Royal Canal (1st to 16th lock) otter survey 2025



Triturus

REDACTED

Prepared by Triturus Environmental Ltd. for

Roughan & O'Donovan Consulting Engineers

February 2026

*** Given the content of highly sensitive and legally protected breeding & resting areas, the location of sensitive data has been redacted by the authors**

Please cite as:

Triturus (2026). Royal Canal (1st to 16th lock) otter survey 2025. Report prepared by Triturus Environmental Ltd. for Roughan & O'Donovan Consulting Engineers. February 2026.

Table of contents

1. Introduction 3

1.1 Project background 3

1.2 Legislative protection 3

1.3 Study area description 4

2. Methodology 5

2.1 Desktop review of otter records 5

2.2 Otter signs 5

2.3 Total corridor otter survey (TCOS) methodology 5

2.4 Biosecurity 6

3. Desktop review 8

4. Results 9

4.1 Otter signs 9

5. Discussion 20

5.1 Otter sign distribution (2025) 20

5.2 Otter marking site fidelity 22

5.3 Breeding and resting areas 22

5.4 Management considerations 23

6. References 25

7. Appendix A – otter signs database 29

REDACTED

1. Introduction

1.1 Project background

Triturus Environmental Ltd. were commissioned by Roughan & O'Donovan Consulting Engineers (ROD) to undertake annual baseline otter (*Lutra lutra*) surveys of the Royal Canal between the 1st lock (Spencer Dock, Dublin City) and the 16th lock (Kilcock, Co. Kildare). The survey area encompassed a total of 33km of the Royal Canal and associated corridors. In light of various proposed infrastructural projects in the vicinity of the Royal Canal in the coming years, it was deemed pertinent to complete annual baseline assessments of otter signs to better inform development design, mitigation and otter conservation.

The baseline survey helped to identify the presence of otters and map their range in the survey area by identifying the occurrence of field signs (e.g. holts, couches, spraints, prints and other signs). The distribution of these signs functioned as an indicator regarding areas of canal and aquatic habitat used by otters, including potential breeding areas. The survey was undertaken in the November-December 2025 period and this report constitutes the third of four annual reports (2023-2026 inclusive).

1.2 Legislative protection

The Eurasian otter is a species of conservation concern and high priority, having suffered major declines in its range and population throughout Europe since the 1950s. It is classified as 'near threatened' by the IUCN Red List with a decreasing population trend and, as such, is listed in Appendix I of CITES, Appendix II of the Bern Convention (Council of Europe, 1979) and Annexes II and IV of the EC Habitats Directive (92/43/EEC).

In Ireland, otters, along with their breeding and resting places, are protected under provisions of the Wildlife Acts 1976 to 2023. Otters have additional protection because of their inclusion in Annex II and Annex IV of the Habitats Directive 92/43/EEC, which is transposed into Irish law by the European Union (Birds and Natural Habitats) Regulations 2011 to 2021 (S.I. No. 477 of 2011).

The protection of otters under S.I. No. 477 of 2011 is outlined in Article 51(1) and (2): Protection of fauna referred to in the First Schedule;

51.(1) *The Minister shall take the requisite measures to establish a system of strict protection for the fauna consisting of the species referred to in Part 1 of the First Schedule.*

51.(2) *Notwithstanding any consent, statutory or otherwise, given to a person by a public authority or held by a person, except in accordance with a license granted by the Minister under Regulation 54, a person who, in respect of the species referred to in Part 1 of the First Schedule (listed below). Items (b) and (d) may be considered most relevant to developments.*

- ***(a)*** *deliberately captures or kills any specimen of these species in the wild,*
- ***(b)*** *deliberately disturbs these species, particularly during the period of breeding, rearing, hibernation and migration,*
- ***(c)*** *deliberately takes or destroys eggs of those species from the wild,*

REDACTED

(d) *damages or destroys a breeding site or resting place of such an animal, or*

(e) *keeps, transports, sells, exchanges, offers for sale or offers for exchange any specimen of these species taken in the wild, other than those taken legally as referred to in Article 12(2) of the Habitats Directive, shall be guilty of an offence.*

In an Irish context, according to the most recent Article 17 reporting (NPWS, 2025), otters remain at 'Favourable' conservation status with a stable trend. Otters were considered to be previously 'Near Threatened' (Marnell, 2009) based on a 20-25% decline between 1980 and 2005 (Bailey & Rochford, 2006). However, the current conservation status in Ireland is now of 'Least Concern' (Marnell et al., 2019). Otters remain 'Near Threatened' at a global level according to the IUCN Red List (Loy et al., 2022).

1.3 Study area description

The Royal Canal is some 150km long and links the River Liffey in Dublin City with the River Shannon in Co. Longford. The canal is fed by Lough Owel, Co. Westmeath and flows east to Dublin and west to the River Shannon. Though originally constructed for the transport of goods (work was completed in 1817), the Royal Canal was closed to typical navigation in 1961. The present-day canal serves as a highly valuable recreational amenity site and regionally important ecological corridor. The entire length of the Royal Canal is designated as a proposed Natural Heritage Area (pNHA) (site code: 002103) (NPWS, 1995).

The Royal Canal is known to support a range of fish species, including pike (*Esox lucius*), perch (*Perca fluviatilis*), roach (*Rutilus rutilus*), rudd (*Scardinius erythropthalmus*), bream (*Abramis brama*), roach x bream hybrids, three-spined stickleback (*Gasterosteus aculeatus*), tench (*Tinca tinca*) and Red-listed European eel (*Anguilla anguilla*) (Triturus data; McCloone, 2011; Tierney et al., 1999). These species provide a good prey resource for otter. Whilst white-clawed crayfish (*Austropotamobius pallipes*) are known from the western extent of the Royal Canal (NCPSP[1], EPA & NPWS data), no records are available for the canal in the vicinity of Dublin (NBDC, NPWS data, pers. obs.), despite some good physical habitat and physicochemical suitability.

In terms of water quality, the Royal Canal within and outside of the survey area was of good ecological potential under the 3rd cycle of the Water Framework Directive (WFD) in the 2019-2024 period.

Otters are widespread along the Royal Canal, including within the survey area (see section 3.1 for more details).

[1] National Crayfish Plague Surveillance Programme

2. Methodology

2.1 Desktop review of otter records

A desktop review of published and unpublished data for the Royal Canal and associated habitats was undertaken in respect of otter. Data pertaining to otters held by the National Parks and Wildlife Service (NPWS), National Biodiversity Data Centre (NBDC) and Environmental Protection Agency (EPA) were also reviewed.

2.2 Otter signs

The annual survey area comprised approximately 33km of contiguous canal between the 1st lock at Spencer Dock (River Liffey confluence) and the 16th lock at Kilcock, Co. Kildare (**Figure 2.1**). Otter sign surveys of the Royal Canal, using total corridor otter survey (TCOS) methodology (see below), were undertaken in the November-December 2025 period. This period is considered optimal for surveys, given a greater propensity for otter marking (pre-breeding) and a higher likelihood of sign detection due to decreased vegetation cover. The survey was completed during dry, mild, bright and settled conditions, which ensured that a good representation of habitat marked by otter could be recorded in the field, including territorial marking or marking of feeding and potential breeding areas.

Each otter sign was logged by type, location (handheld GPS), condition and approximate age for later interpretation to distinguish differences in habitat use and activity. Spraints were subjectively assessed as either very fresh, fresh, mixed-age (recent and older spraints, typically indicative of a regular sprainting site) or old (spraint not recently deposited and degrading). Furthermore, indicative counts of spraint (i.e. number of individual spraints) and the number of sprainting sites (often separate clusters in one area) were noted. This helped indicate the frequency of otter marking, which can clarify levels of activity in particular areas, inclusive of breeding (holt) and resting (couch) areas.

2.3 Total corridor otter survey (TCOS) methodology

The survey broadly followed the best practice 'standard survey' methodology for otter as recommended by Bailey & Rochford (2006), Chanin (2003) and Lenton et al. (1980) (all based on observations by Erlinge, 1967). However, methodology differed in that the entire waterline was surveyed rather than the standard 500-600m sections selected at regular (5-8km) intervals from accessible points (e.g. bridges). The novel survey technique, known as a total corridor otter survey (TCOS) (Macklin et al., 2019), involved a continuous, unbiased survey effort along both banks of the Royal Canal, encompassing the entire channel and riparian zones. A boat or kayak facilitated the survey of areas of channel or bank with poor access.

Total corridor survey methodology typically involves the use of two (or more) surveyors working independently (in tandem) along each respective bank of an individual watercourse (where practical). This also facilitates one to work from a more elevated position (e.g. bank top) with one surveying (with appropriate PPE such as a dry suit or chest waders) from within the channel/watercraft. This holistic, labour-intensive approach greatly increases the likelihood of otter sign detection and facilitates a more accurate estimation of otter usage and activity at the river or catchment scale. This is especially

REDACTED

true of more cryptic signs, such as holts and couches that are often located in poorly accessible areas not covered by a standard survey approach.

2.4 Biosecurity

A strict biosecurity protocol following IFI (2010) and the Check-Clean-Dry approach was adhered to during surveys for all equipment and PPE used. Disinfection of all equipment and PPE before and after use with Virkon™ was conducted to prevent the transfer of pathogens or invasive propagules. Any aquatic invasive species or pathogens recorded within or adjoining the survey areas were geo-referenced. All Triturus staff are certified in 'Good fieldwork practice: slowing the spread of invasive non-native species' by the University of Leeds.

REDACTED



Figure 2.1 Overview of the Royal Canal otter survey area, 2025

3. Desktop review

The number of otter records within the survey area from resources like the National Biodiversity Data Centre (NBDC) and National Parks and Wildlife Service (NPWS) are low (<10, data not shown) and many otter records along the Royal Canal are anecdotal. It has been previously noted that otter activity along the Royal Canal is much less evident than in the neighbouring River Tolka or River Liffey (Keeley, 2004).

However, targeted otter surveys completed by Triturus along various sections of the Royal Canal in recent years (2019-2024) have revealed a significant number of otter signs, inclusive of legally protected breeding and resting areas. For example, a total of 39 no. signs, including spraint sites, slides, couches and a number of potential holts were recorded along the Royal Canal corridor between the M50 (12th lock, Castleknock) and the River Liffey confluence (Spencer Dock) in January 2022 (Triturus, 2022).

Previous annual otter surveys completed by Triturus in January to April 2023 and January-April and November 2024 recorded a total of *n*=54 and *n*=59 otter signs, respectively, within the 33km survey area (Triturus, 2024a; Triturus, 2024b). These surveys also recorded a low number of holts and couches.

Otter utilisation of the canal is widespread between Spencer Dock (River Liffey confluence) and Kilcock, Co. Kildare, although several areas repeatedly feature a greater concentration of otter marking (e.g. near Maynooth & 7th lock to Kennan Bridge) and are more valuable as breeding and resting areas. Many marking and breeding/resting sites along the Royal Canal are used inter-annually, as evidenced by previous surveys (pers. obs.).

REDACTED

4. Results

4.1 Otter signs

A total of *n*=63 otter signs were recorded within the survey area during the current November-December 2025 otter survey, comprising a total of 33km of contiguous canal habitat (**Table 4.1; Figures 4.1-4.3**). This equated to a mean of 1.9 otter signs per kilometre of linear canal habitat (i.e. 64 signs along 33km of canal), a frequency similar to the 2024 survey (59 signs, 1.8 per km) and the 2023 survey (54 signs, 1.6 per km). A total of 30 no. of these otter sign/marking sites were at the same locations as 2024.

Signs were well distributed along the survey area, with many previously identified marking areas and features utilised again in 2025 (**Figure 4.1**). In keeping with the previous 2024 survey, no evidence of regular otter activity was recorded between the 1st lock (Spencer Dock) and the 6th lock at Phibsborough (**Figure 4.2**). However, a low number of old spraints were recorded in the vicinity of Croke Park, between the 1st and 2nd locks during the 2025 survey (**Figure 4.2**). A high number of signs were recorded between the 14th and 16th locks near Kilcock, consistent with the findings of the 2024 survey (**Figure 4.3**). This indicates the continued presence of a likely breeding territory in the vicinity of Bailey's Bridge (see Discussion for further detail).

The majority of signs were represented by spraint sites (39) and latrines[2] (9) with a low number of slides (5) and an anal jelly deposition also identified (**Table 4.1**). A total of 5 no. holts (breeding areas) were recorded along the canal corridor during the survey, all of which had been identified previously (i.e. no new holt sites identified). A low number of couches (resting areas, 5 no.) were recorded. All couches were at the same locations as per the 2023 and or 2024 surveys.

A database of all signs recorded is available from the authors, summarising sign type, age, frequency and specific location.

Table 4.1 Summary of the otter signs recorded in the Royal Canal survey area, November-December 2025 compared with previous years

	Total no. signs		
Otter sign	**2025**	**2024**	**2023**
Spraint site	39	28	36
Latrine	9	15	2
Holt	5	5	8
Couch	5	5	5
Slide	5	5	2
Anal jelly	1	1	1
Total	**63**	**59**	**54**

[2] Latrines are defined as regularly used faecal/spraint deposition sites with digging behaviour, often on sand, mud or grass (pers. obs.) and are often associated with resting places of otter (Findlay et al., 2023)

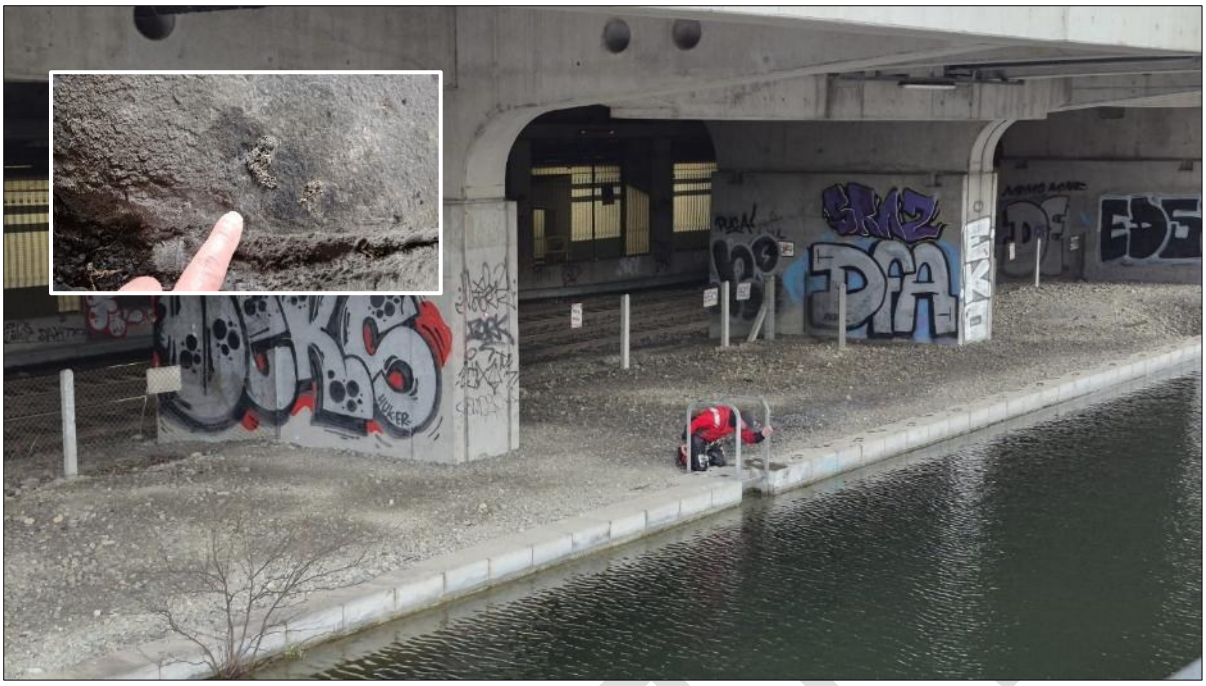


Plate 4.1 Inspecting an old sprainting site at a quay wall ladder under the overhang at Croke Park, December 2025



Plate 4.2 Recently completed Greenway construction works on the Royal Canal between the 1st and 2nd locks in December 2025 (poor quality otter habitat with high levels of disturbance)



Plate 4.3 Typical urban section of the Royal Canal west of the 6th Lock with narrow riparian zones and high levels of disturbance



Plate 4.4 Regular spraint site on boulder/grassy bank east of the R102 road crossing



Plate 4.5 Ongoing Royal Canal Urban Greenway works west of Callaghan Bridge, with significant clearance of riparian vegetation



Plate 4.6 Potential otter holt in [redacted] near [redacted] (previously identified in 2023 and 2024 & still inactive)



Plate 4.7 Regular sprainting site under Coolmine Pullway Bridge with mixed age spraint on discarded carpet



Plate 4.8 Regular latrine site on the grassy banktop with well-worn tracks to canal, west of Bailey's Bridge



Plate 4.9 Example of regular otter latrine (with urine scorching) on open grassy bank opposite the towpath/R148 road near Kilcock



Plate 4.10 Fresh spraint with anal jelly in grass verge below Shaw's Bridge, Kilcock

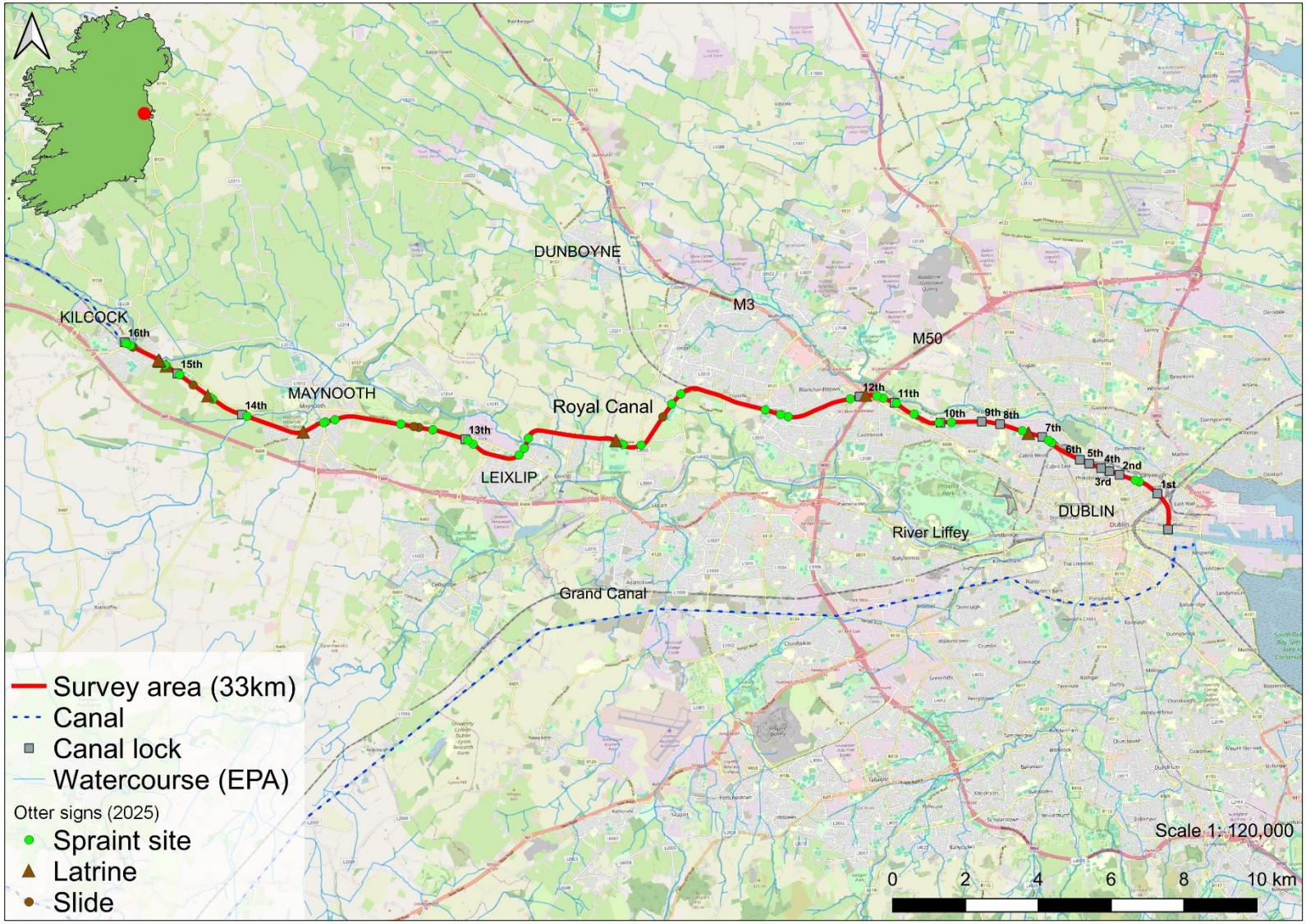


Figure 4.1 Overview of the otter signs recorded in the Royal Canal survey area, November-December 2025 (holts & couch sites redacted)

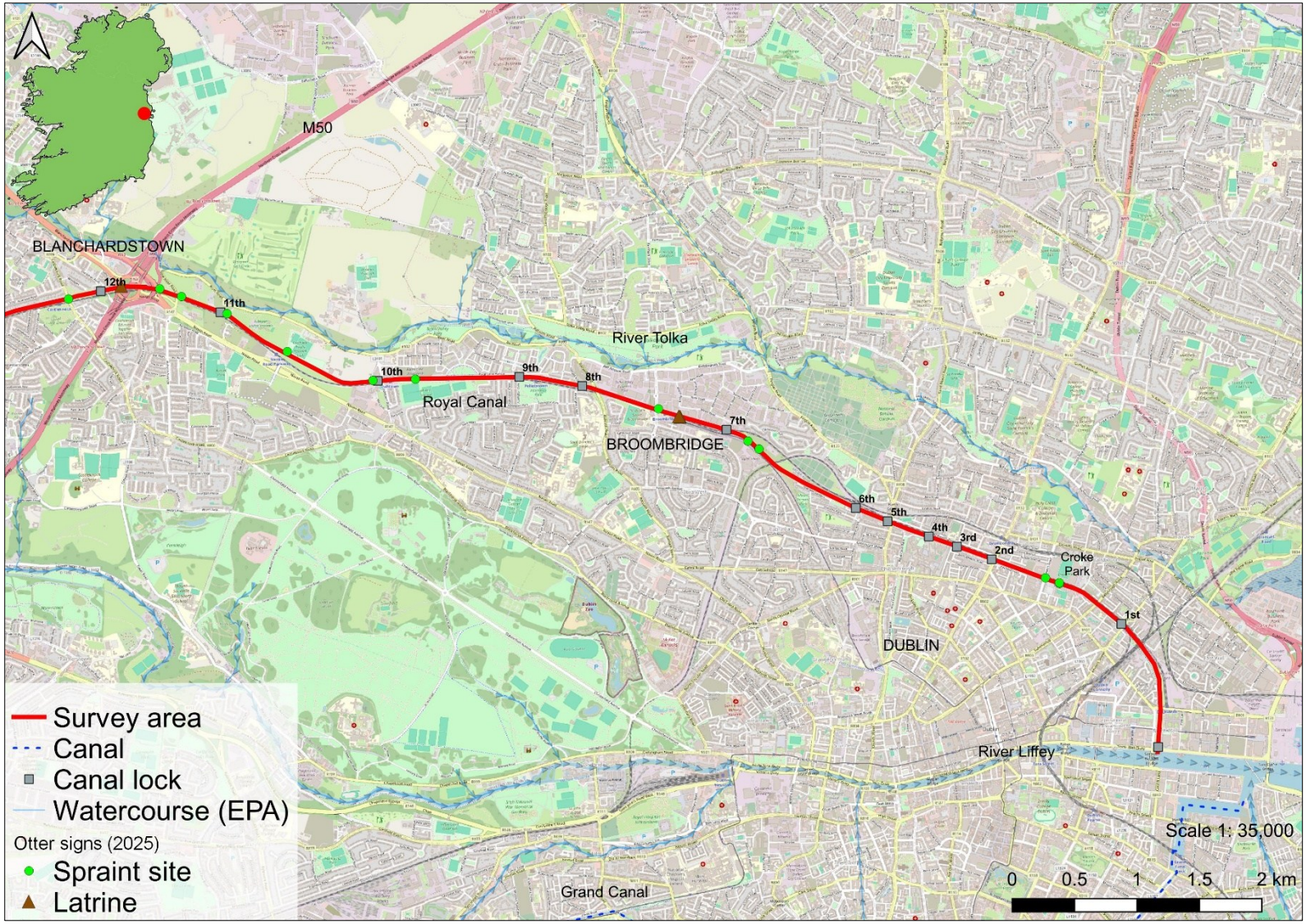


Figure 4.2 Otter signs recorded in the eastern extent of the survey area (1st lock to 12th lock) in 2025 (holts & couch sites redacted)

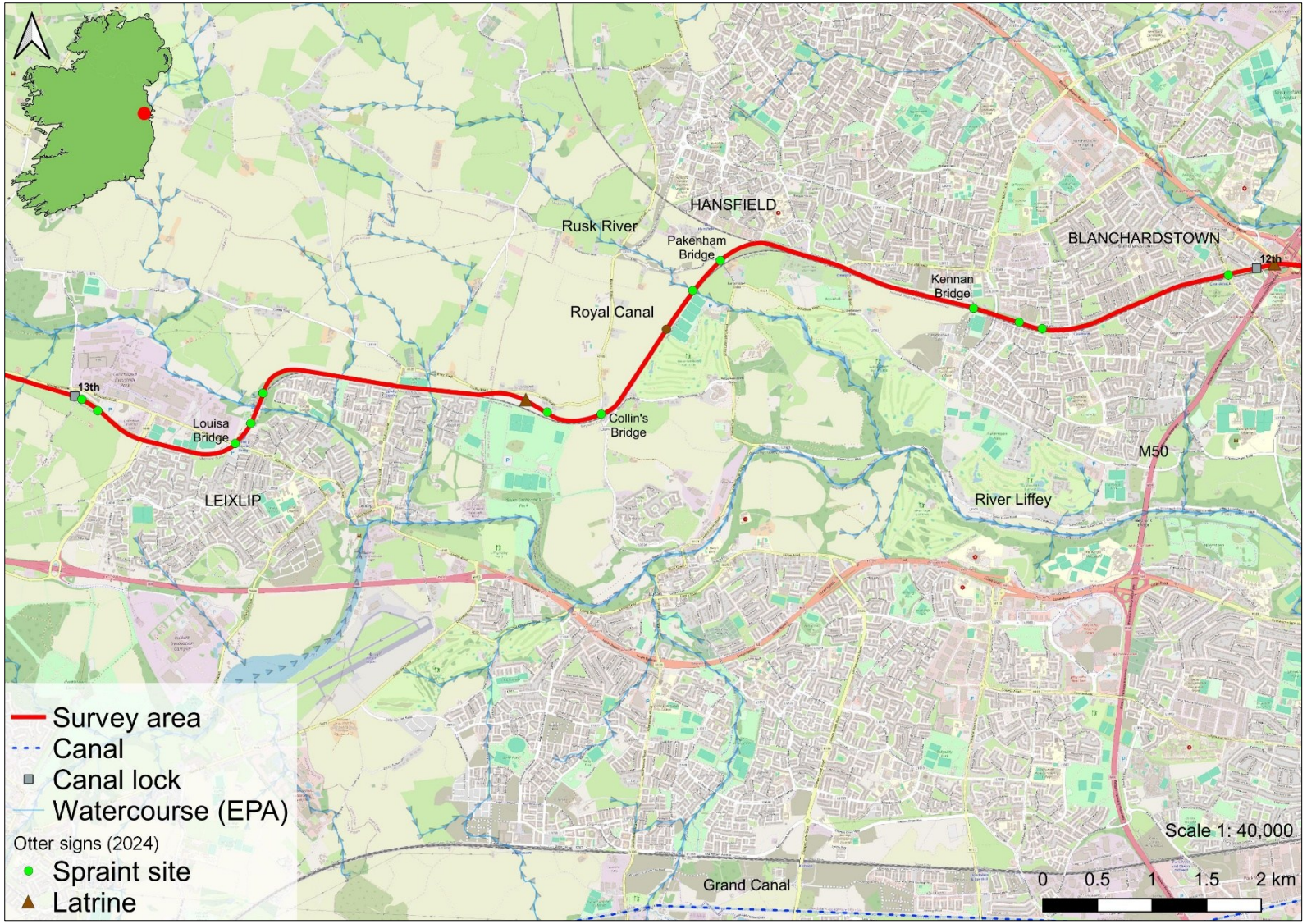


Figure 4.3 Otter signs recorded in the western extent of the survey area (12th lock to 13th lock) in 2025 (holts & couch sites redacted)

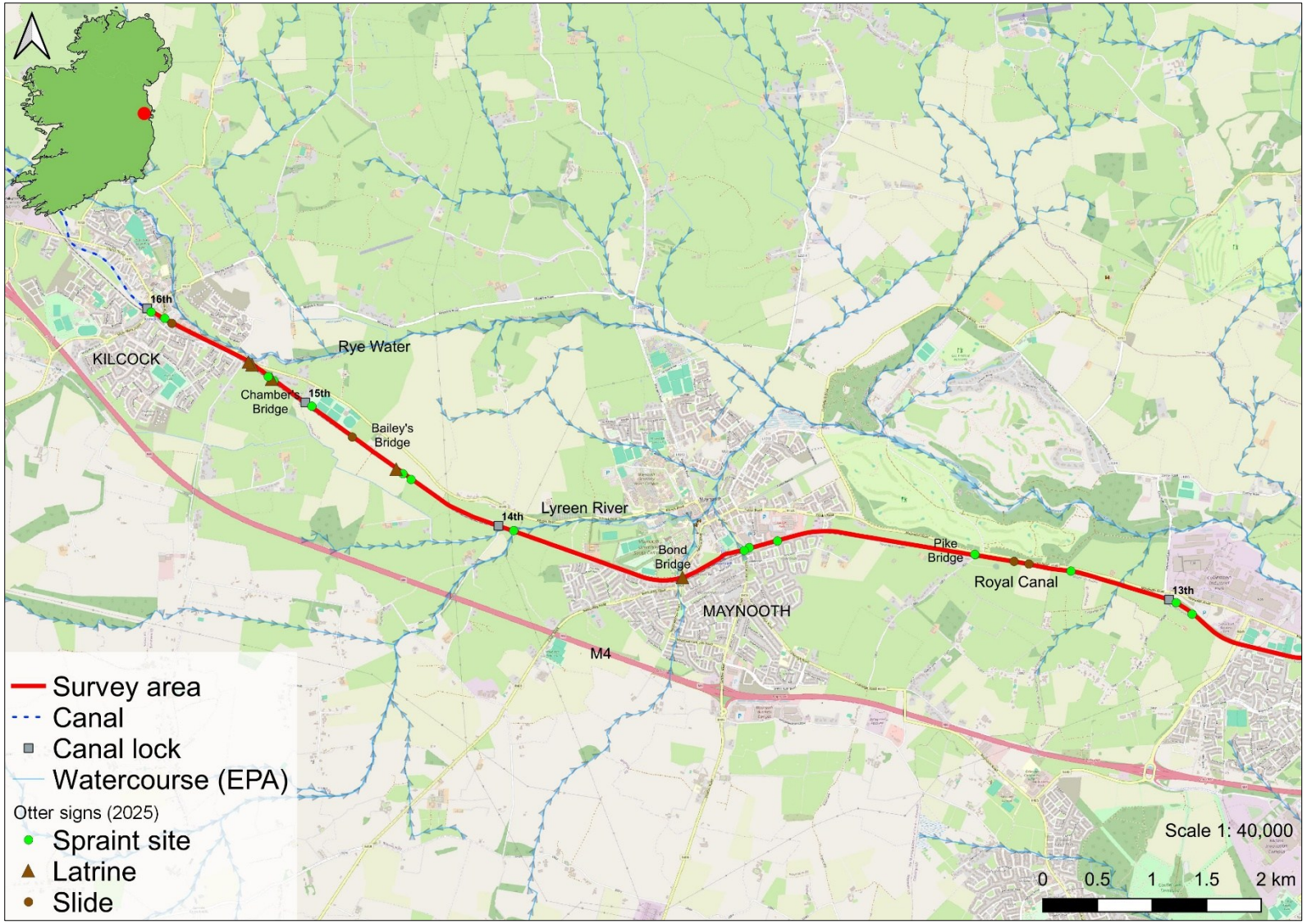


Figure 4.4 Otter signs recorded in the western extent of the survey area (13th lock to 16th lock) in 2025 (holts & couch sites redacted)

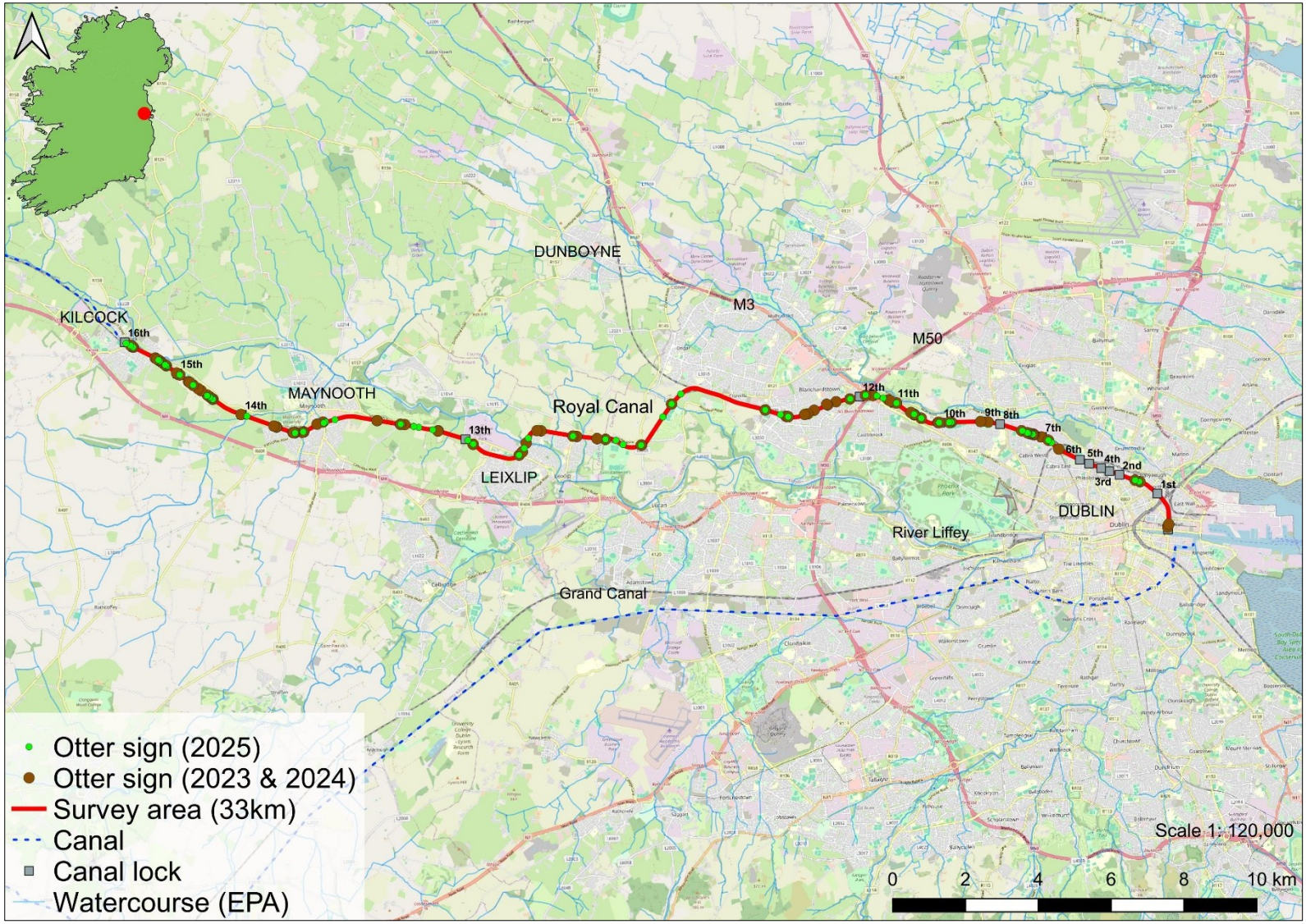


Figure 4.5 Summary and comparison of otter sign locations recorded in the Royal Canal survey area in 2023, 2024 & 2025

5. Discussion

The 2025 baseline otter survey builds on the previous knowledge of otter along the Royal Canal between the 1st and 16th locks. Our comprehensive approach, utilising total corridor otter survey (TCOS) methodology along both banks (inclusive of boat/kayak surveys), has facilitated the identification of the most important areas for otter along 33km of canal corridor. The current survey has again highlighted the propensity otters along the Royal Canal have for marking and using the same areas/sites inter- and intra-annually, with sign distribution and the location of key areas of habitat largely unchanged from previous surveys. The data collated will further inform mitigation measures to protect otters and their habitat in light of future developments along the Royal Canal.

Whilst of value to otter, particularly in terms of foraging habitat (i.e. healthy fish stocks), the Royal Canal corridor is inherently homogenous with intermittent mature riparian vegetation, typically heavily modified (given its location in urban and peri-urban areas) and exposed to relatively high levels of human-related disturbance with towpaths and DART lines along much of the survey area (typically on the north and south banks, respectively). As outlined below, our findings suggest that otter sign distribution and the location of otter marking correlate strongly with less disturbed areas of habitat and lower levels of human-related disturbance. This includes areas of semi-natural fringe habitat that are poorly accessible to people and often on banks opposite public access. This pattern is evident in other Irish otter studies of urban and peri-urban areas, particularly throughout Dublin (e.g. Brazier & Macklin, 2025; Brazier & Macklin, 2020; Macklin et al., 2019), including along the Royal Canal (Triturus, 2024a, 2024b, 2022).

5.1 Otter sign distribution (2025)

The 2025 survey recorded a total of *n*=63 otter signs along approximately 33km of contiguous canal habitat (**Table 4.1; Figures 4.1-4.3**). Signs, including spraint sites, latrines, slides, holts and couches, were well distributed along the survey area (**Figure 4.1**) with sign distribution similar to both 2023 and 2024 (**Figure 4.5**).

The localised changes observed during the 2024 survey (i.e. a marked increase in the number of signs recorded between the 14th and 16th locks near Kilcock) remained evident during the 2025 survey, indicating continued regular use of these sections of the canal by otter. A relatively high concentration of signs remained present between Broombridge and Castleknock, which is currently the primary area of otter activity east of the M50. Signs were more evenly distributed between Leixlip and Maynooth (**Figure 4.4**) but were scarce in the inner Dublin City area, east of the 7th lock (**Figure 4.2**). Similar distribution patterns of otter signs along the Royal Canal have been observed previously (Triturus data).

Few signs were observed between the 1st lock (Spencer Dock) and the 6th lock at Phibsborough (**Figure 4.1**), with only very old otter spraint recorded at Croke Park and under Bloody Sunday Bridge (**Plate 4.1**). Previous Greenway construction works between the 1st and 2nd locks that restricted access for surveys throughout 2024 had been completed prior to the current survey (**Plate 4.2**). However, high levels of disturbance, the paucity of suitable marking sites (e.g. for spraint deposition) and barriers to otter passage (i.e. particularly high locks) are likely to limit regular otter activity within these sections of the canal. Similarly, higher levels of disturbance and scarce marking opportunities resulted in the

REDACTED

absence of signs between Kennan Bridge and Collin's Bridge (except for a spraint site on the Rusk River, flowing under the canal and a slide adjacent to the Westmanstown Sports Centre) (e.g. **Plate 4.5**). This c.4km section provides relatively poor quality fisheries habitat compared with elsewhere on the canal (high levels of shading, low wind fetch, low macrophyte cover, etc.) and poorer quality foraging habitat for otter, whose primary prey resource is fish (Krawczyk et al., 2016). These canal sections routinely contain a relatively low number of otter signs.

Otter sign intensity was often higher in the vicinity of riverine watercourses or watercourse crossings (aqueducts). For example, the low number of signs recorded between the 10th and 12th locks are situated close to the River Tolka (a highly important otter habitat) and those near Kilcock were located adjacent to the Rye Water (**Figure 4.2, 4.4**). A new sprainting site was identified in 2025 on the canal bank top near the Lyreen River culvert east of the 14th lock. It is likely that these areas provide improved otter prey resources[3] given a greater range of profitable foraging habitats in close proximity (i.e. canal plus river). This is supported by the regular cross-road movement of otters between the Royal Canal and the adjacent Rye Water, which resulted in the installation of Ireland's first 'otters crossing' road signage (**Plate 5.1**). Presumably the marking of such crossings and confluences by otters advertises their foraging value to conspecifics and provides easily recognisable features for other otters to detect and mark.



Plate 5.1 'Otter crossing' signage between the Royal Canal and the Rye Water River, Kilcock, Co. Kildare, an indication of high otter traffic between the respective watercourses (source: Sunday Times)

[3] sprainting activity increases significantly in areas with higher fish biomass availability (Almeida et al. 2012; Hutchings & White 2000)

5.2 Otter marking site fidelity

Many previously identified marking areas and features were utilised by otters again in 2025, i.e. inter-annual marking sites. These are visually highlighted in **Figure 4.5** above. A total of 30 no. otter sign/marking areas were at the same locations as 2024, with many also utilised in 2023. These included bridges such as Kennan Bridge, Collin's Bridge, Bond Bridge, Pike Bridge and other characteristic pronounced areas, including culverts, canal locks, tree root systems, marginal boulders and grassy promontories/tussocks. As a species, otters routinely mark the most prominent of features and are known to have a high level of marking site fidelity (Triturus data; Wang et al., 2021; Sittenthaler et al. 2020; Lampa et al., 2015; Remonti et al., 2011; Kruuk, 2006), a trait amplified in more homogenous/modified habitats such as the Royal Canal.

Generally, otter marking was located in those areas of lowest relative disturbance (poor or no human accessibility), such as the bank opposite public footpaths/Greenways. This was true even in survey sections with narrow riparian buffers (typically <10m) adjoined by higher overall levels of disturbance, such as roads or rail lines. Bridges are frequently marked by otters in higher disturbance habitats (Triturus data; Kraševec et al., 2022; Brazier & Macklin, 2020; Macklin et al., 2019), given a greater level of seclusion and cover relative to adjoining areas.

The deposition of spraint and other marking behaviour (e.g. scent marking via urination, typically observed as 'scorching' of vegetation due to high nitrogen concentrations; e.g. **Plate 4.9**) is known to serve a variety of territorial and communicative functions in otter populations (Sittenthaler et al., 2020; Mumm & Knörnschild, 2018; Remonti et al., 2011; Kean et al., 2011; Hutchings & White, 2000; Kruuk, 1992). Sign marking, inclusive of spraint sites, latrines and anal jelly secretions, is routinely associated with prominent features (including holts & couches, where present), as well as at key foraging sites (Martin-Collado et al., 2020; Almeida et al., 2012; Guter et al., 2008; Kruuk, 2006; Macdonald & Mason, 1987; Erlinge, 1968). Should such suitable features be scarce or unavailable, or exposed to high levels of disturbance (such as along extended sections of the Royal Canal), otter signs may be sporadic or even absent entirely (Kim & Hong, 2024; Reuther et al., 2000) (e.g. between Kennan Bridge and Collin's Bridge). As noted previously (Triturus, 2024a, 2024b), this does not imply the absence of otter, rather habitat less appropriate to otter marking. Animals may regularly use lower value areas for foraging and or commuting between more amenable habitats (Hong et al., 2022; Van Looy et al., 2014; Kloskowski et al., 2013), as indicated by this and previous surveys of the Royal Canal. The evaluation of areas for otter should remain cognisant of the overall quality and potential of otter habitat rather than simply inferring presence/absence based on detectable signs.

5.3 Breeding and resting areas

A total of 5 no. holts (potential breeding areas) were recorded along the canal corridor during the 2025 survey, all of which had been previously identified by Triturus in separate surveys during the 2020-2024 period. No new holts were identified in 2025. Otter activity was particularly high in the vicinity of [redacted] with multiple regular latrines, spraint sites, trails and slides. As postulated in 2024, it was considered highly likely that a new breeding territory has been established in this area. Based on observed signs, otters appeared to be traversing the rail line and accessing mature (albeit steep) field boundary hedgerows and treelines to the south of the track, likely accessing holt (breeding) areas. Further investigations in this area are required (with permission from Irish

Rail/larnród Éireann). No signs of recent otter utilisation were identified in 2025 at the other holt sites located near [redacted], [redacted] or [redacted], although trail camera monitoring would be required to confirm the utilisation of these sites by breeding otter.

Several previously identified holts near Ashtown (1) and Coolmine (3) again showed no signs of utilisation or activity in 2025 (as per 2024), with infilling occurring. Thus, these sites have not been included in the current database or mapping. As per previous surveys, no holts or couches were identified east of Broombridge, where human disturbance levels peaked (i.e. Dublin City), although an active holt is known near the Royal Canal-Liffey confluence in a quay wall at [redacted] (Triturus data, not shown). Despite the aforementioned inter-annual utilisation of marking, breeding and resting areas, otter behaviour can and does change based on various factors, and this reinforces the need for regular resurvey effort.

Whilst many of the identified holts showed no signs of otter use at the time of survey, this does not mean these locations will not become active or occupied in the future. This is especially so in light of the relative paucity of suitable breeding areas for otters along the Royal Canal corridor in terms of disturbance levels and excavation feasibility (e.g. compacted/modified banks). Continued annual otter monitoring along the Royal Canal will help to establish the status of existing holts and help detect the presence of newly excavated/utilised breeding areas.

A low number of couches (5) were identified during the 2025 survey (**Appendix A**). All couches were at the same locations as per the 2024 survey. All were regularly used by otter given the frequency of associated spraint deposition. Otters, along with their breeding (holts) and resting places (couches), are protected under provisions of the Wildlife Acts 1976 to 2023.

All holts (whether active or not) and couches identified in 2025 (and 2024) were located in areas with limited or no access to humans (i.e. under rail platforms, adjacent to the rail line corridor, heavy vegetation cover, steep banks, fencing, absence of towpaths etc.) and can be considered as the most important areas for otters within the survey area. This same disturbance-related trend regarding the location of breeding and resting areas has been repeatedly observed across the wider Dublin area in previous studies (Brazier & Macklin, 2025; Brazier & Macklin, 2020; Macklin et al., 2019), including along the Royal Canal (Triturus data). Otter breeding areas are especially sensitive to direct human disturbance (Mason & Macdonald, 2009), with otter reproductive success known to be higher in less disturbed habitats; hence their preferential fidelity for low-disturbance areas (Dettori et al., 2021; Martin-Collado et al., 2020; Scorpio et al., 2016; Ruiz-Olmo et al., 2011; Loy et at., 2009; Kruuk, 2006). Human disturbance also strongly influences resting (couch) site selection, with mature riparian vegetation and overhead cover (natural or otherwise) providing crucial shelter in higher disturbance landscapes (Tolrà et al., 2024; Weinberger et al., 2019), as corroborated in the current survey.

5.4 Management considerations

Despite many areas of the Royal Canal being open and subject to disturbance, they nonetheless remain important for otter colonisation by allowing otters to commute between core areas of habitat (Hong et al., 2022; Macklin et al., 2019; Van Looy et al., 2014; Guter et al., 2008). With high and increasing rates of suburbanisation, the Royal Canal remains one of the most important ecological corridors in the vicinity of Dublin.

REDACTED

The current survey has identified and confirmed the most important areas for otter. The data will help to meet the requirements of local biodiversity policies and will facilitate the prioritisation of areas for otter conservation and future management, inclusive of legally-protected breeding and resting areas. Whilst Greenways and other developments adjoining waterways provide important socioeconomic benefits, they should aim to avoid conflict with all wildlife (Hubbard & Brookes, 2021), including otters, which require seclusion for breeding and resting.

Furthermore, given the high value of the canal for otter (as well as many other species), existing riparian buffers should be retained and conserved along the Royal Canal corridor. The provision and retention of riparian tree cover (buffers) is particularly important for otter (Kim & Hong, 2024; Weinberger et al., 2019; Teresa et al., 2014; Remonti et al., 2011), especially in light of urbanisation and infrastructural developments (Hong & Joo, 2021). The retention of some poorly accessible areas of canal corridor is especially warranted, as these are invariably the areas where holts and couches are situated. This will support local and national biodiversity objectives, thus helping to meet the conservation requirements for otter under the EU Habitats Directive (92/43/EEC) as an Annex II and Annex IV species.

Well-developed and complex riparian zones can buffer anthropogenic (disturbance) impacts to otters and myriad other animals, facilitate healthy prey resources and likely play an increasingly important role in otter dispersion and commuting in light of climate change impacts (Cianfrani et al., 2018) and growing urbanisation pressures. These ecological corridors will provide avenues that allow wide-ranging animals to travel and genetic mixing to occur, whilst facilitating the movement of populations in response to environmental stressors, thus giving threatened species the opportunity to be replenished from other source areas (Liu et al., 2018; Walker & Craighead, 1997). It appears that otters actively move between bordering rivers and the Royal Canal, and also longitudinally along the canal corridor. In the future, it will be important to maintain open linkages between nearby watercourses and the canal, inclusive of the River Tolka, Rye Water and Lyreen River, which appear to be important source contribution areas for canal otter populations.

Investigation into otter prey resources via modern genetic techniques (e.g. DNA metabarcoding) would provide valuable ecological data and help to target management and conservation objectives for both otters and aquatic habitats in general. Genetic sampling (of fresh spraints) would also help to clarify otter demographics and population status along the Royal Canal, elucidate movement between foraging habitats and potentially identify individual animals, thus facilitating more accurate population size estimates. Similar approaches have been successfully applied recently by Triturus and their associates in both Cork City and Dublin City.

REDACTED

6. References

Almeida, D., Barrientos, R., Merino-Aguirre, R., & Angeler, D.G. (2012). The role of prey abundance and flow regulation in the marking behaviour of Eurasian otters in a Mediterranean catchment. Animal Behaviour, 84(6), 1475-1482.

Barry Transportation EGIS (2023). Luas Finglas Environmental Impact Assessment Report. Chapter 9: Biodiversity. 2024.

Bailey, M & Rochford, J., (2006). Otter survey of Ireland 2004/2005. Irish Wildlife Manual, No 23. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

Brazier, B. & Macklin, R. (2025). Fingal otter (*Lutra lutra*) survey 2024 - rivers. Report prepared by Triturus Environmental Ltd. for Fingal County Council. February 2025.

Brazier, B. & Macklin, R. (2020). Dún Laoghaire-Rathdown otter survey. Report prepared by Triturus Environmental Ltd. for Dún Laoghaire-Rathdown County Council. November 2020.

Chanin, P.R.F. (2003). Ecology of the European otter. Conserving Natura 2000 Rivers Ecology Series No. 10. English Nature, Peterborough.

Cianfrani, C., Broennimann, O., Loy, A., & Guisan, A. (2018). More than range exposure: Global otter vulnerability to climate change. Biological Conservation, 221, 103-113.

Dettori, E. E., Balestrieri, A., Zapata-Perez, V. M., Bruno, D., Rubio-Saura, N., & Robledano-Aymerich, F. (2021). Distribution and diet of recovering Eurasian otter (*Lutra lutra*) along the natural-to-urban habitat gradient (river Segura, SE Spain). Urban Ecosystems, 24(6), 1221-1230.

Erlinge, S. (1968). Territoriality of the otter *Lutra lutra* L. Oikos, 81-98.

Erlinge, S. (1967). Home range of the otter *Lutra lutra* L. in southern Sweden. Oikos, 186-209.

Findlay, M. A., Briers, R. A., Ingledew, R. P., & White, P. J. (2023). An evidence-based approach to identifying resting sites of Eurasian otter *Lutra lutra* from camera-trap and field-sign data. Wildlife Biology, 2023(1)

Guter, A., Dolev, A., Saltz, D., & Kronfeld-Schor, N. (2008). Using videotaping to validate the use of spraints as an index of Eurasian otter (*Lutra lutra*) activity. Ecological indicators, 8(5), 462-465.

Hong, S., & Joo, G. J. (2021). Secondary forest development during urbanisation sustains apex carnivore populations of Eurasian otters (*Lutra lutra*). Landscape and Urban Planning, 208, 104021.

Hong, S., Di Febbraro, M., Kim, H. G., & Loy, A. (2022). Is scat marking a reliable tool for otter census and surveys at the landscape scale?. Journal of Environmental Management, 315, 115098.

Hubbard, P. & Brooks, A. (2021). Animals and urban gentrification: Displacement and injustice in the trans-species city. Progress in Human Geography. 2021;45(6):1490-1511.

Hutchings, M. R., & White, P. C. (2000). Mustelid scent-marking in managed ecosystems: implications for population management. Mammal Review, 30(3-4), 157-169.

IFI (2010). Biosecurity Protocol for Field Survey Work. Available at http://www.fisheriesireland.ie/Invasive-Species/biosecurity-protocol-for-field-survey-work.html

REDACTED

Kean, E.F., Müller, C.T. & Chadwick, E.A. (2011). Otter scent signals age, sex, and reproductive status. Chem. Senses 36 (6), 555–564.

Keeley, B. (2004). The mammal fauna of the Royal Canal. Report prepared for Waterways Ireland and Fingal County Council (Parks Division). December 2004.

Kim, J., & Hong, S. (2024). Spraint density of the Eurasian otter (*Lutra lutra*) is an accurate indicator of its population status in urban areas. Environmental and Sustainability Indicators, 24, 100479.

Kloskowski, J., Rechulicz, J., & Jarzynowa, B. (2013). Resource availability and use by Eurasian otters *Lutra lutra* in a heavily modified river-canal system. Wildlife Biology, 19(4), 439-451.

Kraševec, R., Trajbarič, A., & Fležar, U. (2022). Under the bridge: marking sites prove the presence of Eurasian otter *Lutra lutra* in the Poljanska Sora River valley, Slovenia. Natura Sloveniae, 24(1), 17-29.

Krawczyk, A. J., Bogdziewicz, M., Majkowska, K., & Glazaczow, A. (2016). Diet composition of the Eurasian otter *Lutra lutra* in different freshwater habitats of temperate Europe: a review and meta-analysis. Mammal Review, 46(2), 106-113.

Kruuk, H. (1992). Scent marking by otters (*Lutra lutra*): signalling the use of resources. Behavioural Ecology, 3(2), 133-140.

Kruuk, H. (2006). Otters, Ecology, Behaviour and Conservation. Oxford University Press.

Lampa, S., Mihoub, J. B., Gruber, B., Klenke, R., & Henle, K. (2015). Non-invasive genetic mark-recapture as a means to study population sizes and marking behaviour of the elusive Eurasian otter (*Lutra lutra*). PLoS One, 10(5), e0125684.

Lenton, E.J., Chanin, P.R.F. & Jefferies, D.J. (1980). Otter Survey of England, 1977-79. Nature Conservancy Council, London.

Liu, C., Newell, G., White, M., & Bennett, A. F. (2018). Identifying wildlife corridors for the restoration of regional habitat connectivity: a multispecies approach and comparison of resistance surfaces. PloS one, 13(11), e0206071.

Loy, A., Carranza, M.L., Cianfrani, C., D'Alessandro, E., Bonesi, L., Di Marzio, P. & Regiani, G. (2009). Otter *Lutra lutra* population expansion: assessing habitat suitability and connectivity in southern Italy. Folia Zoologica, 58(3), 309.

Macklin, R., Brazier, B. & Sleeman, P. (2019). Dublin City otter survey. Report prepared by Triturus Environmental Ltd. for Dublin City Council as an action of the Dublin City Biodiversity Action Plan 2015-2020.

Marnell, F., Looney, D. & Lawton, C. (2019). Ireland Red List No. 12: Terrestrial Mammals. National Parks and Wildlife Service, Department of the Culture, Heritage and the Gaeltacht, Dublin, Ireland.

Martin-Collado, D., Jiménez, M. D., Rouco, C., Ciuffoli, L., & de Torre, R. (2020). Potential of restored gravel pits to provide suitable habitats for Eurasian otters in anthropogenic landscapes. Restoration Ecology, 28(4), 995-1005.

Mason, C.F., & Macdonald, S.M. (2009). Otters: ecology and conservation. Cambridge University Press.

McCloone, P. (2011). Monitoring Fish Stocks in Irish Recreational Waterways. Presentation by Paul McLoone, Inland Fisheries Ireland.

REDACTED

Mumm, C. A., & Knörnschild, M. (2018). Mustelid communication. In: Vonk, J., Shackelford, T. (eds) Encyclopedia of Animal Cognition and Behavior, p 1-11. Springer

NPWS (1995). Site synopsis: Royal Canal pNHA 002103. February 1995.

NPWS (2025). The Status of EU Protected Habitats and Species in Ireland. Volume 1: Summary Overview. Unpublished NPWS report. December 2025.

NPWS (2019). The Status of EU Protected Habitats and Species in Ireland. Volume 3: Specie Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill.

Reuther, C., Dolch, D., Green, R., Jahrl, J., Jefferies, D., Krekemeyer, A., ... & Trindade, A. (2000). Surveying and monitoring distribution and population trends of the Eurasian otter (*Lutra lutra*): guidelines and evaluation of the standard method for surveys as recommended by the European section of the IUCN/SSC Otter Specialist Group.

Ruiz-Olmo, J., & Jiménez, J. (2009). Diet diversity and breeding of top predators are determined by habitat stability and structure: a case study with the Eurasian otter (*Lutra lutra* L.). European Journal of Wildlife Research, 55(2), 133.

Scorpio, V., Loy, A., Di Febbraro, M., Rizzo, A., Aucelli, P. (2016). Hydromorphology meets mammal ecology: river morphological quality, recent channel adjustments and otter resilience. River Res. Appl. 32, 267–279.

Sittenthaler, M., Schöll, E. M., Leeb, C., Haring, E., Parz-Gollner, R., & Hackländer, K. (2020). Marking behaviour and census of Eurasian otters (*Lutra lutra*) in riverine habitats: what can scat abundances and non-invasive genetic sampling tell us about otter numbers? Mammal Research, 65(2), 191-202.

Teresa, C. M., Antoine, G., Carmen, C., Tiziana, S., Anna, L., & Laura, C. M. (2014). A multi-temporal approach to model endangered species distribution in Europe. The case of the Eurasian otter in Italy. Ecological modelling, 274, 21-28.

Tierney, D., Donnelly, R. E., & Caffrey, J. M. (1999). Growth of bream, Abramis brama (L.), in Irish canals and implications for management. Fisheries Management and Ecology, 6(6), 487-498.

Tolrà, A., Riera, J. L., & Ruiz-Olmo, J. (2024). Assessing river ecological status through Eurasian otter diet analysis. River Research and Applications.

Triturus (2024a). Royal Canal (1st to 16th lock) otter survey 2023. Report prepared by Triturus Environmental Ltd. for Roughan & O' Donovan Consulting Engineers. January 2024.

Triturus (2024b). Royal Canal (1st to 16th lock) otter survey 2024. Report prepared by Triturus Environmental Ltd. for Roughan & O' Donovan Consulting Engineers. December 2024.

Triturus (2022). Royal Canal Greenway Cycle and Pedestrian Route Phase 4 (Phibsborough to Ashtown) otter survey 2022. Report prepared by Triturus Environmental Ltd. for Roughan & O'Donovan. February 2022.

Van Looy, K., Piffady, J., Cavillon, C., Tormos, T., Landry, P., & Souchon, Y. (2014). Integrated modelling of functional and structural connectivity of river corridors for European otter recovery. Ecological Modelling, 273, 228-235.

Walker, R., & Craighead, L. (1997). Analyzing wildlife movement corridors in Montana using GIS. In Proceedings of the 1997 ESRI user conference, Redlands, USA.

REDACTED

Wang, Q. Y., Zheng, K. D., Han, X. S., He, F., Zhao, X., Fan, P. F., & Zhang, L. (2021). Site-specific and seasonal variation in habitat use of Eurasian otters (*Lutra lutra*) in western China: implications for conservation. Zoological research, 42(6), 825.

Weinberger, I. C., Muff, S., Kranz, A., & Bontadina, F. (2019). Riparian vegetation provides crucial shelter for resting otters in a human-dominated landscape. Mammalian Biology, 98, 179-187.

REDACTED

7. Appendix A – otter signs database

Data is withheld by the authors and available upon request

REDACTED



Triturus Environmental Ltd.,

Unit 5 Anchor Business Park,

Little Island,

Co. Cork,

T45 XN59.

REDACTED