present and samples were elutriated and fixed in 70% ethanol for laboratory identification. Any rare invertebrate species were identified from the NPWS Red List publications for beetles, stoneflies, mayflies and other relevant taxa. Macro-invertebrate samples were converted to Q-ratings as per Toner et al. (2005). The reference classes for Q rating are shown on Table 2.3 below.

Table 2.3 Reference Categories for EPA Q-Ratings (Q1 to Q5)

Q-value	WFD status	Pollution status	Condition
Q5 or Q4-5	High	Unpolluted	Satisfactory
Q4	Good	Unpolluted	Satisfactory
Q3-4	Moderate	Slightly polluted	Unsatisfactory
Q2-3 or Q3	Poor	Moderately polluted	Unsatisfactory
Q1, Q1-2 or Q2	Bad	Seriously polluted	Unsatisfactory

White-clawed crayfish survey

2.1.6 Trapping survey

The crayfish survey was undertaken under the National Parks and Wildlife Service (NPWS) under national license no. C82/2018, as prescribed by Sections 9, 23 and 34 of the Wildlife Act (1976-2012) to capture and release them to their site of capture under condition no. 7 of the license. As per Inland Fisheries Ireland recommendations (and as with other surveys conducted e.g. electro-fishing), the crayfish license sampling started at the uppermost site on a given, connected sub-catchment (where applicable) to minimise the risk of transfer of crayfish plague or invasive species in an upstream direction.

For the larger watercourses surveyed – namely the Dodder, Tolka, Ward and Broadmeadow - six 51 x 20cm, 19mm mesh polypropylene "Trappy" crayfish traps, ballasted with extra rock to prevent excessive movement, were positioned in the vicinity of each proposed crossing location. Similarly, the same methodology was applied to the Royal and Grand Canal crossing points. Traps were fished in pairs and were positioned in suitable marginal areas the night before and retrieved the following morning.

Since trapping has been shown to select for larger individuals and possibly introduce a sex-bias (Gallagher, 2006), a subset of the traps were wrapped with 10mm green garden mesh. Mesh-modified traps have been found to be far more effective at retaining juveniles and therefore result in a higher CPUE (O'Connor et al., 2009). To this end, 50% of traps at each site were mesh-modified. Traps were re-meshed between sites to minimise transfer of disease. All traps were baited with 100grams of tuna-flavoured cat food placed in cable-tied mesh bags. Oily food such as tuna-based products offer greater attractant properties to crayfish because of the oil-scent dispersion (pers. obs.).

Triturus

2.1.7 Sweep netting

Sweep netting (following Reynolds et al., 2010) was employed at survey sites where the small, shallow nature of the channels precluded effective trapping, i.e. the Slang, Santry, Mayne, Cuckoo, Sluice and Staffordstown channels. Sweep netting was also utilised at each trapping site to better detect both adult and juvenile crayfish that may have been localised in mats of aquatic vegetation or which did not enter traps due to the presence of others or temporal constraints. Sweep netting involves sampling of both in-channel macrophytes, in addition to checking typical boulder and cobble refugia. This process involves the lifting of littoral boulders (single boulder considered a single refuge) while the net is swept underneath to trap any crayfish positioned underneath.

2.1.8 Riparian walkover survey

Further to physical survey methods, it was important to undertake a riparian walkover survey to examine any spraint from mustelids (i.e. otters and mink) feeding along the riparian corridor, when other sampling techniques (i.e. hand searching, trapping and sweep netting) returned a zero result. Given that mustelids hunt large areas of river, they can detect cryptic prey, present at low densities, which are not easily attainable via conventional survey methodologies. Whilst not quantitative, riparian walkover/spraint surveys are useful for clarifying the presence of absence of crayfish at a particular site.

Biosecurity

A strict biosecurity protocol following the Check-Clean-Dry approach was employed during the surveys. All equipment and PPE used during the survey was disinfected with Virkon® disinfectant prior to and post-survey completion, and best practice precautions were employed to prevent the potential spread of invasive species and water-borne pathogens, according to best practice biosecurity protocols. Surveys were strictly conducted in an upstream direction to avoid the potential spread of pathogens.

3. Results

An electro-fishing survey of *n*=10 sites covering the Slang, Dodder, Tolka, Santry, Mayne, Sluice, Ward, Broadmeadow and Staffordstown channels was conducted on Friday 28th and Saturday 29th September 2018 following notification to Inland Fisheries Ireland (Blackrock), Dublin City and County Councils and Transport Infrastructure Ireland (TII). The results of the survey are discussed below in terms of fish population structure, population size and the suitability and value of the surveyed areas as nursery and spawning habitat for various conservation interest fish species, including lamprey species as well as Atlantic salmon, in addition to European eel.

Macro-invertebrate species compositions for the riverine and canal samples are provided in Appendix A. Representative survey site images including images of fish species recorded are provided in Appendix B.

Site descriptions

3.1.1 Site 1 – Slang River, Dundrum

The Slang River (also known locally as the Dundrum River) is a short watercourse which rises on Three Rock Mountain and flows through Ticknock, Ballinteer, Dundrum and Windy Arbour before joining the River Dodder at Milltown, near the Nine Arches viaduct which supports the Luas line. The survey site was located adjacent to the Dundrum Luas bridge, although access difficulties due to retaining walls meant that the electro-fishing site was located at the back of Circle K service station on Dundrum Road, approx. 90m downstream of the Luas line. As indicated, the river has been significantly straightened and deepened historically, with high retaining walls along much of the channel in this heavily urbanised area. Nevertheless, the river retains some limited semi-natural characteristics in terms of river bed – dominated by cobble and coarse gravels – and its riffle-glide-pool profile. However, the river is predominantly shallow (<30cm) and both siltation and filamentous algae cover is high. As well as evident enrichment, the overall water quality is poor with numerous storm drains and urban run-off present near the survey site. The gravels were evidently suffering from moderate to high levels of siltation and compacted. Conductivity levels were somewhat elevated at 478µs, but dissolved oxygen levels were good at 10.9mg/l. The pH was recorded at 7.95 and considered within the normal range. The site supported limited macrophyte cover with fool's watercress (*Apium nodiflorum*) and the non-native, high-risk impact (Kelly et al., 2013) Canadian pondweed (*Elodea canadensis*). The water moss *Fontinalis antipyretica* was common on larger instream cobble and boulder.

The banks of the heavily canalised river, where not bounded by largely-bare retaining walls, were heavily scrubbed with vegetation typical of enriched, highly disturbed urban environments. Species included nettle (*Urtica dioica*), buddleja (*Buddleja davidii*), hedge bindweed (*Calystegia sepium*), ivy (*Hedera helix*), willowherb species (*Epilobium* spp.), osier willow (*Salix viminalis*), montbretia (*Crocosmia x crocosmiiflora*), common figwort (*Scrophularia nodosa*) and bramble (*Rubus fruticosus* agg.). The retaining walls also supported ivy-leaved toadflax (*Cymbalaria muralis*) and, more commonly, red valerian (*Centranthus ruber*). The medium-risk invasive (Invasive Species Ireland) shrub snowberry (*Symphoricarpos albus*) was also present locally. Treelines, where present, consisted largely of sycamore (*Acer pseudoplatanus*), ash (*Fraxinus excelsior*) and sally willow (*Salix cinerea*).

3.1.2 Site 2 - River Dodder, Patrick Doyle Road

The River Dodder rises at Kippure Mountain in the Wicklow Mountains and flows in an arc to the sea over a course of circa. 29km. It takes a north-easterly course through Dublin City (Donnybrook and Ballsbridge) and enters the River Liffey near the Grand Canal Harbour at Ringsend. The survey area was situated near Patrick Doyle Road, Rathmines. The River Dodder was historically straightened and deepened (with evident retaining walls on the south bank) but retained a semi-natural channel profile with riffle, glide and pool sequences. Large cracked bedrock slabs are present upstream of the Luas crossing that have created glide runs into deeper pool habitat. The substrata are mixed with bedrock, cobble, gravels, sand and silt. The River Dodder supported limited macrophyte cover with <1% cover by surface area of spiked water-milfoil (*Myriophyllum spicatum*) and the non-native, high-risk impact (Kelly et al., 2013) Nuttall's pondweed (*Elodea nuttallii*). The latter species is considered invasive in Ireland. Emergent macrophytes were present very locally and included watercress (*Nasturtium officinale*), and water pepper (*Persicaria hydropiper*). There were moderate siltation levels of the gravels, which were partially bedded and covered with filamentous algae (30% cover). The conductivity levels in the Dodder at the time of the survey were 477µs. These are likely to be slightly elevated due to enrichment, albeit the river has base-rich influences due to its geology (pH 8.38). The dissolved oxygen levels were good at 11.3mg/l and capable of supporting a salmonid population.

The riverbanks supported mature trees predominantly sycamore with weeping willow (*Salix babylonica*), buddleja and elder (*Sambucus nigra*) common. Bramble and winter heliotrope (*Petasites fragrans*) were common in the understory. A single Himalayan balsam (*Impatiens glandulifera*) plant was present (ITM 0716513, 0730054) near the survey area but may be more frequent during mid-summer. The species is considered invasive of riparian corridors.

3.1.3 Site 3 - River Tolka, Dean Swift Bridge, Drumcondra

The River Tolka rises in Pelletstown and flows south-east through Mullhuddart, Ashtown, Glasnevin, and enters Dublin Bay at Clontarf. The River Tolka at the survey area (Drumcondra) was situated in a heavily-modified channel which has been straightened and deepened with flood defence gabions and high retaining walls present. The channel was 8-9m wide and relatively deep (0.5-0.6m), dominated by deep glide and pool habitat with very localised riffle. Where not concreted, the riparian zone supported extensive buddleja and bramble. The riverbed substrata were composed of abundant boulder and large cobble (50% by surface area) with pockets of coarse medium and fine gravel (40% cover) which offered spawning habitat potential for salmonids. Pockets of superficial silt covered much of the river bed (10% cover). The River Tolka was evidently enriched given the exuberant filamentous algae growth (30% cover). The conductivity was also high (853µs) and was likely in part due to the high pH (8.38) but also due to enrichment. There are abundant storm drains adjoining the Tolka in Dublin City that appear to be contributing to a decline in its overall water quality. The dissolved oxygen levels however, appear to be relatively good (12.1mg/l) and capable of supporting a salmonid population.

3.1.4 Site 4 - Santry River, Old Ballymun Road

The Santry River rises near Harristown and flows south east under the M50 and enters Dublin Bay at St. Anne's Park near Bull Island. At the survey area near Ballymun/ Santry Demesne, the Santry River was modified but retained some semi-natural features with glide sequences and localised pool. The channel was 1.5m wide, 0.2m deep and had a 1.5m bankfull height. The river bed comprised cobbles and coarse gravel that were bedded and suffering from heavy siltation. The silt was anoxic and black in colour. The stream was heavily enriched, and this was reflected by the high conductivity value (877µs), blue-green water coloration and moderate dissolved oxygen levels (7.9 mg/l). The stream was bordered by pockets of mixed broad-leaved woodland with sycamore and beech (*Fagus sylvatica*) being the dominant species.

3.1.5 Site 5 - River Mayne, Dardistown

The River Mayne rises in Ballystruan south of Dublin airport. The river flows for 6km east (north of Turnapin and Darndale) to Balgriffin where it forms a confluence with the River Mayne and then enters Baldoyle Bay at Mayne Bridge (2km to the east). The River Mayne in its upper reaches near Dardistown (survey area) was situated in a very heavily modified channel and was more representative of a drainage channel habitat than a lowland river. The watercourse had a very low flow at the time of survey with shallow water (≤0.1m deep) situated in a U-shaped channel. The channel bed contained pockets of coarse gravel and cobble (all bedded) and had at least 40% cover of silt. The river could be considered as completely channelised with no natural stream habitat in the upper reaches. It was also heavily polluted with very high conductivity readings of 1106µs and extremely low dissolved oxygen levels (1.8mg/l). The pH levels were also high at 8.17. The channel was bordered by species tolerant of disturbed ground and high nutrient levels such as lesser burdock (*Arctium minus*), hogweed (*Heracleum sphondylium*), creeping thistle (*Cirsium arvense*), bramble and willowherbs (*Epilobium* spp.). The channel adjoined intensive tillage land.

3.1.6 Site 6 - Cuckoo Stream, Swords Road, Dublin Airport

The Cuckoo stream rises in lands at Dublin Airport and flows eastwards into Baldoyle Bay after forming a confluence with the River Mayne. The stream was situated in a channel that has been straightened and deepened historically but retained some naturalness in terms of riffle and glide sections east of the R132 road. The stream was 1.5m wide, 0.15m deep and had a moderate flow rate. This watercourse has long been known as a heavily polluted river in the Greater Dublin area. At the time of survey, the stream had extremely high conductivity (1342µs), a high pH of 8.11 and a low dissolved oxygen level (5.8mg/l). Hydrocarbon slicks were visible on the surface and sewage fungus was covering much of the river bed in addition to grey sediment covering much of the stream base. Water quality and the stream habitat was extremely poor.

3.1.7 Site 7 - Sluice Stream, Naul Road, north of Dublin Airport

The Sluice Stream was a small, heavily-modified, deepened and straightened channel, with very little remaining natural value. The bank heights were between 2.0m and 2.5m which, in the context of the narrow 1.5m wide U-shaped channel, increases riparian shading significantly. Water depths were very shallow (0.05m) at the time of survey and the flow was slow, either comprised of riffle or glide (given the shallow nature of the water). Some areas were almost running dry and pools of water were localised. The channel bed was dominated by cobble and gravels (70%) with clay, sand and silt making up to 30% of the bed composition. Hard material on the channel bottom was bedded and thus made the stream unviable for spawning salmonids. There was abundant fly-tipping of waste in the stream with tyres, car batteries and other household waste present. The conductivity was high at 628µs and the dissolved oxygen levels surprisingly moderate at 8.6mg/l. The pH was measured at 7.93. The stream was bordered by mature ash, hawthorn (*Crataegus monogyna*) and blackthorn (*Prunus spinosa*) with frequent scrub in the understory comprising predominantly bramble, spear thistle (*Cirsium vulgare*), nettle and hedge bindweed. The stream was bordered by intensive tillage and pasture.

3.1.8 Site 8 - Ward River, Ballyheary Park, Swords

The Ward River at the survey site was represented by a small, shallow, stone-bottomed river with a semi-natural profile. The improved profile of the river and water quality over more heavily urbanised areas, is likely as a consequence of its peri-urban surrounds. The bed of the river was predominantly cobbled (circa 70% cover) with pockets of coarse gravels and localised boulder. Silt pockets were also present but typically very shallow as light fluffy surface deposits with the exception of one pool area, where one bed of deeper anoxic silt was present. Siltation was considered as moderate with silt plumes visible under foot and partial bedding of the river cobbles and gravels. The river had been deepened historically (bankfull height of 2.5m) and thus was more shaded by riparian trees that were dominated by sycamore and elder with ivy, bramble and hedge bindweed on the understories. Macrophytes were absent with the exception of very localised watercress. The channel width was 7-8m with water depths ranging from 0.3m to 1.5m. The river supported moderate flows over predominantly glide and riffle habitat with more localised pool areas. The generalist water moss species *Fontinalis antipyretica* was also present only boulders. The site did not appear to be influenced by the tide due to the downstream culvert being above the normal high tide range. The conductivity in the Ward River was high (754µs), perhaps due to it being more base-rich as would be indicated by the pH of 8.23. The high conductivity is also likely to be as a result of heavy enrichment of the river (evident strong smell and discoloration). The dissolved oxygen levels were good at 11.8mg/l. These levels would support salmonid fish.

3.1.9 Site 9 - Broadmeadow River, Lissenhall Bridge, Swords

The Broadmeadow River near Lissenhall Bridge, Swords was a heavily enriched part of the channel at the upper extent of the tidal range and hence was a transitional watercourse at the sampling area. Filamentous algae and common duckweed *(Lemna minor*) were locally abundant. The channel was dominated by long, straightened sections of pool up to 2.0m deep with localised shallower runs of glide and riffle. The channel width was 8m wide with bank heights up to 3.0m. The water conductivity was measured at 908µs which is high and likely due to a combination of enrichment but also the tidal influence (i.e. salinity). The dissolved oxygen levels were moderate at 7.9mg/l and the pH level was normal at 7.68. The dissolved oxygen levels would support salmonid fish but are likely prone to fluctuations that would stress salmonid species (typical of rivers with do levels less than 8mg/l).

The river banks were heavily scrubbed over with nutrient tolerant species i.e. nettle, great willowherb (*Epilobium hirsutum*), broad leaved dock (*Rubex obtusifolius*), hogweed, teasel (*Dipsacus fullonum*), butterbur (*Petasites hybridus*), hedge bindweed and reed canary grass (*Phalaris arundinacea*). The Broadmeadow at this site suffered from gross levels of siltation with deep banks of soft silt in slow channelised sections. These appeared to be largely anoxic (apart from short sections of riffle and glide where patches of silt did not release black plumes of silt).

The faster flowing glide and riffle areas of channel were locally dominated by coarse gravel (60% cover), coarse gravels (20%), silt (10%) with smaller gravels making up the rest of the composition. However, the slow moving heavily channelised sections had much higher proportions of silt that made up to 60% cover of the channel bed. Macrophytes were present locally and often growing from gravelly islands in the channel margins. Emergent macrophyte species included watercress, Fool's watercress and blue-water speedwell (*Veronica anagallis-aquatica*).

3.1.10 Site 10 - Staffordstown River, Lissenhall

The Staffordstown River is part of a short catchment just 2.5km long. It rises near Jamestown and flows south east under the R132 and M50 entering the Malahide Estuary near Seapoint. The survey area was near Sunday's Well Bridge upstream of the R132 crossing of the channel. At the survey location, the channel effectively no longer represented a stream due to its physical profile being more characteristic of a drainage channel than of a lowland river. The channel was trapezoidal shaped, deepened and straightened and had very limited water flow (imperceptible flow rates). The channel dimensions were 1m wide, 0.1m deep with a bank height of 2m.

The bordering land use was heavily improved pasture. As with many improved agricultural grassland areas in recent times, due to heavy stocking rates and associated intensive grassland management, the Lissenhall Stream was heavily enriched. This was reflected by the high conductivity reading (1256µs), heavy blanket algae cover and low dissolved oxygen (2.3mg/l). The banks were scrubbed up with bramble, creeping thistle, ivy, dog rose (*Rosa canina*) and nettle. Herbaceous species on the banks included great willowherb and wild angelica (*Angelica sylvestris*). Macrophytes instream included localised water mint (*Mentha aquatica*) and fool's watercress. A few isolated patches of water horsetail (*Equisetum fluviatile*) were also present. The floating algae common duckweed was abundant in the channel.

3.1.11 Site A - Grand Canal, Charlemont

The Grand Canal flows for 132km from the River Shannon (Victoria Lock) to Dublin City where it outfalls, via a lock gate, to the River Liffey Estuary at Grand Canal Harbour, Ringsend. The Grand Canal is situated south of the River Liffey and flows eastwards through Clondalkin, Inchicore, Kilmainham, Dolphins Barn and Ranelagh. The survey area was situated in Charlemont, Ranelagh near the existing Luas Green Line crossing.

Although surrounded by heavily urbanised areas, the Grand Canal had well-developed riparian fringes supporting a good diversity of species including yellow flag (*Iris pseudacorus*), reed sweet grass (*Glyceria maxima*), gypsywort (*Lycopus europaeus*), meadowsweet (*Filipendula ulmaria*), perennial sowthistle (*Sonchus arvensis*), wild angelica, curled dock (*Rumex crispus*), winter heliotrope and great willowherb.

The canal itself supported a good diversity of aquatic macrophytes. Yellow water lily (*Nuphar lutea*) was frequent with the following emergent species; amphibious bistort (*Persicaria amphibia*), Arrowhead (*Sagittaria sagittifolia*) and water plantain (*Alisma plantago-aquatica*) with fool's watercress and water mint recorded as occasional species. Non-native Canadian pondweed (*Elodea canadensis*) was abundant. The invasive macrophyte New Zealand pigmyweed (*Crassula helmsii*) was recorded as locally abundant in the canal edges – this constitutes a new location for this species according to current records (NBDC data). This species is listed under the 3rd schedule of the European Communities (Birds and Natural Habitats) Regulations S.I. No. 477/ 2011. Ivy-leaved duckweed (*Lemna trisulca*),a small perennial macrophyte species was also locally abundant.

The canal base had mixed cobble and coarse, medium and fine gravels substrata but was dominated by soft silt (60% cover). The depth was between 1.5m to 2.3m and approximately 8m wide. The conductivity of the Grand Canal was recorded at 477µs, the pH at 8.39 and dissolved oxygen at 11.3mg/l. The water was clear with a secchi depth of 1.5m.

3.1.12 Site B- River Liffey, Dublin City centre (Rosie Hackett Bridge)

The proposed alignment crossing lies between Rosie Hackett and Butt Bridges in Dublin City centre, over the River Liffey estuary. Here the river is approx. 40-45m wide, an average of 4-5m deep (high tide) and is retained, as is typical for many city centres, by high retaining quay walls. Channel wrack (*Pelvetia canniculata*) is present on the quay walls and mixed sediment bed (soft and hard areas) are present typical of a tidal section of large river. The River Liffey being tidal at this point, and is known to support a range of fish species such as flounder (*Platichthys flesus*), sand goby (*Pomatoschistus minutus*), three-spined stickleback and European eel (*Anguilla anguilla*), as well as brown trout (*Salmo trutta*) and river lamprey (*Lampetra fluviatilis*) (CFB, 2009; Kelly et al., 2011). Urban examples of otter (*Lutra lutra*) are also known from this location (NBDC data; Macklin et al., 2019).

3.1.13 Site C - Royal Canal, 5th level, Cross Gun's Quay, Cabra

The Royal Canal flows from the River Shannon at Cloondara for 145km through Dublin city's northside and enters the River Liffey Estuary at North Wall Quay. The study area is situated near Prospect Road, Cabra at Cross Gun's Quay (5th level) and represents a wider basin of the canal, with an average width of 17m and an average depth of 1.5-2m. The canal bed here is composed largely of silt and clay substrata and supports a very high cover of *Myriophyllum verticillatum* (60%) at this location. Along the canal bed at 1.5-2m depth common stonewort (*Chara vulgaris*) was frequent (20% cover). Canadian pondweed and Nuttall's pondweed both considered as high-risk impact species in Ireland; Kelly et al., 2013had a low percentage cover (<1%). The duckweed species ivy-leaved duckweed (*Lemna trisulca*) was present floating in small pockets of the canal lock (<1% cover).

The rare and protected opposite-leaved pondweed (*Groenlandia densa*) is known from levels 1, 2, 3 and 4 of the canal (BEC, 2011; NBDC data). This area is immediately downstream (east of the survey site) but no stands were recorded in the 5th level during this survey, possibly due to depth constraints or the excessive cover of *Myriophyllum verticillatum*.

Electro-fishing surveys

3.1.14 Site 1 – Slang River, Dundrum

The fish stock was limited to three-spined stickleback (*Gasterosteus aculeatus*) in the Slang River. Stickleback are often the last species of fish to survive in streams impacted by pollution given their higher tolerance to pollutants than salmonids and other species – such degradation was evident on this watercourse. A total of *n*=27 stickleback were recorded with a number of fish cohorts present (see Figure 3.1 below). The Slang River has been artificially straightened historically in the vicinity of the survey site. Retaining walls, culverts and numerous storm drains are ubiquitous in its urban surrounds. Nonetheless, it retains some semi-natural fisheries habitat in the form of riffle-glide sequences and a decent flow volume, along with cobble and coarse gravel substrata, although these were often silted. These characteristics have helped the stream remain viable for stickleback at least. No salmonids or other fish species were captured or observed during the survey and the poor water quality would likely preclude their presence.

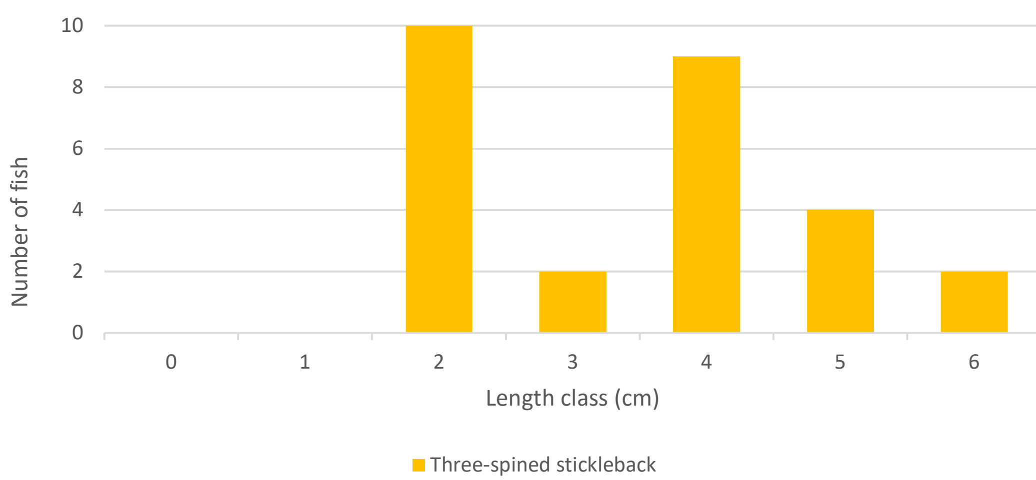

Figure 3.1 Fish stock length distribution recorded via electro-fishing in the Slang River, Dundrum, September 2018.

3.1.15 Site 2 – River Dodder, Patrick Doyle Road

Five fish species totalling *n*=29 fish were recorded from site 2 on the River Dodder near Patrick Doyle Road (see Figure 3.2). Brown trout (*n*=11) followed by stone loach (*Barbatula barbatula*) (*n*=9) were the most numerous species encountered during the survey. Moderate numbers of minnow (*Phoxinus phoxinus*) were also recorded. Single examples of European eel and three-spined stickleback were also captured.

The brown trout at this site were of mixed age, with 0+, 1+ and 2 to 3+ age classes represented. Adult fish were most numerous (i.e. 2 to 3+). This stretch of the Dodder had ample sequences of glide and riffle between broken slabs of bedrock with deeper pools up to 1.5m in depth, locally. These areas provide good holding habitat and, to a lesser extent, nursery areas. The absence of extensive riffle with clean cobble and gravels reduced the nursery value of the site, which is also reflected by the relatively low density of small trout (*n*=5). Enrichment and siltation of the river from adjoining storm drains and point sources of pollution are evidently reducing the viability of the salmonid habitat at this location. The presence of moderate to heavy siltation on the gravels and cobbles (many of which are bedded) and the presence of a high covering of filamentous algae, support this observation.

The occurrence of stone loach and minnow are also indicative of enrichment as these species tend to proliferate in rivers which are more enriched. Whilst only moderate number of minnow were captured, very high abundances were observed locally (often not deliberately targeted due to small sizes). The cracked bedrock and areas of associated large cobble and small boulder present in the Dodder provided some habitat for European eel, which often favour large crevices and cobble/boulder habitat to bury under. While only one eel was captured at least three more individuals were observed but not captured as they retracted in faster flows into crevices in the bedrock slabs.

There were no lamprey ammocoetes captured despite electro-fishing beds of silt and sand in the channel margins. These areas were, however, sub-optimal due to evident compaction, shallow depth (<5cm) and also apparent anoxic conditions (black silt).

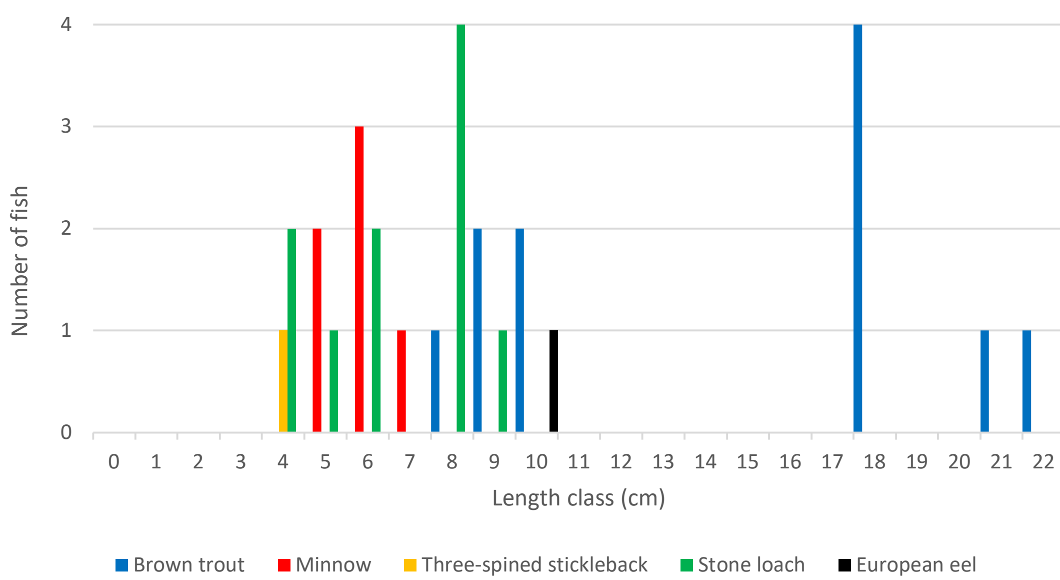

Figure 3.2 Fish stock length distribution recorded via electro-fishing at site 2 on the River Dodder near Patrick Doyle Road, September 2018.

3.1.16 Site 3 – River Tolka, Dean Swift Bridge, Drumcondra

Five fish species were recorded from the River Tolka at Dean Swift Bridge, with brown trout the most abundant (*n*=21). Several age and size classes of trout were captured, including several large fish in the 24-40cm class. These were observably introduced (farmed) fish and not of wild progeny. The River Tolka, as well as several other Dublin rivers, are regularly stocked with large farmed trout to supplement recreational angling and bolster declining wild stocks. This site (Drumcondra Bridge, Griffith Park) was heavily modified with retaining walls, culverts and artificial weirs, the latter of which provided valuable deep (>1.5m) pool areas with optimal holding habitat for salmonids. Deep glide habitat (up to 2m in depth) existed upstream of the culvert (bridge) and also offered good holding, and to a lesser extent nursery, habitat for salmonids.

Despite the site featuring good cobble and boulder in the small weir pools as well as upstream of Drumcondra bridge, eel density was surprisingly low, with only two juveniles captured. Stone loach and three-spined stickleback were also present in low densities. As with other survey sites, local enrichment (storm drains etc.) appears to be providing optimal conditions for minnow, which, again despite actual numbers captured, were present in often high abundances locally.

No lamprey were recorded at this site. This is understandable as no suitable areas of soft sediment were observed in the high flow environment.

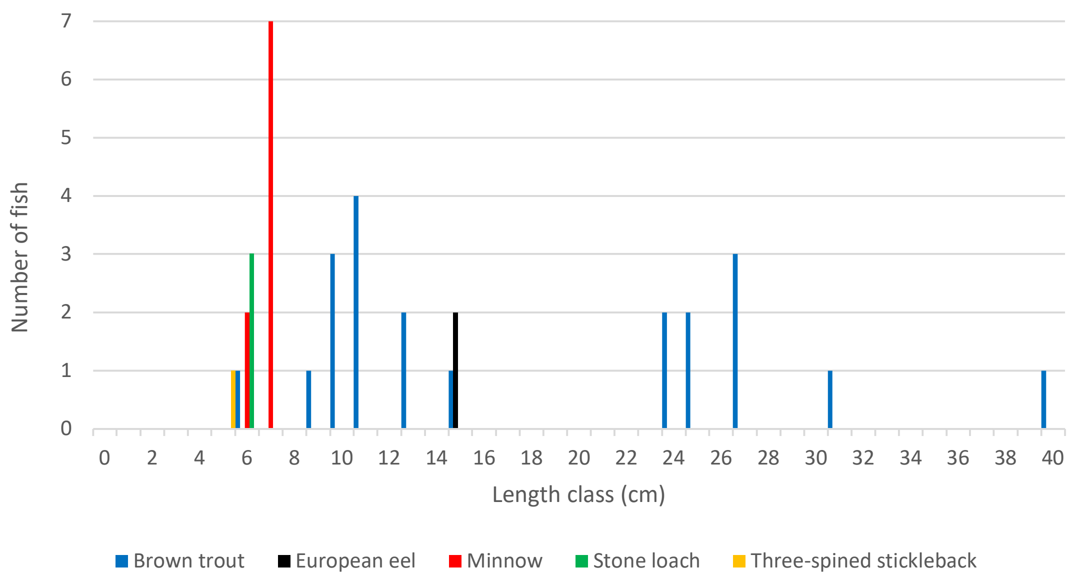

Figure 3.3 Fish stock length distribution recorded via electro-fishing at site 3 on the River Tolka near Griffith Park, September 2018.

3.1.17 Site 4 – Santry River, Old Ballymun Road

The fish stock of the survey site (4) on the Santry River was represented only by three-spined stickleback, as per the Slang River (site 1). Stickleback are often the last species of fish to survive in streams impacted by pollution given their higher tolerance to declining/degraded water quality than salmonids and other species. A total of *n*=7 stickleback were recorded with both juveniles and adults present (see Fig 3.4).

The Santry River has been artificially modified for large parts of the catchment, as well as in the vicinity of the survey site, with culverts and numerous storm drains present. Nonetheless it retains some semi-natural fisheries habitat as it flows locally through heavily modified mixed broadleaf woodland, in the form of riffle-glide sequences and an ample flow volume to keep the dissolved oxygen levels high enough to support stickleback (measured average during survey = 7.9mg/l). Gravel substrata, typically required to supports salmonids, were frequent at the site in various grades but were bedded and invariably heavily silted. Water quality was evidently very poor at this site on the upper Santry. Marginal areas of soft sediment (potential lamprey ammocoete sites) were anoxic and wholly unsuitable for lamprey juveniles.

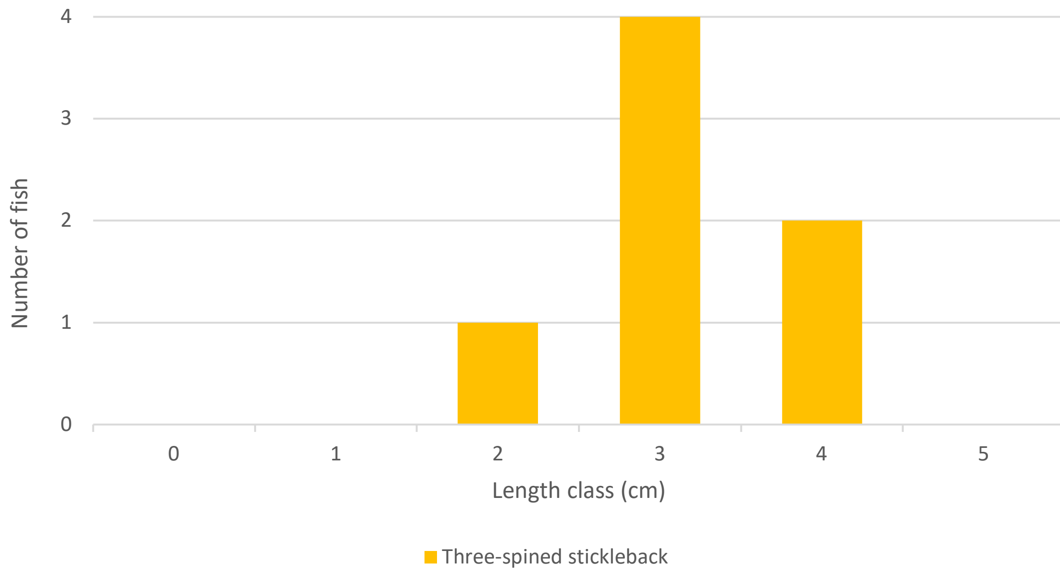

Figure 3.4 Fish stock length distribution recorded via electro-fishing at site 4 on the Santry River, Old Ballymun Road, September 2018.

3.1.18 Site 5 – River Mayne, Dardistown, 0.5km south of Dublin Airport

The River Mayne downstream of Dublin Airport was grossly polluted with extremely high conductivity levels of 1106µs and extremely low dissolved oxygen levels (1.8mg/l). The pH levels were also high at 8.17 – conditions which are not suitable for any fish species, even the highly pollution-tolerant three-spined stickleback. No fish were recorded or observed during the survey and, observably, even macro-invertebrate communities were poorly represented (dominated by abundant Tubificid worms) due to the extremely poor water quality of the site.

3.1.19 Site 6 – Cuckoo Stream, Swords Road, Dublin Airport

As with the nearby River Mayne, the Cuckoo Stream (site 6) downstream of Dublin Airport was also grossly polluted. Abnormally high conductivity levels at the time of survey the stream of 1342µs, a high pH 8.11 and a low dissolved oxygen level (5.8mg/l) meant it was unsuitable for fish life. Sewage fungus was covering much of the river bed at this site and hydrocarbon slicks were visible on the surface. The presence of an invertebrate community dominated by Tubificid worms exemplifies the gross levels of pollution observed. No fish were recorded or observed during the survey.

3.1.20 Site 7 – Sluice Stream, Naul Road, north of Dublin Airport

No fish were recorded from the Sluice Stream, (site 7). At the time of survey (September 2018), the narrow, steep-sided, historically-straightened and modified stream was practically running dry with only local, shallow pools of water remaining in the vicinity of the proposed crossing point. No fish were recorded but may be present further downstream, i.e. fish may have retreated downstream due to reducing water levels. However, in any case, run-off from intensive agriculture (crop production) adjoining the stream appears to have exacerbated siltation of the instream gravels and degraded the overall habitat considerably, in addition to the ubiquitous storm drains and urban run-off present further up the catchment.

3.1.21 Site 8 – Ward River, Ballyheary Park, Swords

A total of six fish species were recorded from the Ward River at Ballyheary Park (see Figure 3.5 below), with minnow being the most abundant species (*n*=30). The site was located in the lower reaches of the river, <1km from the sea. Despite its proximity to the sea, there was little tidal influence at this location due to a high-fall culvert under the old, disused Lissenhall road. Brown trout were present in good numbers, with the population dominated by larger (adult) fish despite the presence of good nursery glide habitat in addition to deeper pools. Spawning habitat, in the form of smaller gravel fractions, was limited throughout, which may partly explain the lack of juveniles at this site. The cobble/boulder-dominated substrata throughout the survey section (upstream of the culvert) offered good refuge and feeding habitat for European eel, which were present in good numbers. Low densities of flounder (indicating some estuarine accessibility at especially high tides), stone loach and three-spined stickleback were also captured.

In comparison to most other sites surveyed, water quality was appreciably better (except for instream litter) with comparatively low levels of siltation over gravels and cobbles and acceptable water quality parameters for such an urban watercourse. Enrichment and storm drain run-off was still evident, however (e.g. at the culvert footbridge bridge). Riparian shading was often high (so-called tunnelling effect) which provides seclusion from disturbance and predation alike, therefore benefiting local fish populations, especially brown trout. Silt pockets were also present but were typically very shallow, presenting as light, fluffy surface deposits with the exception of one pool area, where a bed of deeper anoxic silt was present. None of these areas were considered suitable for larval lamprey nor were any found to contain ammocoetes.

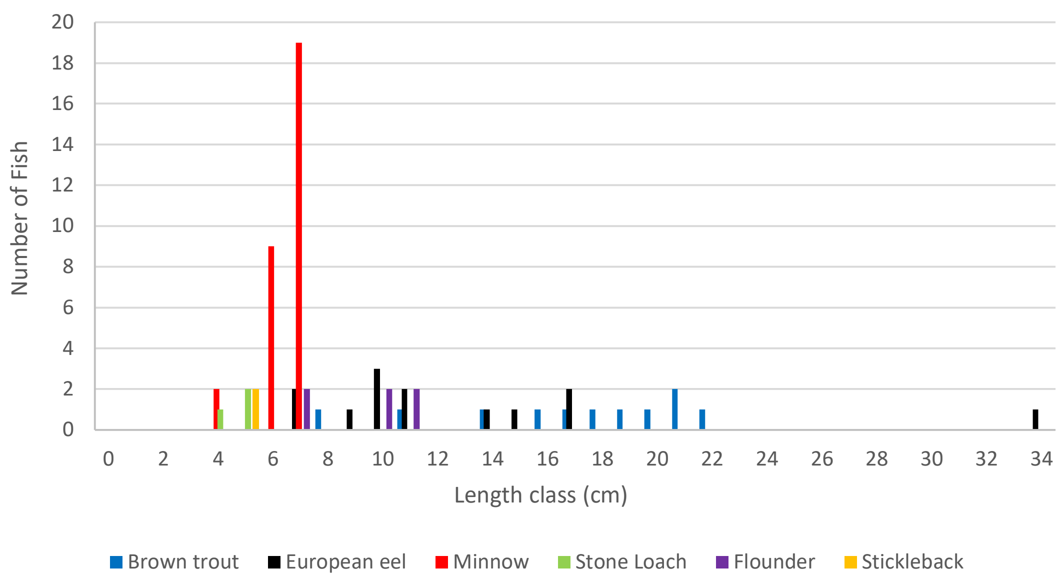

Figure 3.5 Fish stock length distribution recorded via electro-fishing at site 8 on the Ward River, Ballyheary Park, Swords, September 2018.

3.1.22 Site 9 – Broadmeadow River, Lissenhall Bridge, Swords

A total of seven fish species were recorded from the Broadmeadow River at Lissenhall Bridge (see Figure 3.6 below), with minnow the most abundant (*n*=30). The site was located in the lower reaches of the river and is tidally influenced with direct connectivity, via the R132 culvert, to the sea <1km downstream. A number of brackish water fish species were present, namely sand goby and flounder, albeit in small numbers.

Water quality was evidently poor with high conductivity, high turbidity (suspended solids) and high levels of siltation instream. Despite this, and the tidal influence, brown trout were present in small numbers, found in small pools at the tail end of cobbled-riffle areas. European eel were present in modest numbers, with both juveniles and several maturing adults captured, particularly in association with the boulder-dominated habitat underneath the old bridge arches.

High numbers of minnow and to a lesser extent stone loach were again, as with other survey sites on this project, indicative of the high levels of enrichment at the site along with characteristic high nutrient-loving riparian vegetation such as abundant nettle, hogweed, hedge bindweed and great willowherb. Siltation was often excessive, apart from in locally present higher flow areas, and although soft and deep (>15cm invariably) was largely anoxic and not suitable for lamprey ammocoetes, of which none were recorded.

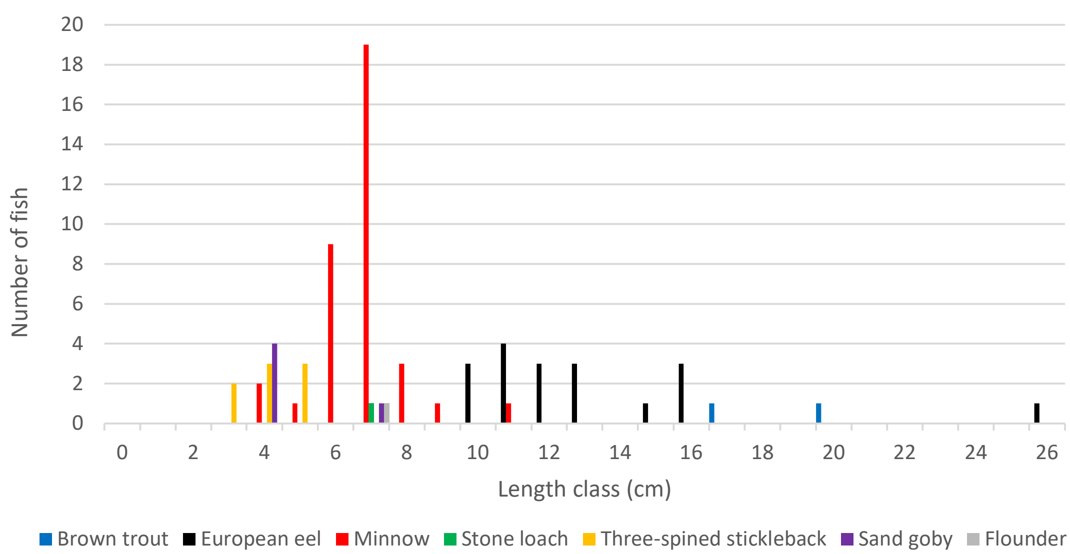

Figure 3.6 Fish stock length distribution recorded via electro-fishing at site 9 on the Broadmeadow River, Lissenhall bridge, Swords, September 2018.

3.1.23 Site 10 – Staffordstown River, Lissenhall, Swords

Three-spined stickleback were the only fish species recorded from the Staffordstown River (see Figure 3.7 below), with low numbers present (*n*=7). Water quality and fish habitat quality were both very poor. The watercourse is effectively no longer a stream due to its physical profile being more characteristic of a drainage channel than of a lowland river form. The channel was trapezoidal-shaped, deepened and straightened and had very limited water flow (imperceptible flow rates at the time of survey). The channel dimensions were 1m wide, 0.1m deep with a bank height of approx. 2m.

The bordering land use was heavily improved pasture. As with many improved agricultural grassland areas in recent times, due to heavy stocking rates and associated intensive grassland management the stream was and heavily silted and evidently heavily enriched. This was reflected by the high conductivity reading (1256µs), heavy blanket algae cover, abundant common duckweed and low dissolved oxygen levels (2.3mg/l). The banks were scrubbed up with bramble, creeping thistle, ivy, dog rose and nettle. Herbaceous species on the banks included great willowherb and wild angelica (*Angelica sylvestris*). Macrophytes instream included localised water mint and fool's watercress with a few isolated patches of water horsetail (*Equisetum fluviatile*) were also present.

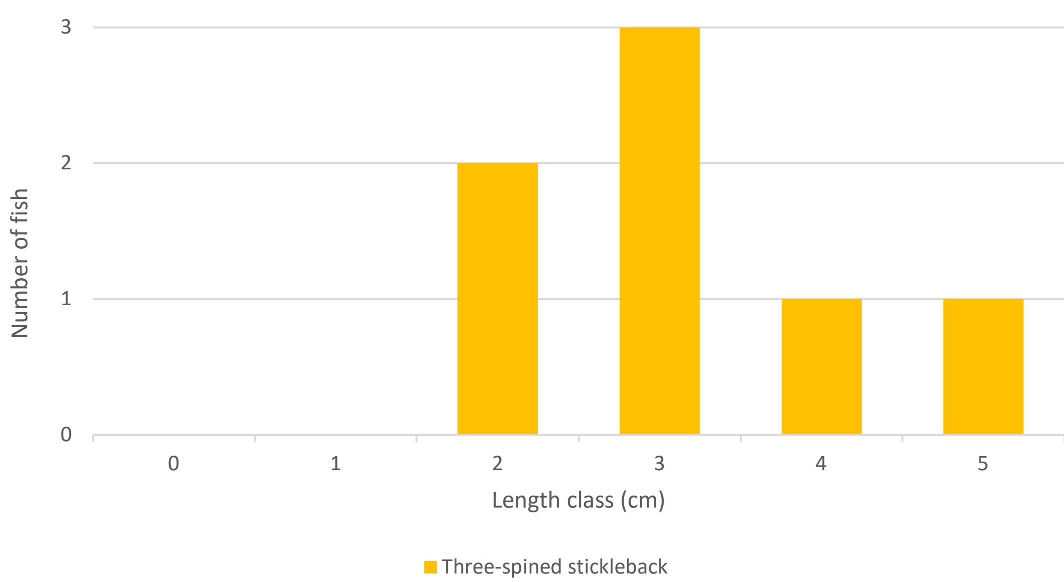

Figure 3.7 Fish stock length distribution recorded via electro-fishing at site 10 on the Staffordstown RIver, Lissenhall, Swords, September 2018.

Fisheries habitat

3.1.24 Salmonid habitat

No Atlantic salmon were recorded during this survey with brown trout the only salmonid species captured. The Dodder, Tolka and Ward rivers offered the best overall salmonid habitat, with good numbers of brown trout present across these sites. However, whilst nursery and holding habitat was good, the quality of spawning gravels was moderate at best given overall levels of siltation, the bedded nature of the substrate and the overall threat from water quality issues (enrichment). Evidently, this is having an impact on trout recruitment, with the numbers of juveniles appreciably low at these sites compared to adults.

The Broadmeadow River offered only moderate salmonid value, despite the presence of small number of brown trout in this tidal section of river. The salmonid value of the river was diminished due to the high levels of siltation and poor spawning opportunities as well as sub-optimal nursery and holding habitat (see table 3.2 below). The Sluice stream offered some suitability for salmonids via localised, fine spawning gravels although they were not recorded – some brown trout *may* have been present were it not for the dangerously low water levels at the time of survey. The Slang, although offering some suitability for brown trout, did not support any salmonids, likely due to the very poor water quality. Poor water quality is a serious threat to salmonids across all the sites surveyed.

Table 3.2 Summary of the salmonid Life Cycle Unit scores for the *n*=10 sites surveyed as part of the proposed MetroLink (after Kennedy, 1984; O Connor & Kennedy, 2002)

Site no.	Salmonid habitat value	Spawning	Nursery	Holding	Total score	Salmonids recorded
1	Moderate	3	3	3	9	No
2	Good	3	2	2	7	Yes
3	Good	3	2	1	6	Yes
4	Poor	4	4	4	12	No
5	Poor	4	4	4	12	No
6	Poor	4	4	4	12	No
7	Moderate	3	4	4	11	No
8	Good	3	2	2	7	Yes
9	Moderate	4	3	3	10	Yes
10	Poor	4	4	4	12	No

(*lower scores indicate superior habitat)

3.1.25 Lamprey habitat

No lamprey ammocoetes were recorded during the electro-fishing surveys from any of the *n*=10 sites and there was limited suitability overall, grading as 'moderate' at best. Nursery habitat was sub-optimal in all cases (Table 3.3), with soft sediment areas either too shallow and compacted (e.g. Dodder, Tolka and Ward) or subject to poor water quality and highly anoxic in nature. Several sites, namely the Santry, Mayne, Cuckoo and Staffordstown, had such poor water quality (see section 3.3 below for more details) that they were incapable of supporting lamprey species, or indeed any fish other than the highly pollution-tolerant three-spined stickleback.

Although soft sediment areas corresponding to Type 2 habitat were present at the Dodder, Tolka and Ward sites, they were highly localised and invariably shallow (<5cm) in nature and too compacted for lamprey ammocoete burrowing.

Some sites – the Dodder, Tolka and Ward - offered moderate spawning potential in the form of finer gravels. However, the cover of filamentous algae due to local enrichment greatly reduced the quality of this habitat, as did overall levels of siltation and suspended solids at these sites. Theoretically, the Sluice stream offered some good potential spawning habitat for brook lamprey but the seriously low water levels prohibited their presence from the survey site. Poor water quality may also be inhibiting their survival.

Table 3.3 Lamprey Habitat Quality Index (LHQI) scoring system for lamprey habitat value at the *n*=10 sites surveyed as part of the proposed MetroLink

Site no.	Lamprey habitat value	Spawning	Nursery	Total score	Salmonids recorded
1	Poor	4	4	8	No
2	Moderate	3	4	7	No
3	Moderate	3	4	7	No
4	Poor	4	4	8	No
5	Poor	4	4	8	No
6	Poor	4	4	8	No
7	Moderate	3	4	7	No
8	Moderate	3	4	7	No
9	Poor	4	4	8	No
10	Poor	4	4	8	No

(*lower scores indicate superior habitat)

Q-sampling (macro-invertebrates)

3.1.26 Riverine macro-invertebrate samples

Overall, the water quality across the riverine water quality sampling sites was poor with all sites achieving water that was moderately to seriously polluted. As such, the sites scored between Q1 and Q3 and are not achieving the target 'good status' Q4 as required under the Water Framework Directive (2000/60/EC). A summary of the Q-sample results is illustrated in Table 3.4 below with full species lists for the riverine samples presented in Appendix A. Figure 3.8 below provides an overview of Q-ratings across the survey sites.

The Rivers Mayne and Cuckoo (sites 5 & 6) were the most seriously polluted (achieving Q1) which was reflected by the presence of only a single highly pollution-tolerant taxa in high numbers (i.e. *Tubifex* spp. worms). Tubificid worms are placed in the most pollution tolerant category, i.e. EPA class E, and when present in isolation, with the absence of other species, a river falls within the worst EPA category (i.e. Q1).

The Santry (site 4) also fell within the seriously polluted class (Q2). This was due to the absence of EPA Class A and B taxa at both sites (i.e. clean water indicator species), small numbers of Class C invertebrates (with exception of *Gammarus* shrimp) and higher numbers of EPA class D and E taxa.

The Rivers Tolka (site 3) and Sluice (site 7) had Q2-3 water quality (moderately polluted), falling into a slightly better water quality class than the Santry. While EPA class A and B invertebrates were absent, EPA class C invertebrates were common. However, the presence of good numbers of class D and or E is strongly indicative of moderately polluted water and therefore both rivers fell into the Q2-3, moderately polluted class.

The rivers Slang, Dodder & Ward (sites 1, 2 & 8 respectively) all had Q3 (moderately polluted water). The absence of EPA class A invertebrates (clean water mayflies & stoneflies) and low numbers or absent EPA class B (e.g. cased caddis, narrow bodied Baetids, Leuctrids etc.) precluded them from falling into a higher class (i.e. Q3-4). The presence of EPA class D and or E (polluted water indicators) in these samples also resulted in them falling into the Q3 category.

In summary, none of the watercourses surveyed as part of this project were achieving Q4 (good status, unpolluted water) as required under the Water Framework Directive (2000/60/EC).

Table 3.4 Macro-invertebrate composition and associated Q-ratings for the watercourses associated with the proposed MetroLink

Site no.	EPA Q-rating	Pollution status	WFD status
1	Q3	Moderately Polluted	Poor Status
2	Q3	Moderately Polluted	Poor Status
3	Q2-3	Moderately Polluted	Poor Status
4	Q2	Seriously Polluted	Bad Status
5	Q1	Seriously Polluted	Bad Status
6	Q1	Seriously Polluted	Bad Status
7	Q2-3	Moderately Polluted	Poor Status
8	Q3	Moderately Polluted	Poor Status
9	Transitional water	n/a	n/a
10	Q2	Seriously Polluted	Bad Status

3.1.27 Canal macro-invertebrate samples

3.1.27.1 Site A - Grand Canal, Charlemont

Fourteen species of invertebrate (*n*=14) were recorded from the Grand Canal at Charlemont (Ranelagh) between locks 5 and 6. A single cased caddis species was recorded from the family Phryganeoidea (*Phryganea bipunctata*). The species favours slow moving or still habitats and substrata of organic particulates and is often present attached to the stems of macrophytes, which were abundant at this canal site.

Gastropod diversity was good with six individual species recorded. Of note *n*=2 specimens of the striking river nerite (*Theodoxus fluviatilis*) was recorded (green shell with yellow marbling). The snail species favours well oxygenated water over calcareous bedrock (Anderson, 2016). Two rare invertebrate species were recorded from the samples, namely the Glutinous snail (*Myxas glutinosa*) and false orb pea mussel (*Pisidium pseudosphaerium*). *Myxas glutinosa* is thought to favour lower trophic states and this may explain its occurrence in the Grand Canal (Anderson, 2016) which has evidently good water quality. *Myxas glutinosa* is considered endangered in Ireland (Byrne et al., 2009) and, according to the ICUN Red List accessed 30th November 2018, the species is in the 'data deficient' category.

The false orb pea mussel is also listed as endangered in Ireland (Byrne et al, 2009). *Pisidium pseudosphaerium*'s distribution is centred in the Royal and Grand Canals and is thought to be at risk from dredging activities (Byrne et al., 2009), which are routinely carried out annually on these waterways.

3.1.27.2 Site C - Royal Canal, 5th level, Cabra

Seven macro-invertebrate species (*n*=7) were recorded at the 5th level on the Royal Canal, Cross Gun's Quay, Cabra. These included the cased caddis *Anthripsodes cinereus*. This relatively common cased caddis species has a characteristic curved, tapering case of fine grains that occurs in a variety of surface waters, including canals. Gastropod snail species recorded included the common bladder snail (*Physa fontinalis*) and Leach's bithynia snail (*Bithynia leachii*). Both species are widespread and not of high conservation value. The bivalve species known as the horney orb mussel (*Sphaerium corneum*) was recorded as common in the samples. The species is widespread in Ireland, especially in hard water areas. Only one coleopteran genus was recorded in the sample. These were larvae of the *Haliplus* genus. No rare or protected invertebrates were recorded in the Royal Canal at this site.

White-clawed crayfish survey

No examples of white-clawed crayfish were recorded from any of the riverine or canal survey sites via trapping or sweep netting techniques. Riparian walkover surveys, whilst recording several individual otter spraints on the Dodder and Tolka rivers, failed to identify any crayfish remains. Our results are, nevertheless, unsurprising in light of the observed poor water quality across the majority of the survey sites (refer to section 3.3 and Table 3.4 above).

For example, the river Mayne (site 5) and Cuckoo (site 6) demonstrate such grossly polluted conditions that they are physically and chemically incapable of supporting crayfish (or indeed fish life). Likewise, the seriously polluted status of the Santry (site 4), Sluice (site 7) and Staffordstown River (site 10) – as supported by Q-sampling – would also preclude crayfish and, indeed, none were found at these sites.

The Broadmeadow River (site 9) is tidal and thus is not suitable for crayfish, as is the proposed crossing point over the Liffey near Rosie Hackett bridge in Dublin City centre.

Historically, crayfish are not known from watercourses within the existing M50 ring around Dublin, i.e. in heavily urban environments. The nearest extant populations are supported in the Camac River, Clondalkin, which adjoins the Liffey near Heuston Station, as well as the upper reaches of the Liffey and its tributaries, upstream of Leixlip Reservoir (NBDC data).

Whilst the Grand Canal contains locally abundant crayfish throughout much of its length (Reynolds et al., 2002; Triturus, unpublished data), none are known in the vicinity of Dublin. Similarly, any crayfish records for the Royal canal occur at the western extent, near its source at Lough Owel, Mullingar, Westmeath, and not near Dublin. Our results support the known distribution of the species, with no crayfish captured via trapping or hand net sweeps in either site on the Grand canal (Charleston) or Royal canal (5th level, Cabra).

Figure 3.8 Distribution of Q-ratings for the riverine sites surveyed as part of the proposed MetroLink project, September, 2018

4. Discussion & conclusions

Fisheries habitat evaluation

4.1.1 Watercourses of importance for salmonids

In the context of the proposed MetroLink and associated watercourses, the overall salmonid habitat quality was generally moderate, with only three of the *n*=10 riverine sites achieving a 'good quality' score in terms of spawning, nursery and holding habitat. These river sites were the larger Dodder, Tolka and Ward rivers, where brown trout were recorded in modest densities. Only two adult brown trout were recorded in the tidal reaches of the Broadmeadow River (site 9), the only other site found to contain salmonids. However, a noticeable pattern across the salmonid-containing sites was the paucity of juveniles. Whilst the 0+ age class was evidently present at the Dodder, Tolka and Ward Rivers, numbers of adults were appreciably greater. This would suggest poor recruitment, at least in recent years. No Atlantic salmon were recorded at the survey sites.

Brown trout populations are known to be influenced by a number of density-dependent (typically as fry) and density-independent factors (typically as adults), including predation, prey availability, hydrology (water levels) and temperature regimes (Cattanéo et al., 2002; Armstrong et al., 2003; Nicola et al., 2008). However, declining water quality is considered a serious threat to the survival and persistence of salmonid populations (Hendry et al., 2003; Milner et al., 2003) especially in urban environments which are typically subjected to greater anthropogenic pressures than rural watercourses, e.g. urban run-off, siltation, pollution episodes.

The water quality of even the better salmonid sites was poor (Table 3.4), with all of the ten survey sites at least moderately, if not grossly, polluted and failing to meet Water Framework Directive standards (i.e. Q4). No salmonids were recorded from any site which achieved a rating of Q2 or below and it could be argued that any existing salmonid populations in the context of this project are in a precarious position. Our surveys indicate that species such as minnow and stone loach, as well as three-spined stickleback, were more abundant than brown trout. This is a commonly observed pattern in rivers associated with eutrophication (enrichment) and declining water quality. Species such as minnow and stone loach are better able to tolerate temperature and oxygen fluctuations, have less specific spawning requirements and are more adaptable to changing prey resources as a result of eutrophication (Winfield & Nelson, 2012). Irish studies have shown that non-salmonid fish species dominate the fish community at Q2–3 sites and gradually decrease to less than 10% of the fish population at Q4–5 and Q5 sites (e.g. Kelly et al., 2007).

4.1.2 Watercourses of importance for lamprey species

No lamprey ammocoetes were recorded during electro-fishing surveys, principally due to unsuitable or a lack of soft sediment areas for burrowing larvae, in addition to the often-poor spawning opportunities for adults. Ammocoetes, regardless of species, require soft sediment in which to burrow, be it mud, sand, silt, clay or a matrix of all types, which is ≥5cm in depth (Maitland, 2003). Depth of said soft substrate is an important factor for determining the abundance of larval lampreys (Potter et al., 1986; Kelso & Todd 1993; Goodwin et al., 2008; Aronsuu & Virkkala, 2014). Typically, such areas contain substantial amounts of undecomposed organic material such as twigs and leaves (Applegate 1950; Kainua & Valtonen, 1980; Young et al., 1990; Quintella et al., 2007) and are characteristically found at eddies or backwaters, on the inside of bends or behind obstructions, where current velocity is below that of the main stream and where fine sediment tends to accumulate (Byrne et al., 2000; Kelly & King, 2001; Igoe et al., 2004).

However, where present at our survey sites, soft sediment areas were either too compacted/shallow for ammocoete burial (e.g. Dodder) or were simply unsuitable due to their anoxic nature (e.g. Broadmeadow, Slang). Additionally, the fact that all sites were, at best, moderately polluted, would likely preclude *Lampetra* species, through a combination of poor dissolved oxygen in gravels (used for redd construction) and anoxic conditions in sediments used for ammocoete burial. Lamprey ammocoetes are tolerant of low oxygen and poor water quality for short periods only and adults are considered sensitive to pollution (Maitland, 2003).

4.1.3 Watercourses of importance for European eel

European eel are the most threatened fish in Irish freshwaters (King et al., 2011) and the alarming decline of the species in recent decades has resulted in a classification of 'critically endangered' (Pike et al., 2020). Numbers of eel captured across the survey sites was relatively low with the Dodder, Tolka, Ward and Broadmeadow offering the best eel habitat in terms of both prey resources and diurnal refugia such as large boulders, cracks in bedrock and submerged structure. Despite the highly degraded water quality present at the site (and much of the lower river in general), the Broadmeadow supported the highest density of eels of any of the sites (n=18), with all bar one being juveniles. Clearly, given the accessibility and proximity of this site to the sea (<1km), the Broadmeadow acts as a valuable migration corridor for the species.

4.1.4 Other fish species - three-spined stickleback

Apart from the River Mayne and Cuckoo stream, which were both grossly polluted and incapable of supporting fish life at the survey sites (i.e. Q1), three-spined stickleback were recorded from all sites. This species is known to be a highly pollution-tolerant species, capable of establishing and sustaining populations in a wide variety of low-quality waters where other fish cannot persist (Ostlund-Nilsson et al., 2006). Three-spined stickleback are also one of the first aquatic species to naturally recolonise a site following chronic pollution and have a high displacement threshold (i.e. highly pollution tolerant, tend to stay resident in polluted areas). They were the only fish species recorded in the Slang River (site 1), Santry River (site 4) and Staffordstown River (site 10) during this survey and, when occurring in isolation, they are a biomarker species of a highly degraded stream habitat; indeed, these watercourses suffered from poor water quality according to physiochemical readings and Q-sampling results (all ≤Q3).

4.1.5 Watercourses with no fish

Several survey sites were found to contain no fish at the time of survey, namely the River Mayne (site 5) as well as the Cuckoo stream (site 6) and the Sluice stream (site 7). Whilst the latter site may have returned a negative result due to the extremely low water levels at the time of survey, the Mayne and the Cuckoo sites were so grossly polluted (both Q1) that they were simply incapable of supporting fish life, or indeed even a range of typically pollution-tolerant macro-invertebrates (Tubificid worms only). Given the highly-modified, urban nature of these watercourses, and the fact that they drain the lands surrounding Dublin Airport, it is difficult to see how any rehabilitation works could be effectively instigated.

White-clawed crayfish

No white-clawed crayfish were recorded from any of the *n*=10 riverine sites surveyed. Crayfish prefer (though not entirely necessary) a pH range of 6.5-9.0 and calcium levels >5 mg/l (Holdich & Jay, 1977). Whilst these conditions are met in all the rivers surveyed, there are no known historical records for the species in these watercourses (NBDC data). However, crayfish are known from the middle- and upper-reaches of the River Liffey. Historical absence aside, it is considered likely that the widespread poor (and declining) water quality across the survey sites would preclude their presence. Numerous Irish studies indicate that a water quality of Q2-3 is typically a threshold for crayfish occurrence (Demers & Reynolds, 2002) although they have been recorded in Irish catchments in moderately polluted conditions as low as Q2 (see Demers et al., 2005).

Clearly, intra-catchment (local scale) crayfish distribution is dependent on multiple factors aside from water quality as derived from Q-values including temporal pH fluctuations, dissolved oxygen concentrations, suspended solids and total organic carbon (TOC) (Trouilhé et al., 2007; Demers & Reynolds, 2003) as well as periodic pollution episodes. Waters subject to high and ongoing anthropogenic stresses and environmental fluctuations, such as those associated with the proposed MetroLink, are considered sub-optimal for white-clawed crayfish.

Water quality (Q-sampling) & macro-invertebrates

4.1.6 Q-samples

Water quality in the riverine sites surveyed was overall very poor (see Table 3.4 & Appendix A). The Q-ratings ranged between Q1 and Q3 (i.e. seriously polluted to moderately polluted water). None of the river sites were reaching the target Q4 (unpolluted, good status) water as required under the Water Framework Directive (2000/60/EC). The heavily modified urban surrounds, historical channel modifications, storm drains and other point sources of pollution were evidently contributing to a decline in biological water quality. No rare or protected species of macro-invertebrate were recorded from the riverine samples.

4.1.7 Canal macro-invertebrates

A total of *n*=14 and *n*=7 species macro-invertebrates were recorded from the Grand Canal (site A, Charlemont) and Royal Canal (site C Cross Gun's Quay, Cabra), respectively. No rare or protected invertebrates were recorded from the Royal Canal. However, two rare species of invertebrate were recorded from the Grand Canal, namely the glutinous snail (*Myxas glutinosa*) and the false orb pea mussel (*Pisidium pseudosphaerium*). Both species are considered endangered in Ireland (Byrne et al., 2009). According to the NBDC (accessed 25th November 2018) both species were recorded between locks C5 and C6 by Evelyn Moorkens and Ian Killeen on the 5th October 2003 (O161, 325) at the same location as survey site A.

Macrophytes

No rare or threatened macrophytes were recorded during the current survey of the riverine sites or the Grand and Royal Canal sites. However, the rare pondweed species opposite-leaved pondweed (*Groenlandia densa*) was recorded in several sections of the Royal Canal (1st to 4th levels, inclusive) during a survey conducted in 2011 (BEC, 2011). The species is legally protected and is listed on Schedule A of the Flora Protection Order (S.I. No. 356/2015). The nearest location of the *Groenlandia densa* is below the 5th Lock (i.e. east of Cross Gun's Bridge and <50m from the study area). The species occurs quite frequently from below the 5th Lock in the Royal Canal as far as Croke Park (above the 1st Lock canal confluence with the River Liffey).

Historical records also exist in the Grand Canal for *Groenlandia densa* on the NBDC database between Inchicore and Ringsend (accessed 25th November 2018). It is understood that BEC conducted recent studies on behalf of Waterways Ireland and recorded the species at one location. Scott Cawley (2016) specify that the plant has been recorded near Ringsend.

The rare stonewort species, tassel stonewort (*Tolypella intricata*) has been recorded historically from the Royal Canal between Granard Bridge and Cross Gun's Bridge with records from 1992 - the species was recorded typically within 1m metre from the bank growing in silt in 0.5m water depth (Nash & King, 1993). The species was not recorded during the current 2018 survey between the 5th and 6th locks of the Royal Canal. The survey area at Cross Gun's Quay (site C) typically featured water between 1.5m and 2m deep and thus may be unsuitable for the species.

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5. References

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6. Appendix A – macro-invertebrate sample composition

Table 6.1 Macro-invertebrate composition and associated Q-ratings for the riverine watercourses associated with the proposed MetroLink project

Family	Species	Site 1 (Slang)	Site 2 (Dodder)	Site 3 (Tolka)	Site 4 (Santry)	Site 5 (Mayne)	Site 6 (Cuckoo)	Site 7 (Sluice)	Site 8 (Ward)	Site 9 (Broadmeadow)	Site 10 (Staffordstown)	EPA class
Caenidae	*Caenis luctuosa*								11			C
Baetidae	*Baetis rhodani*	42	2						3			C
Ephemerellidae	*Serratella ignita*							3				C
Limephilidae	*Halesus radiatus*							1				B
Lepidosomatidae	*Lepidostoma hirtum*	1							2			B
Hydropsychidae	*Hydropsyche siltalai*	1										C
Ryacophilidae	*Ryacophila dorsalis*	2	2									C
Hydrobiidae	*Potamopyrgus antipodarum*	2		1	5				8			C
Planorbiidae	*Gyraulus crista*	2										C
	Planorbis planorbis		10						2			C
Physidae	*Physa fontanalis*		3									D
Valvatidae	*Valvata piscinalis*									2		C
Ancylidae	*Ancylus fluviatilis*	1	5	6				2	3			C
	Lymnaea peregra			22					1			D
Sphaeriidae	*Sphaerium corneum*			2	3			3	4			D
Elmidae	*Elmis aenea*								2			C
Dytiscidae	*Dytiscid sp. larvae*		1									C
Gammaridae	*Gammarus duebenii*	4		3	20			3	53	38		C
Asellidae	*Asellus aquaticus*	24	5					4			22	D
Hydracarina species	*n/a*	1	12									C
Simuliidae	*Simulium sp.*	1										C
Chironomidae	*Chironomus riparius*									2		E
	Chironomini tribe		20									C
Chaobridae	*Chaobrus sp.*										4	C
Glossiphonidae	*Glossiphonia complanata*	1		4								D
Piscicolidae	*Piscicola geometra*			1								C
Tubificidae	*Tubifex sp.*		8	6	5	144	103			3		E

Family	Species	Site 1 (Slang)	Site 2 (Dodder)	Site 3 (Tolka)	Site 4 (Santry)	Site 5 (Mayne)	Site 6 (Cuckoo)	Site 7 (Sluice)	Site 8 (Ward)	Site 9 (Broadmeadow)	Site 10 (Staffordstown)	EPA class
Abundance		82	68	45	33	144	103	16	89	45	26	
Taxon Richness *n*		12	10	8	4	1	1	6	10	4	2	
Q Rating		3	3	Q2-3	Q2	Q1	Q1	Q2-3	Q3	Transitional water	Q2	
EPA Pollution Class		Moderately Polluted	Moderately Polluted	Moderately Polluted	Seriously Polluted	Seriously Polluted	Seriously Polluted	Moderately Polluted	Moderately Polluted	n/a	Seriously Polluted	
WFD Status for equivalent Q Rating		Poor Status	Poor Status	Poor Status	Bad Status	Bad Status	Bad Status	Poor Status	Poor Status	n/a	Bad Status	

Table 6.2 Macro-invertebrate composition and taxon richness for the Grand and Royal canal sites associated with the proposed MetroLink

Family	Species	Grand Canal (site A)	Royal Canal (site B)	Rare or protected?
Limephilidae	*Halesus radiatus*	1		No
Leptoceridae	*Anthripsodes cinereus*		17	No
Phryganeoidea	*Phryganea bipunctata*	1		No
	Planorbis carinatus	2		No
	Bathyomphalus contortus	2		No
Physidae	*Physa fontanalis*	5	4	No
	Bithynia leachii	4	11	No
	Myxas glutinosa	1		Yes[11] (ICUN Data Deficient species) & Endangered (Byrne et al. 2009)[12]
	Theodoxus fluviatilis	2		No
Sphaeriidae	*Sphaerium corneum*	11	17	No
	Pisidium pseudosphaerium	2		Yes[13] (ICUN Least Concern species) & Endangered (Byrne et al. 2009)[2]
Haliplidae	*Haliplus sp. (larvae)*		2	No
	Brychius elevatus	1		No
Hydroporinae	*Porhydrus lineatus*	2		No
Asellidae	*Asellus aquaticus*	5	14	No
	Chironomini tribe		2	No
Piscicolidae	*Pisciola geometra*	1		No
Abundance		40	78	
Taxon Richness *n*		14	7	

[11] Mollusc Specialist Group 1996. *Myxas glutinosa*. *The IUCN Red List of Threatened Species* 1996: e.T14263A4428448. http://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T14263A4428448.en. Downloaded on 30 November 2018.

[12] Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) Ireland Red List No. 2 – NonMarine Molluscs. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

13 Killeen, I., (2011). *Pisidium pseudosphaerium*. The IUCN Red List of Threatened Species 2011: e.T155821A4849042. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T155821A4849042.en. Downloaded on 30 November 2018.

7. Appendix A – representative site images

Plate 7.1 The heavily modified Slang River (site 1) at Dundrum Luas bridge, bounded by high retaining walls

Plate 7.2 Site 2 on the River Dodder near viaduct

Plate 7.3 Electro-fishing at site 3 on the River Tolka, Drumcondra, one of the better salmonid sites surveyed

Plate 7.4 The heavily degraded upper section of the Santry River (site 4) on the old Ballymun Road, flowing through mixed broadleaved woodland and supporting only three-spined stickleback

Plate 7.5 Site 5 on the River Mayne was grossly polluted and unsuitable for fish life

Plate 7.6 Q-sampling the Cuckoo stream (site 6), also grossly polluted and unsuitable for fish life

Plate 7.7 The Sluice stream (site 7) featured very low water at the time of survey, in addition to poor water quality, and supported no fish life

Plate 7.8 The Ward River (site 8) supported healthy populations of brown trout, European eel, minnow and flounder and was one of the better sites surveyed in terms of water quality

Plate 7.9 The Broadmeadow River at site 9 was tidal and featured poor water quality. Nonetheless, it still supported low numbers of brown trout and European eel

Plate 7.10 Surrounded by intensive pasture, the Staffordstown River at site 10 was heavily overgrown, featured very poor water quality and supported only three-spined stickleback.

7.11 The Luas Green Line crossing over the Grand Canal at Charlemont (Ranelagh). This site had a high cover of macrophytes including the invasive New Zealand pigmyweed and supported the endangered invertebrates *Myxas glutinosa* and *Pisidium pseudosphaerium*

Plate 7.12 The tidal River Liffey in Dublin City centre near survey site B

Plate 7.13 The 5th level on the Grand Canal at Cross Gun's Quay, Cabra looking east (survey site C). No opposite leaved pondweed was recorded here despite its presence downstream (levels 1-4)

Plate 7.14 Male and female three-spined stickleback from the Slang River (site 1), a highly-pollution tolerant fish species

Plate 7.15 Juvenile and (very large) adult minnow from the Broadmeadow River, a species typical of degraded, enriched waters with poor water quality

Plate 7.16 A large 39.7cm FL brown trout captured in the River Tolka (site 3)

Plate 7.17 A juvenile (elver) and maturing adult (yellow) European eel captured from the highly degraded Broadmeadow River (site 9). Despite the poor water quality, sites such as this with good connectivity to the sea can act as valuable migration pathways for this species

Plate 7.18 A flounder and wild brown trout captured from the Ward River (site 8)

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