Water Framework Directive

Compliance Report – 2023

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Front cover: The Royal Canal close to the Island Bridge monitoring site (RCW12) in February 2023.

Back cover: Mullingar Harbour, close to sampling site RCE1, during Fleadh Cheoil 2023.

Executive Summary

1. In 2023, surveillance monitoring was conducted at 43 sites on the Grand & Royal Canals and the Shannon-Erne Waterway, at two sites on Grand Canal Basin and at five designated feeders/drains that discharge to the canals. This is the final year of a three-year WFD reporting cycle for the period 2021 to 2023.

2. Physico-chemical sampling was conducted quarterly (in February, May, August and October 2023) at all 50 WFD surveillance monitoring sites. Macrophyte sampling, to include invasive plant species, was conducted at the 41 WFD monitoring sites (excluding the feeders/drains, Grand Canal Basin and the Shannon-Erne Waterway) between July and August 2023. Macroinvertebrate sampling, to include invasive macroinvertebrate species, was conducted at 13 of the 41 monitoring sites. The other 28 sites had been sampled in 2021 (14) and 2022 (14), in compliance with the WFD monitoring schedule for macroinvertebrate sampling in the canals.

3. Twenty-two of the 43 WFD monitoring sites on the canals and Shannon-Erne Waterway reported Good indicative eco-potential on all four sampling occasions in 2023. This compared with just 10 in 2022 and 23 in 2021. No sites were at Moderate eco-potential in all quarters from 2018 to 2023, inclusive. Of the 172 sets of samples analysed at monitoring sites in 2023 (i.e., 43 sites over four quarters), 142 were assigned Good eco-potential, compared with 128 in 2022 and 138 in 2021.

4. As in 2022, Ammonia was the physico-chemical determinand that was breached most often in 2023, with its threshold limit of 0.12mg/l N being equalled or exceeded on 16 occasions during the four quarters. This compared with 31 in 2022. There followed, in terms of numbers of determinands breached, BOD (10), *E. coli* (3), TON (2) and TP (2). The determinand SRP was not breached on any sampling occasion in 2023.

5. When the physico-chemical results for the 43 canal and Shannon-Erne Waterway monitoring sites for 2023 were assessed, 41 sites were assigned Good indicative ecological potential (results for Q1 to Q4 combined). This compared with 38 in 2022 and 36 in 2021.

6. Fourteen of the 15 canal and Shannon-Erne Waterway AWBs were assigned Good indicative eco-potential based on the combined results from physico-chemical sampling between Q1 and Q4 2023. The one AWB that was at Moderate indicative eco-potential in 2023 was GC_14W, which breached for the determinand parameter BOD. This AWB contains two sites, GCEW8 (east of Rhode) and GCW12 (west of Daingean), and each contributed to the breach of threshold recorded.

7. Because levels of Ammonia $\geq$0.12mg/L N (the threshold limit) have been recorded with unusual regularity at monitoring sites on the canals in recent years, it is recommended that discussions be held with EPA to determine if the threshold value assigned to this determinand parameter is too low for Irish canals.

8. Results from physico-chemical sampling at Grand Canal East (GCE) sites in 2023 suggest some water quality issues at GCE4 (Sallins), probably reflecting the burgeoning number of permanently moored cruisers at this location. While close attention was paid to the monitoring site and its environs during water and biological sampling throughout the year, no direct pollution from any craft was witnessed. However, it was deemed prudent to move the WFD surveillance monitoring site some 600m west along the canal corridor in order to ensure that water (and biological) samples could be collected without interference from moored craft.

9. High TON and Nitrate levels have been a feature of NL1 on the Naas Line for a number of years and were again high in 2023. However, in addition to these high nitrogen levels, unacceptably high levels for other parameters including TP, MRP, SRP, Total coliform, *E. coli* and Ammonia have been recorded here in recent years. These high levels indicate that contaminated effluent is being discharged to the canal, probably *via* the drain into Naas harbour. At the behest of Waterways Ireland (WI), Kildare County Council (KCC) has conducted surveys to identify and eliminate these contaminant source(s) to this canal but, to date, problems relating to water quality for the Naas Line continue.

10. Water quality conditions at SE42 (Leitrim village and marina) were relatively good in 2023, although extremely high counts for *E. coli* and *Enterococci* were reported by WI from bacteriological analysis of water samples collected here in mid-September 2023. These results clearly demonstrate that highly deleterious matter, containing sewage, continues to be discharged to the Shannon-Erne Waterway in the vicinity of the marina and Leitrim village, to the detriment of the aquatic ecology (and possibly human health) in and associated with the river. WI must continue to work with Leitrim County Council to determine and mitigate the source(s) of effluent to the watercourse.

11. Results from physico-chemical analysis in the Grand Canal Basin at GCB4 (inner basin) were good in 2023, with readings for all parameters well within acceptable limits on all sampling occasions. Results for GCB7 (outer basin), however, were less than satisfactory and some significant breaches in determinand threshold limits, including an extremely high *E. coli* count in Q4, were recorded in Q1, Q2 and Q4. These results show that seriously polluted water continues to access the basin and compromise the quality of the water in this high-profile recreational area.

12. The quality of water being discharged to the canals *via* the Monread, Athy and Kilcock Harbour drains was unsatisfactory in 2023 and indicated that deleterious matter, probably containing sewage contamination, is continuing to be fed into these recreational waterways through these drains. Efforts must be redoubled by the responsible Local Authorities to identify the sources of this pollution and to take immediate action to eliminate them.

13. The macrophyte flora of the Grand and Royal Canals remains both healthy and diverse, from the aquatic plants that live in the aquatic habitat to the emergent species that occupy the margins and drier banksides of these unique navigation systems. The macrophyte species that were most

widespread at monitoring sites on the canals in 2023 were *Glyceria maxima* (Reed Sweet-grass)*, Iris pseudacorus* (Yellow Iris), *Nuphar lutea* (Yellow Water-lily), *Alisma plantago-aquatica* (Water-plantain) and *Elodea nuttallii* (Nuttall's Pondweed), present at 37, 37, 34, 34 and 32 of the 41 monitoring sites, respectively. The most uncommon species recorded across the WFD monitoring sites on the canals system were *Utricularia vulgaris* (Greater Bladderwort)*, Potamogeton coloratus (Fen Pondweed)* and *Oenanthe fistulosa* (Tubular Water-dropwort), which were each recorded at just a single site.

14. Continuous and often uninterrupted stands of *Glyceria maxima* characterise the margins of the Royal and Grand Canals, including the Naas and Barrow Lines. This species was recorded at most monitoring sites along the canals in 2023 and its lush and abundant vegetation, at the water's edge, provides shelter for an abundance of wildlife and protection for the banksides from the erosive effects of boat traffic in the canal.

15. During macrophyte sampling in 2023, the aquatic vegetation in the Athy section of the Barrow Canal (BL15) was carpeted with long, deep green and trailing plumes of filamentous algae, probably reflecting the poor quality of the water being discharged to this section of canal *via* the Athy drain (BL15.1).

16. *Sagittaria sagittifolia* (Arrowhead)*,* in its submerged and floating-leaved forms, was the dominant aquatic plant species at monitoring sites throughout the Grand Canal in 2023, supporting a cover abundance score of 5 (>70%) at five of the seven sites in GCE and of $\geq$4 (31-70%) at seven of the 11 sites in GCW. Growing with this level of abundance, it is probable that this species blocks light from other, smaller submerged macrophyte species, as well as competing with them for the limited amount of space that is available in these overgrown channels.

17. *Myriophyllum verticillatum* (Whorled Water-milfoil) is a submerged macrophyte species that, in previous years, caused considerable problems for navigation in the Royal and Grand Canals. In recent years, however, its status as a problematic species here has significantly diminished. In 2023, the species was only recorded at one GCE site, with low abundance, and at six GCW sites. At only three of the latter sites did this submerged species grew abundantly and represent a significant component of the aquatic flora. This year, *M. verticillatum* was present at only nine of the 17 Royal Canal sites and with an abundance of $\geq$4 at only three sites.

18. Thirty-nine of the 41 WFD monitoring sites on the canals and all 14 AWBs were assigned Maximum ecological potential based on the macrophyte quality element in 2023.

19. A total of 44 aquatic macroinvertebrate families were recorded from the Royal and Grand Canals during the current 3-year reporting cycle (2021-2023). Thirty-eight families were recorded from the Grand Canal, including the Naas Line, Barrow Line and the Milltown Feeder, while 41 families were recorded from the Royal Canal. The average number of taxa across all canal sites was 17, with the highest number (25) recorded from RCW3 (Belmont) and the lowest number (9) from

NL1 (Naas Line). The most widely distributed taxa across sites were the snails, mussels and crustaceans, followed by bugs, caddisflies, damsel/dragonflies and true flies.

20. Twenty-one of the 41 sites assessed during this 2021-2023 monitoring cycle were at Maximum eco-potential based on the macroinvertebrate quality element. Fourteen sites were at Good, four at Moderate and two at Poor eco-potential. Six of the 14 AWBs were at Maximum, five at Good, two at Moderate and one at Poor eco-potential.

21. The two sites assigned Poor eco-potential scores in 2022 were NL1 on the Naas Line and GCE4 at Sallins. The former site has reported high TON and Nitrate level for a number of seasons and the bed of the canal was covered with dense carpets of filamentous algae during much of that year, factors that probably impacted the resident macroinvertebrate community (as well as the effective collecting of macroinvertebrates with the sweep net). The towpath margin of the site at Sallins is fully occupied by cruisers that are permanently moored there and it is probable that the presence of these craft had, likewise, adversely affected the resident macroinvertebrate fauna in the area.

22.   Overall, the diversity of macroinvertebrates at canal monitoring sites, plus the families occurring there, are indicative of generally good water quality and diverse habitat across sites, although sites with long-term trends of low diversity, plus short-term declines, should warrant research effort to ascribe causes to these patterns.

23. In addition to the seven monitoring sites that the highly invasive macrophyte *Crassula helmsii* was recorded at in 2021, 2022 and 2023, a single plant of this unwanted species was recorded, for the first time, at NL1 on the Naas Canal in 2023. A detailed examination of the site at that time, visually and using the grapnel, failed to uncover any further specimens. However, it will be important to closely monitor this site, and the length of the Naas Line, for the presence of this invasive species and to physically remove any stands as soon as they are located.

24. In 2021, *C. helmsii* was recorded at MF1 on the Milltown Feeder, with a cover abundance of 1 (<3%). This increased significantly to a cover abundance of 4 (31-70%) in 2022 and to 5 (>70%) in 2023. During recent sampling at this site, this aggressive invasive species dominated the aquatic flora and suppressed the vegetative expression of most native macrophytes. The potential adverse impact of the continued spread of this species in the Milltown feeder, and the receiving Grand and Barrow Canals, is significant. It is, therefore, recommended that action, possibly localised dredging, is taken by WI to limit its further downstream spread.

25. *Crassula helmsii* has not yet been recorded from any site on the Royal Canal or Barrow Line.

26. Two non-native macroinvertebrate species were recorded at canal sites during this monitoring cycle (2021-2023). They were both amphipod crustaceans, the North American *Crangonyx pseudogracilis* (widespread and abundant) and the Ponto-Caspian *Corophium curvispinum*, which is localized and rare. The former is unlikely to influence macroinvertebrate communities and is deemed to be fairly benign, while the latter is too rare to have much ecological influence

at the moment. However, increases in non-native species should be monitored for adverse effects, such as competition or habitat modification.

27. Thirty-three of the 41 WFD monitoring sites on the canals were assessed at Good ecological potential when physico-chemical, macrophyte, macroinvertebrate (2021-2023), invasive species and hydromorphological quality elements were assessed to determine their combined eco-potential. Six sites were at Moderate and two at Poor eco-potential following assessment in 2023.

28. Ten of the 14 AWBs on the canals achieved Good eco-potential, three achieved Moderate and one was assigned Poor eco-potential when physico-chemical, macrophyte, macroinvertebrate (2021-2023), invasive species and hydromorphological quality elements were assessed. This compares with 12 at Good and two at Moderate eco-potential in 2020, at the end of the 2018–2020 monitoring cycle. The Shannon-Erne Waterway AWB (SE_26A) was at Good eco-potential (based solely on the physico-chemical quality element) at the end of 2023.

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1. INTRODUCTION

Water Framework Directive (WFD) surveillance monitoring at designated sites on the Royal and Grand Canals, the canalised section of the Shannon-Erne Waterway, the Grand Canal Basin in Dublin city and five designated feeders/drains to the canals was carried out by INVAS Biosecurity Ltd. in 2023.

A canal is identified as an Artificial Water Body (AWB) in the WFD and is defined as a body of water created by human activity. In recognition of their navigational role, canal AWBs must achieve good ecological <u>potential</u> as opposed to good ecological <u>status</u>, the latter which applies to natural water bodies, such as rivers and lakes. Ecological potential is assessed using a combination of biological (native and invasive macrophytes and macroinvertebrates), physico-chemical and hydromorphological quality elements. For classification purposes, the indicative ecological potential of a site or water body can be Maximum, Good, Moderate, Poor or Bad. Where physico-chemistry alone is being assessed, sites and AWBs can only achieve either Good or Moderate potential. In assigning ecological potential, the one-out-all-out rule applies, whereby the lowest value quality element determines the overall classification of the water body. A system for classifying British and Irish canals based on macrophyte, macroinvertebrate, invasive species, physico-chemical, and hydromorphological quality elements is used to assess the ecological potential of AWBs (Willby 2012).
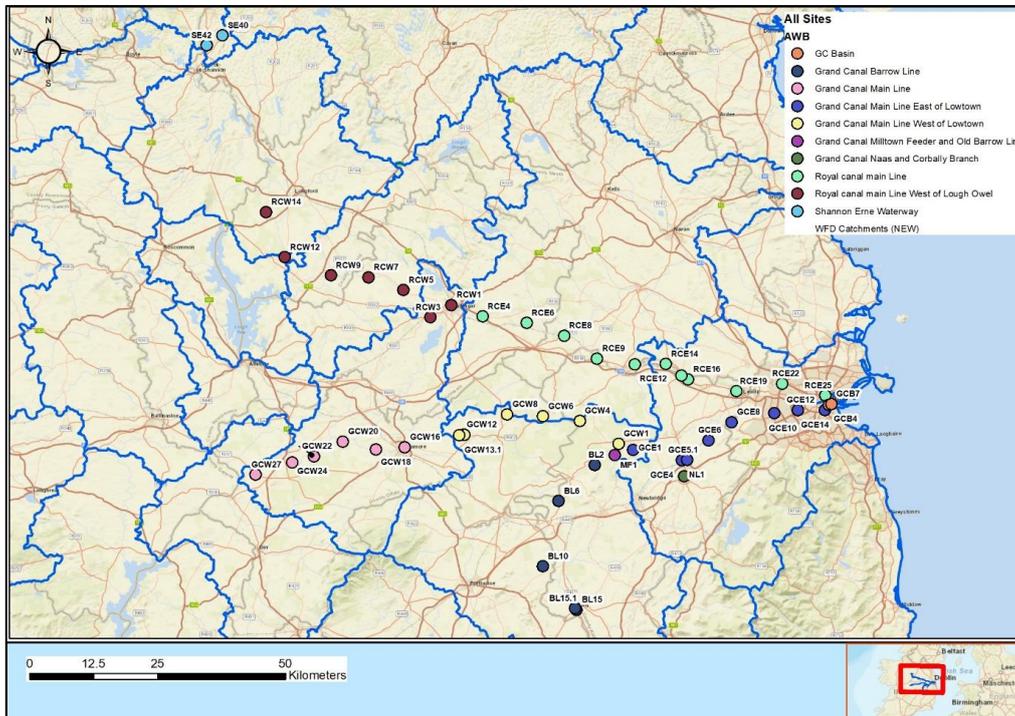
Figure 1.1 Artificial Water Bodies (AWBs), individual canal sites and feeder/drain sites on the Royal and Grand Canals, and the Shannon-Erne Waterway. The AWBs are grouped based on locations within river catchments.

The canals are currently divided into 15 AWBs based on their locations within river catchments (Table 1.1). The Grand Canal supports eight AWBs (this does not include the Grand Canal Basin), the Royal Canal has six AWBs and there is just a single AWB on the Shannon-Erne Waterway. Four of the AWBs have only a single canal monitoring site (Table 1.1), which can be potentially problematic when ecological potential for individual AWBs is being assigned. This reflects the fact that a breach in the threshold level for any determinand parameter can result in the AWB being assigned Moderate rather than Good indicative eco-potential.

For reporting purposes, a simple code has been assigned whereby artificial water bodies (AWB) are labelled according to the river catchment in which they occur (Table 1.1).

Table 1.1   Artificial Water Bodies (AWBs) that are included in the 2023 WFD Canals Surveillance Monitoring Programme. (The Grand Canal Basin is not a designated AWB for the purposes of WFD surveillance monitoring.)

Artificial Water Body (AWB)	Catchment No	New ID Code	New Report Code	Length (km)	No of Sites
GRAND CANAL					
Grand Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_GCMLE	GC_09	41.4	6
Grand Canal Main Line East - Barrow	14	IE_14_AWB_GCMLE	GC_14E	15.7	2
Grand Canal Main Line West - Barrow	14	IE_14_AWB_GCMLW	GC_14W	12.9	2
Grand Canal Main Line - Boyne	7	IE_07_AWB_GCMLW	GC_07	14.5	2
Grand Canal Main Line - Lower Shannon	25A	IE_25A_AWB_GCMLW	GC_25A	47.0	6
Grand Canal Naas Line - Liffey and Dublin Bay	9	IE_09_AWB_GCNL	GCNL_09	11.9	1
Grand Canal Milltown Feeder - Barrow	14	IE_14_AWB_GCMF	GCMF_14	10.5	1
Grand Canal Barrow Line - Barrow	14	IE_14_AWB_GCBL	GCBL_14	50.8	4
Grand Canal Basin - Liffey and Dublin Bay	9	IE_09_AWB_GCB	GCB		2
ROYAL CANAL					
Royal Canal Main Line - Boyne Catchment	7	IE_07_AWB_RCMLE	RC_07	42.6	5
Royal Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_RCMLE	RC_09	39.4	5
Royal Canal Main Line - Lower Shannon	25A	IE_25A_AWB_RCMLW	RC_25A	13.3	2
Royal Canal Main Line - Upper Shannon	26F	IE_26F_AWB_RCMLW	RC_26F	33.8	3
Royal Canal Main Line - Upper Shannon	26E	IE_26E_AWB_RCMLW	RC_26E	3.7	1
Royal Canal Main Line - Upper Shannon	26C	IE_26C_AWB_RCMLW	RC_26C	14.2	1
SHANNON ERNE WATERWAY					
Shannon Erne Waterway - Upper Shannon	26A	IE_26A_AWB_SEW	SE_26A	25.5	2

During 2020, a second monitoring site (SE42) was included on the Shannon-Erne Waterway, to better represent the water quality status of this Waterway and AWB (Table 1.1). This site is located close to Leitrim village, where the Shannon-Erne Waterway discharges to the River Shannon (Figure 1.2).

Because of the density of permanently moored craft at the Sallins (GCE4) monitoring site in 2023 and the attendant difficulty of obtaining water, macrophyte and macroinvertebrate samples from an

open stretch of canal, it was necessary to move this monitoring site some 600m west, to a location just beyond the last moored craft.
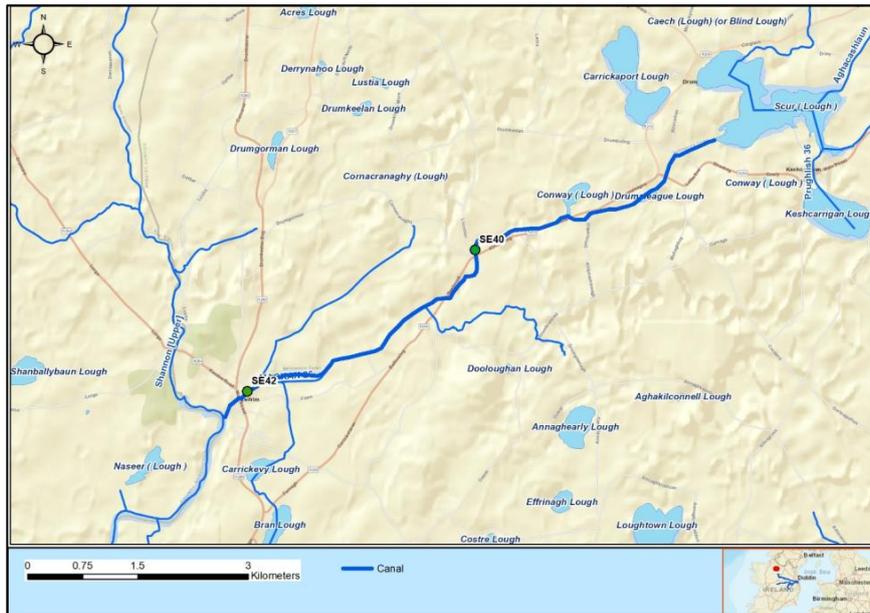
Figure 1.2   WFD monitoring sites on the Shannon-Erne Waterway sampled in 2023.

The overall sampling schedule for the quality elements is presented in Table 1.2. In the current report, AWBs are classified using the physico-chemistry, macrophyte, macroinvertebrate and invasive species quality elements that were sampled at the 41 canal monitoring sites in 2023. As the frequency for macroinvertebrate sampling, including invasive macroinvertebrates, is every three years, it was decided to sample 14 of the 41 canal sites in 2021, 14 in 2022 and 13 in 2023 for this quality element. The results for the 41 sites assessed in 2021, 2022 and 2023 are presented in this report.

Table 1.2   WFD monitoring schedule for the quality elements used to derive ecological potential for the Royal and Grand Canals, Shannon-Erne Waterway, Grand Canal Basin and designated feeders/drains.

Quality Element	Frequency	Seasonality
Physico-chemical	1 Year	Quarterly
Macrophytes	1 Year	Summer
Macroinvertebrates	3 Year	Spring
Invasive macrophytes	1 Year	Summer
Invasive macroinvertebrates	3 Year	Spring
Hydromorphology	6 Year	Spring-Summer

2. Physico-chemical Monitoring

2.1. Introduction and Sample Locations

Physico-chemical sampling is carried out annually during four quarters, in February, May, August and October. As part of this sampling programme, a total of 50 WFD sites are monitored for a wide range of physico-chemical parameters. These sites include 41 on the Grand (24) and Royal (17) Canals, in addition to five on canal feeder streams or drains (see Figure 1.1), two on the Shannon-Erne Waterway (see Figure 1.2) and two in the Grand Canal Basin, Dublin (Figure 2.1). The feeders/drains have been a source of elevated nutrient and coliform inputs to the canals in the past. They include the Monread drain (GCE5.1), the Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeders on the Grand Canal, the Athy drain (BL15.1) on the Barrow Line, and Kilcock Harbour drain (RCE16.1) on the Royal Canal.
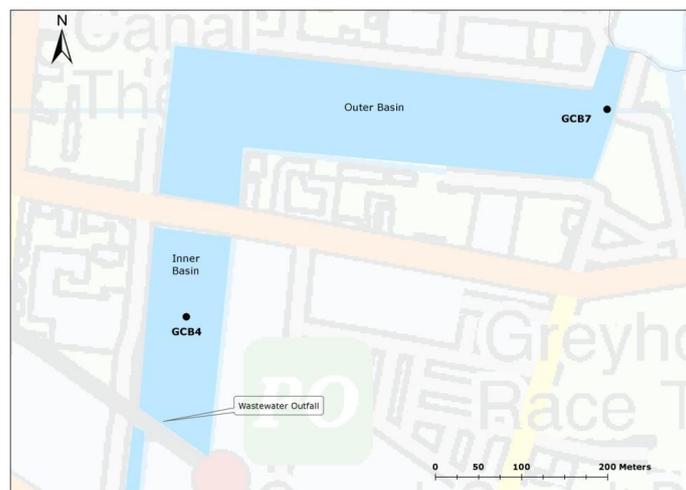
Figure 2.1   Grand Canal Basin (Dublin) showing the two WFD surveillance monitoring sites sampled by INVAS in 2023.

In addition to the quarterly water samples taken by INVAS at two sites in the Grand Canal Basin (GCB4 and GCB7), as part of the annual WFD Canals Surveillance Monitoring Programme, Waterways Ireland (WI) and Dublin City Council (DCC) have, in recent years, conducted regular bacteriological sampling for *E. coli* and *Enterococci* at up to 11 sites in the basin (three in the inner, eight in the outer) and two in the adjacent Grand Canal. Between early 2022 and late March 2023, five samples for bacteriological analysis (rather than 13) were collected and analysed on a roughly fortnightly basis. These were taken from the 1st level of the Grand Canal's Circular Line before it enters the basin (GCB8), two sites in the inner (GCB4 and GCB5) and two sites in the outer basin (GCB6 and GCB7) (Figure 2.2). Between late March and mid-May 2023, when the last set of results was received by INVAS, a sixth sampling site (GCB6B in Figure 2.2), located in the middle of the outer basin, was included in the sampling programme.

During 2023, WI occasionally took water samples for bacteriological analysis (*E. coli* and *Enterococci*) at a number of 'recreational and hotspot' sites on the canals and Shannon-Erne Waterway, at Leitrim village and marina. A small number of these sites roughly correspond with sites monitored as part

of the WFD Canals Surveillance Programme, including Leitrim village/marina, GCE8 (Hazelhatch), GCE14 (Baggot Street), GCE5 (Sallins), RCE12 (Castleknock) and RCE16 (Kilcock). A site in Naas Harbour, upstream of site NL1, has also been sampled by WI during this period. The last sets of results received from WI from this sampling programme were for the following dates – 22nd August, and 20th & 26th September 2023.
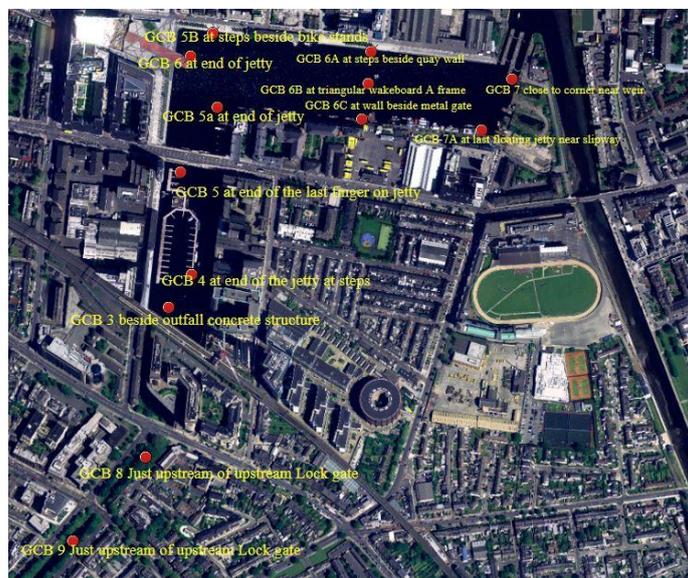
Figure 2.2   Grand Canal Basin (Dublin) showing the 13 sites from which samples have traditionally been taken by Waterways Ireland and Dublin City Council for bacteriology.

Over the last number of months, the water level at the Croke Park (RCE25) monitoring site was significantly lowered and access to the canal was blocked to facilitate Greenway construction activities. It was, therefore, necessary to take the Q3 and Q4 water samples at the nearest accessible upstream site, at Cross Guns Bridge. Also, during the year it was also necessary to permanently relocate the Sallins (RCE4) monitoring site some 600 metres west so that water and biological samples could be collected without interference from the permanently moored craft in this area.

2.2. Materials and Methods

Water sampling involves the field deployment of a YSI water logger at each site to measure water temperature, conductivity, pH and dissolved oxygen (% and mg/l O_2). Water samples are collected and returned to the Independent Analytical Supplies (IAS) laboratory in Bagenalstown, Co Carlow for analysis of a range of parameters that includes Total Phosphorus (TP), Molybdate Reactive Phosphorus (MRP), Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON), Total coliform, *E. coli*, Biological Oxygen Demand (BOD), Ammonia, Nitrite, Nitrate and Alkalinity. Six of these parameters have been selected as determinands to assess indicative ecological potential and include Total Phosphorus, Soluble Reactive Phosphorus, Total Oxidised Nitrogen, Ammonia, Biological Oxygen Demand and *E. coli* (count/100ml) (Table 2.1). Chlorophyll monitoring was discontinued in 2021.

Values in red in the results tables and in Appendices I to VII indicate breaches in the threshold limits for any of the six physico-chemical determinands.

Table 2.1   Physico-chemical determinands measured as part of the WFD monitoring programme in 2023. (Chlorophyll monitoring was discontinued in Q1 2021.)

Determinand	Limit	Determinand	Limit
Total Phosphorus (TP) (mg/l P)*	0.063 mg/l P	Dissolved Oxygen (DO) (mg/l and % saturation)	>5.0 mg/l O_2
Molybdate Reactive Phosphorus (MRP) (mg/l P)	0.025 mg/l P	pH	
Soluble Reactive Phosphorus (SRP) (mg/l P)*	0.025 mg/l P	Conductivity (µS)	
Total Oxidised Nitrogen (TON) (mg/l N)*	4.1 mg/l N	Alkalinity (meq/l)	
Nitrite (mg/l)		Chlorophyll (µg/l)	
Nitrate (mg/l)		Biological Oxygen Demand (B.O.D.) (mg/l O_2)*	<2.5 mg/l O_2
Ammonia (mg/l N)*	0.12 mg/l N	Total Coliforms (TC) (counts/100ml)	5000/100 ml
Temperature (°C)		Faecal Coliforms (counts/100ml)*	1000/100 ml

* Determinands used to assign ecological potential to the Artificial Water Bodies (AWBs)

2.3. Results

Four reports that present the results for the physico-chemistry and classification of indicative eco-potential for the 50 WFD monitoring sites on the Grand and Royal Canals, Grand Canal Basin, Shannon-Erne Waterway, and the designated feeders/drains in each quarter (February, May, August and October) in 2023 are presented individually in Appendices IV to VII.

Prolonged dry weather preceded water sampling in February and May, and water levels in the canals during sampling were near normal for the time of year. There was a moderate flow in most of the feeders/drains in February, but the dry weather was reflected in the low levels recorded in these systems in May. July 2023 was the wettest month on record across Ireland and high levels of rainfall were also reported during August, prior to and post the Q3 sampling dates. The heavy rainfall continued into October and sampling in this fourth quarter was preceded by Storm Babet, which brought extremely heavy rainfall. As a consequence of the heavy rainfall through the summer and autumn of 2023, water levels throughout the canals and their feeder/drain systems during sampling were high and, in places, the water was highly coloured or peat stained.

2.3.1. *Physico-chemistry at Surveillance Monitoring Sites on the Grand & Royal Canals and the Shannon-Erne Waterway*

Water sampling was conducted on 16th and 23rd February, 17th and 25th May, 17th and 23rd August and 19th and 26th October 2023. Water temperatures over the sampling period varied from 6.3°C recorded at RCW1 (Mullingar) in February to 20.9°C recorded at GCW4 (Lock 20) in May.

Water quality conditions were generally good at most of the seven sites on Grand Canal East (GCE1 to GCE14, see Figure 1.1) in 2021 and 2022, including the three sites that host permanently moored cruisers – GCE14 (Baggot Street), GCE8 (Hazelhatch) and GCE4 (Sallins). One site that reported high Ammonia levels in 2022, with an exceptionally high maximum value of 4.1mg/l N in Q2, was GCE6 (Ponsonby Bridge). This site was closely examined during sampling in 2022 and 2023 but no

apparent reason for the high Ammonia values recorded could be found. Values for Ammonia at the site were low throughout 2023, with a high of 0.07mg/l N reported in Q2 (see Appendix I). Water quality conditions at GCE sites remained generally good in 2023. Levels for TP, MRP, SRP, TON and Nitrate were mostly low in Q1 to Q4, with all levels well within acceptable limits (see Appendices IV to VII). BOD values were generally low, except in Q1 when values at five sites were at 2mg/l O_2 and one (GCE8, Hazelhatch) was at 3mg/l O_2. Bacteriological counts were low at most of the monitoring sites in 2023, although very high Total coliform counts (>24,000 per 100ml) were recorded at GCE4 (Sallins) in both Q1 and Q2. A correspondingly high *E. coli* count was recorded in Q2 but that for Q1 was very low (see Appendix IV). Ammonia levels varied significantly through the year, with mostly low levels recorded in Q1 and Q4 but occasionally high levels in Q2 (four sites $\geq$0.1mg/l N) and Q3 (three sites $\geq$0.1mg/l N). The highest levels of 0.17 and 0.15mg/l N were recorded at GCE4 in Q2 and Q3, respectively.

Results from sampling in GCE in 2023 suggest some water quality issues at GCE4, probably reflecting the burgeoning number of moored cruisers at this site. However, while close attention was paid to the monitoring site and its environs during water and biological sampling throughout the year, no direct pollution from any of the craft was witnessed. However, it was deemed prudent to move the WFD surveillance monitoring site some 600m west along the canal corridor in order to ensure that samples could be collected without interference from moored boats.

Plate 2.1: Collecting water samples at the slipway at Clondalkin (GCE10) in August 2023.

The levels recorded for the nutrients TP, MRP, SRP, TON and Nitrate were low at most of the 11 GCW sites in 2023, excepting the very high value of 0.13mg/l P recorded at GCW22 (west of Pollagh) in Q3. Readings for all other parameters at this site on this occasion were well within acceptable limits and there was no indication of any artificial input to the canal, suggesting the possibility of sample contamination. Results for nutrient parameters at this site in 2021, 2022 and 2023, bar GCW22 in Q3 2023, were excellent. In Q1 2023, three very high readings for BOD were recorded,

at GCW8 (east of Rhode) – 9mg/l O_2, GCW18 (Ballycowan) - 4mg/l O_2 and GCW20 (Cornalaur) – 6mg/l O_2. BOD readings for the remainder of the year at GCW sites were within acceptable limits, except for one reading of 3mg/l O_2 at GCW12 (west of Daingean) in Q3 (see Appendix I). In 2022, the *E. coli* threshold limit was breached at GCW20 (Cornalaur) in Q2 and Q3, although no cause for the contamination could be found. This site was closely observed during sampling in 2023 but, again, there was no sign of any disturbance in or around the site. Counts for *E. coli* at this site were very low in Q1, Q2 and Q4, while in Q3 an elevated count of 687 per 100ml was recorded. One site on GCW where water quality conditions have been a regular cause for concern over the years is GCW12 (west of Daingean). This site is located between the Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeders, which commonly discharge enriched and even polluted water to the canal. In 2023, however, water quality conditions at this site were reasonably good and only one high BOD (3mg/l O_2) and one high Ammonia (0.12mg/l N) reading were reported - in Q3 and Q4, respectively. This is a significant improvement on water quality conditions at this site in 2021 and 2022, when high levels for most parameters, including Total coliforms and *E. coli*, were regularly reported.

From October 2021 to February 2023 there was an opaqueness to the water at NL1 on the Naas Line, with no obvious explanation for it. From February to the end of this year, the water was clear, to the canal bed, on all sampling occasions. High TON and Nitrate levels have been a feature of this monitoring site for a number of years and a survey conducted in summer 2020 determined that a main contributor to this high nitrogen level was the discharge from a drain that feeds directly into Naas Harbour. In 2021, levels for TON from Q1 to Q4 were high and two were in breach of the threshold limit (4.1mg/l N). In 2022, TON readings were again consistently high but within the threshold limit, while in 2023, levels were again high and the threshold limit was breached on just one occasion, in Q1 (see Appendix I). In addition to high nitrogen levels, occasionally high levels for other parameters have been recorded at this site, including TP, MRP, SRP and Ammonia in Q3 2021, high Ammonia in Q3 and Q4 2022, and high Total coliform and *E. coli* in Q4 2023. These high readings indicate that contaminated effluent, sometimes containing sewage and/or animal waste material, is being discharged to the canal, probably *via* the drain into the harbour. At the behest of WI, Kildare County Council (KCC) has conducted surveys to identify and eliminate these contaminant source(s) to this canal but, to date, problems relating to water quality for the Naas Line continue.

The water quality in the Milltown Feeder (MF1) in 2023 was excellent from Q1 through Q4, although an elevated BOD reading of 2mg/l O_2 was recorded here in Q2. However, on that occasion, results for all other parameters were well within acceptable limits. TON and Nitrate levels have always been reasonably high, between 2 and 3mg/l N, in this feeder, which probably reflects the source of the water in the nearby Pollardstown Fen. In 2022, somewhat elevated Ammonia levels (0.06 to 0.09mg/l N) were recorded here on each sampling occasion, something that had not occurred in 2021 and was not repeated in 2023.

The levels of TP, MRP, SRP and *E. coli* in water sampled during 2023 at the four WFD monitoring sites on the Barrow Line were low and well within acceptable limits (see Appendix I). The levels recorded for TON and Nitrate were also relatively low at most sites, although a very high reading of 4.88mg/l N was reported at BL10 (upstream of Vicarstown) in Q1. This contrasts with results for

2022, where very high TON and Nitrate levels were recorded at BL10 in Q1, Q2 and Q3. Interestingly, nitrogen results for 2021, at all Barrow Line sites, were well within acceptable limits. A survey conducted in August 2020 by INVAS identified the Annonock feeder stream, which feeds into the Barrow Canal immediately upstream of BL10, as the main contributor to the high nitrogen levels recorded in this waterway. High Ammonia levels were recorded at BL2 (downstream of Lock 22), BL10 and BL15 (Athy) in Q2 2023, with the highest level of 0.19mg/l N being reported from BL10. In 2022, unacceptably high Ammonia levels were recorded at each of the four Barrow Line sites in Q1(see Appendix I). Ammonia levels in 2021 were satisfactory at all four sites throughout the year.

Plate 2.2: Artificially low water levels and an abundance of filamentous green algae in the Royal Canal at Croke Park (RCE25) in August 2023.

Low values for TP, MRP, SRP, TON, Nitrate, Total coliform and *E. coli* were recorded at all ten sites on Royal Canal East during the four quarters of 2023 (see Appendix I). Similarly low readings for TP, MRP, SRP, TON and Nitrate were recorded at all RCE sites in 2022 and 2021, with the exception of one extremely high TON reading of 7.83mg/l N that was reported at RCE14 (Fern's Lock) in Q2 2021. It is interesting that no reading greater than 1.7mg/l N (the threshold limit for this determinand is 4.1mg/l N) was recorded at this site since that time. Ten Ammonia readings $\geq$0.1mg/l N were reported during Q1 to Q4 2023 at eight of the ten monitoring sites (see Appendix I), although only three readings were in breach of the threshold limit (0.12mg/l N) and two of those were recorded at RCE25 (Croke Park). In 2022, some 20 Ammonia readings $\geq$0.1mg/l N were recorded at RCE sites, with each site reporting at least on such reading. BOD levels were generally within acceptable limits in 2023, although one reading of 3mg/l O_2 was reported for RCE25 in Q1. (This

was before the water level was artificially lowered to facilitate Greenway construction – see Plate 2.2.)

Readings that indicate good quality conditions for TP, SRP, MRP, TON and Nitrate were recorded at all seven sites on Royal Canal West during Q1 to Q4 2023 (see Appendix I). Counts for Total coliform and *E. coli* were generally very low and well within acceptable limits at all sites, except RCW7 (Kelly's Bridge) and RCW12 (Island Bridge), where relatively high counts were reported in Q3 2023 (see Appendix VI). Two BOD readings above the threshold limit were reported at RCW9 (Allard's Bridge) and RCW12, both in Q3. In 2022, Ammonia values $\geq$1mg/L N were recorded on ten of the 28 sampling occasions (i.e., 7 sites in 4 quarters), with all sites reporting at least one such value during sampling that year. In 2023, only three Ammonia readings $\geq$1mg/L N were recorded and most readings were $\leq$0.7mg/l N (see Appendix I).

Readings for most parameters measured at SE40 (upstream of Leitrim village) on the Shannon-Erne Waterway were low and well within acceptable limits during sampling through 2023 (see Appendices IV to VII). However, in Q3, an exceptionally high TP reading of 0.14mg/l P (threshold limit is 0.063mg/l P) was reported, although levels for all other nutrient parameters (both phosphorus and nitrogen) were very low on this occasion. Subsequent monitoring and close examination of the site in October 2023 revealed no apparent cause for this very high reading and the TP level on this occasion was relatively low, at 0.04mg/l P. The highest TP reading recorded at this site in the last three years, excepting that in Q3 2023, was 0.05mg/l P, recorded in Q3 2021. The reason for the unusually high reading in Q3 2023 is unknown but the site will be closely monitored in 2024.

Water quality conditions at SE42 (the marina in Leitrim village) were relatively good in 2023, although a number of elevated readings for TP, MRP and SRP were recorded in Q1, Q3 and Q4 (see Appendices I, IV – VII). Ammonia levels were low through 2023, with a high of 0.06mg/l N in Q4. BOD levels were elevated in Q1 and Q4 but high, at 4mg/l O_2, in Q3. Counts for Total coliform and *E. coli* were low in Q1 through Q4, with a high for *E. coli* of 631 per 100ml recorded in Q4. It is noteworthy that this figure was far lower than the counts of 44,000 and 26,000 per 100ml for *E. coli* and >1,000 per 100ml for *Enterococci* reported by WI from bacteriological sampling at this location in mid-September 2023. These latter results clearly demonstrate that highly deleterious matter, containing sewage, continues to be discharged to the Shannon-Erne Waterway in the vicinity of the marina and Leitrim village, to the detriment of the aquatic ecology (and possibly human health) in and associated with the river. In 2021 and 2022, unacceptably high readings for a number of key determinands, including TP, SRP, *E*. coli, BOD and Ammonia, were reported at this site, particularly in Q3 and Q4, possibly suggesting that incidents of contamination to the waterway may be more common in the latter, often wetter, part of the year. WI has been continuing to work with Leitrim County Council in order to determine and mitigate the source(s) of effluent to the watercourse.

2.3.2. *Indicative Ecological Potential of Surveillance Monitoring Sites on the Grand & Royal Canals and the Shannon-Erne Waterway*

In 2023, some 22 of the 43 WFD monitoring sites on the Grand and Royal Canals and Shannon-Erne Waterway were assigned Good indicative eco-potential in all four quarters of 2023, based on an analysis of the physico-chemistry of the canal water at each site (see Appendix I). This compared with just 10 at Good in all four quarters in 2022, 23 in 2021 and 18 in 2020. Thirteen sites were assigned Good indicative eco-potential in three quarters, seven were assigned Good in two quarters and one was assigned Good in just one quarter (see Appendix I). No monitoring site on the canals was assigned Moderate indicative eco-potential in all four quarters in the past six years.

Of the 172 canal and Shannon-Erne Waterway sites monitored in 2023 (i.e., 43 sites on four sampling occasions), 142 were assigned Good indicative eco-potential (see Appendix I). This compared with 128 sites that were assigned Good indicative eco-potential in 2022 and 138 in 2021, 2020 and 2019.

Just ten of the 43 monitoring sites breached the threshold limit for one or more of the six determinand parameters in Q1 2023 and, consequently, were assigned Moderate rather than Good indicative eco-potential (see Appendix I). This compared with 15 sites at Moderate status in Q1 2022 and 8 in Q1 2021. Some nine sites breached threshold limits for at least one determinand parameter in both Q2 and Q3 2023, while in Q4 the number of sites where breaches were recorded was only two (see Appendix I). In 2022, the number of sites that breached threshold limits in Q2, Q3 and Q4 was seven, seven and 14, respectively, while in 2021, the numbers were 11, eight and seven, respectively.

The physico-chemical determinand whose threshold limit was breached most often in 2023 was Ammonia, where the designated limit of 0.12mg/L N was equalled or exceeded on 16 occasions at canal sites (see Appendix I). The highest level recorded was 0.19mg/l N at BL10 (Umeras) in Q2, while the threshold limit was just equalled at six of the 16 sites. This was the determinand that was also most breached in 2022 and 2021, with 30 and 18 breach events recorded, respectively.

The next most breached determinand in 2023 was BOD, whose threshold limit of 2.5mg/l O_2 was breached at canal sites on ten sampling occasions, as it was in 2022. This compared with nine breaches in 2021. An extremely high reading of 9mg/l O_2 was reported at GCW8 (east of Rhode) in Q1 2023.

The next most breached parameter was *E. coli,* where the threshold limit of 1,000 counts/100ml was exceeded on just three occasions in 2023. This compared with six and nine breach events for this determinand in 2022 and 2021, respectively. The highest count (1,515 per 100ml) was recorded on the Naas Line (NL1) in Q4.

TON and TP threshold limits were each breached at canal and Shannon-Erne Waterway sites on only two occasions in 2023, while SRP was not breached at any of these sites during the 2023 water

sampling campaign (see Appendix 1). The threshold limit for TON was breached at nine sites in 2022 and three sites in 2021, while that for TP was breached at 2 and 6 sites, respectively, in 2022 and 2021. The threshold for SRP was breached at five sites in both 2022 and 2021.
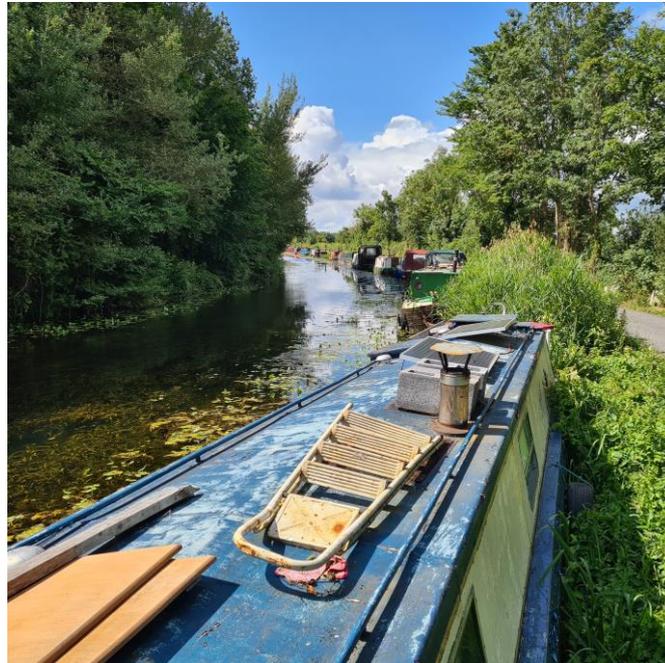
Plate 2.3: Large numbers of permanently moored cruisers at the surveillance monitoring site at Sallins (GCE4) in 2023. (The monitoring site has subsequently been moved 600m westward.)

Three of the seven sites on Grand Canal East were assigned Good indicative eco-potential in all four quarters of 2023, compared with just one in 2022 and five in 2021. These were GCE1 (Robertstown), GCE6 (Ponsonby Bridge) and GCE10 (Clondalkin). Two sites were at Moderate status for a breach of one determinand and two sites for a breach of two determinands. Of the seven determinand breaches, five were for Ammonia (see Appendix I).

Six of the 11 monitoring sites on GCW were at Good indicative eco-potential on all four quarters in 2023, while four were at Good in three quarters and one was at Good on just two sampling occasions (see Appendix I). The latter site was GCW12 (west of Daingean), which is located between the discharge points from the Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeder streams, both of which are known to discharge enriched and even polluted water into the Grand Canal close to this monitoring site. In 2022, this site breached threshold limits for five of the six determinand parameters and was at Moderate indicative eco-potential for three of the four quarters. In 2023, however, just two determinand breaches were recorded here, for BOD and Ammonia, with neither being significantly in excess of the threshold limit (see Appendix I). Four significant breaches of the BOD limit were recorded in this section of the Grand Canal in 2023, with the three highest reported in Q1. The only other determinand breaches were for Ammonia (2) and TP (1), although that for the latter parameter was very high, at 0.13mg/l P.

NL1 on the Naas Line was at Moderate indicative eco-potential on two of the four quarters, resulting from a breach in TON in Q1 and *E. coli* in Q4 (see Appendix I). No breach in any of the determinand parameters was reported here in 2022, while five breaches for four parameters in 2021 resulted in this monitoring site being at Good status in the fourth quarter only.

As in previous years, there were no breaches in any of the determinand parameters on MF1 (Milltown Feeder) in 2023 and the site was at Good indicative eco-potential following sampling in all four quarters.

None of the surveillance monitoring sites on the Barrow Line were assigned Good indicative eco-potential on all four sampling occasions in 2023, compared with just one in 2022 and all four in 2021. The threshold limit for TON was breached in Q1, Q2 and Q3 of 2022, and just once, in Q1, of 2023. The Ammonia limit was breached at three of the four sites in Q2 2023 and with a high level of 0.19mg/l N at BL10 (Umeras) in Q2.

Eight of the ten WFD monitoring sites on Royal Canal East were assigned Good indicative eco-potential on all four sampling occasions in 2023. This compared very favourably with just one in 2022 and three in 2021. One site (RCE4 – McNead's Bridge) was at Moderate because of a breach in the limit for Ammonia in Q1, while the remaining site (RCE25 – Croke Park) was at Moderate on three of the four quarters resulting from breaches in BOD (1) and Ammonia (2).

Four of the seven sites on Royal Canal West achieved Good indicative eco-potential following the four sampling events in 2023, compared with just one in 2022 and three in 2021. One site was at Moderate in one quarter, while the remaining two sites were at Moderate on two quarters. The latter sites were RCW9 (Allard's Bridge) and RCW12 (Island Bridge). The Ammonia limit at RCW sites was breached on three sampling occasions in 2023, on seven in 2022 and on six in 2021.

Both sites on the Shannon-Erne Waterway were at Good indicative eco-potential following physico-chemical analysis in Q1, Q2 and Q4 2023 (see Appendix I). In Q3, an extremely high TP reading of 0.14mg/l P (GCB4) and a high BOD reading of 4mg/l O_2 (GCB7) resulted in both sites being at Moderate rather than Good.

When the physico-chemical results for the 43 WFD surveillance monitoring sites on the canals and Shannon-Erne Waterway for the four quarters of 2023 were assessed, 41 sites were assigned Good indicative eco-potential (Table 2.3). This compared with 38 in 2022 and 36 in 2021. The two sites that were at Moderate indicative eco-potential at the end of 2023 were GCW8 (east of Rhode) and GCW20 (Cornalaur), and each had breached the threshold limit for BOD. Very high BOD readings of 9 and 6mg/l O_2 were recorded in Q1 at GCW8 and GCW20, respectively, and these results were primarily responsible for the end-of-year breaches that resulted in these sites being assigned Moderate status.

Table 2.3   Physico-chemical results for the six classifying determinands at WFD monitoring sites on the Grand & Royal Canals, the Shannon-Erne Waterway and the Grand Canal Basin between Q1 and Q4 2023, combined. The indicative ecological potential for each site is presented.

AWB	Site Code	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	GCE4	2023	0.024	0.013	1.978	504.250	1.250	0.095	Good
	GCE6	2023	0.017	0.010	1.778	60.750	1.250	0.053	Good
	GCE8	2023	0.017	0.010	1.650	39.000	1.500	0.060	Good
	GCE10	2023	0.012	0.010	1.355	29.000	1.250	0.048	Good
	GCE12	2023	0.013	0.010	1.133	132.250	1.500	0.065	Good
	GCE14	2023	0.022	0.010	1.068	15.000	1.500	0.078	Good
GCNL_09	NL1	2023	0.021	0.010	3.703	411.750	1.500	0.060	Good
GCMF_14	MF1	2023	0.011	0.010	2.388	10.000	1.250	0.045	Good
GCBL_14	BL2	2023	0.012	0.010	0.973	32.500	1.250	0.070	Good
	BL6	2023	0.012	0.010	1.838	15.250	1.500	0.045	Good
	BL10	2023	0.018	0.010	1.870	10.000	1.250	0.080	Good
	BL15	2023	0.020	0.010	1.473	148.250	1.750	0.073	Good
GC_14E	GCE1	2023	0.011	0.010	1.475	15.250	1.250	0.083	Good
	GCW1	2023	0.011	0.010	1.510	28.500	1.500	0.038	Good
GC_14W	GCW8	2023	0.027	0.010	1.268	13.500	3.250	0.063	Moderate
	GCW12	2023	0.039	0.013	1.568	37.750	2.250	0.068	Good
GC_07	GCW4	2023	0.011	0.010	1.303	16.000	1.500	0.038	Good
	GCW6	2023	0.011	0.010	1.118	7.750	1.500	0.040	Good
GC_25A	GCW16	2023	0.021	0.010	1.360	11.250	1.750	0.038	Good
	GCW18	2023	0.018	0.010	1.323	86.250	2.250	0.040	Good
	GCW20	2023	0.016	0.010	1.418	189.750	2.500	0.045	Moderate
	GCW22	2023	0.041	0.010	1.363	7.500	1.500	0.048	Good
	GCW24	2023	0.011	0.010	1.233	7.500	1.500	0.043	Good
	GCW27	2023	0.011	0.010	0.875	15.750	1.500	0.045	Good
GCB*	GCB4	2023	0.027	0.010	1.353	56.500	1.000	0.070	Good
	GCB7	2023	0.045	0.020	1.278	6,196.750	1.750	0.120	Moderate
RC_07	RCE4	2023	0.016	0.010	0.875	8.500	1.500	0.075	Good
	RCE6	2023	0.013	0.010	1.445	26.250	1.000	0.063	Good
	RCE8	2023	0.012	0.010	1.200	100.000	1.500	0.060	Good
	RCE9	2023	0.014	0.010	0.750	29.000	1.500	0.063	Good
	RCE12	2023	0.016	0.010	1.335	31.000	1.500	0.060	Good
RC_09	RCE14	2023	0.014	0.010	1.075	12.500	1.250	0.058	Good
	RCE16	2023	0.018	0.010	1.258	32.500	1.500	0.050	Good
	RCE19	2023	0.013	0.010	1.165	37.750	1.250	0.058	Good
	RCE22	2023	0.019	0.010	0.975	223.750	1.250	0.090	Good
	RCE25	2023	0.031	0.013	0.973	53.250	1.750	0.075	Good
RC_25A	RCW1	2023	0.011	0.010	0.875	16.000	1.250	0.043	Good
	RCW3	2023	0.013	0.010	0.875	7.500	1.500	0.040	Good
RC_26F	RCW5	2023	0.011	0.010	0.973	8.000	1.500	0.043	Good
	RCW7	2023	0.011	0.010	1.148	226.750	1.000	0.045	Good
	RCW9	2023	0.013	0.010	1.085	45.750	1.750	0.065	Good
RC_26E	RCW12	2023	0.011	0.010	0.875	355.500	1.500	0.065	Good
RC_26C	RCW14	2023	0.011	0.010	0.875	8.250	1.500	0.075	Good
SE_26A	SE40	2023	0.059	0.010	0.875	25.500	1.750	0.065	Good
	SE42	2023	0.044	0.015	0.875	202.750	2.250	0.038	Good

*Grand Canal Basin is not a designated AWB

2.3.3. Indicative Ecological Potential for the 15 Artificial Water Bodies

The physico-chemical results for the six determinands in the 15 AWBs, in each sampling quarter of 2023, are presented graphically in Figures 2.3 to 2.5 and also in Appendix II. Eight of the AWBs were assigned Good indicative eco-potential on all four sampling occasions in 2023. This compared with six and seven in 2022 and 2021, respectively. In 2023, five AWBs were assigned Good indicative eco-potential in three quarters, while two sites were at Moderate in two of the sampling quarters (see Appendix II).

Plate 2.4: *Oily scum, probably a natural microbial film, on the water surface at GCW12 (west of Daingean) in May 2023.*

Of the 11 determinand threshold breach events recorded among the 15 AWBs in 2023, four were for BOD, three were for Ammonia, two were for *E. coli*, one each were for TP and TON. SRP was the only determinand for which no breach was recorded this year (see Appendix II).

Of the five AWBs that contain WFD monitoring sites on the Grand Canal system (GC_09 - 6 sites, GC_14E - 2 sites, GC_14W - 2 site, GC_07 - 2 sites and GC_25A - 6 sites), breaches were only reported, for BOD, in two of them (GC_14W and GC_25A) and both in Q1 2023 (Figure 2.3 and Appendix II). The very high reading of 9mg/l O_2 at GCW8 explains the breach in the former AWB, which supports just two sites, while two high readings (4 and 6mg/l O_2), combined with four elevated readings (2mg/l O_2), explain the breach in GC_25A, which supports six sites.
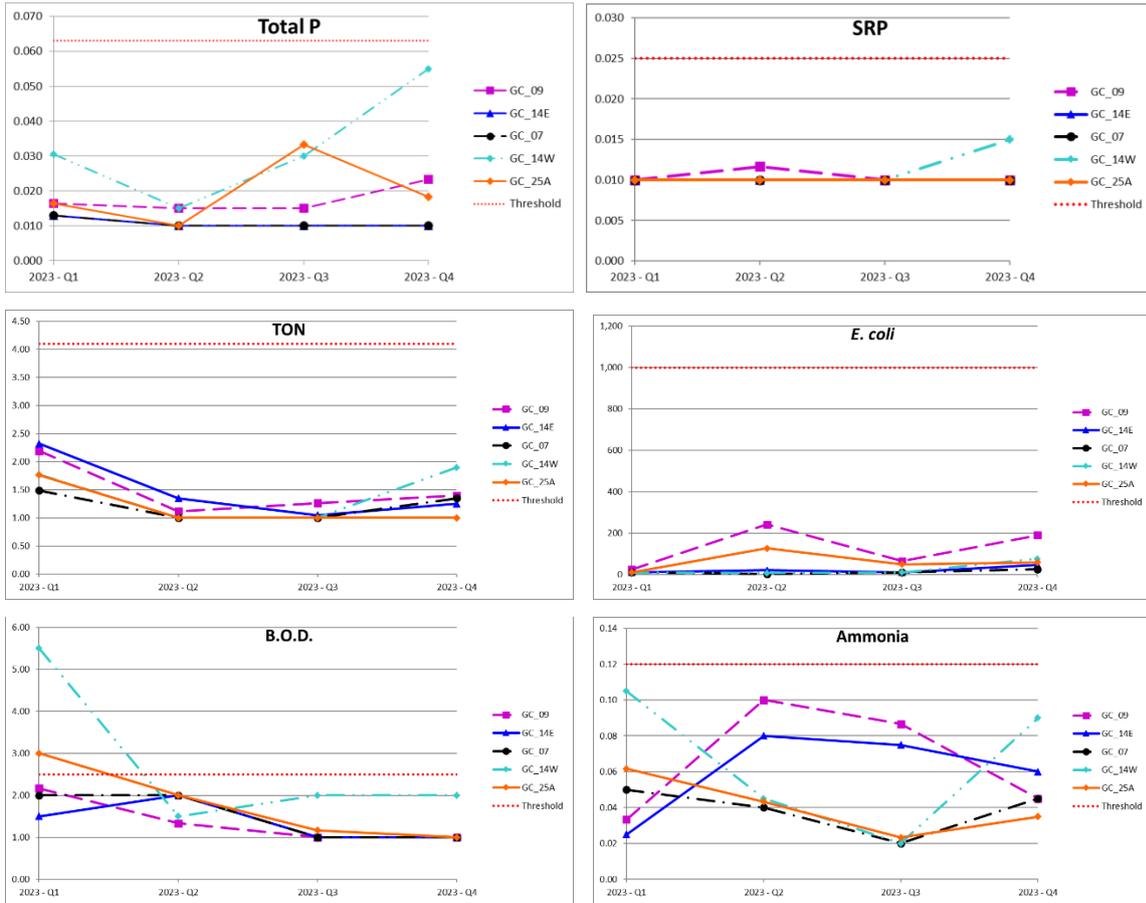
Figure 2.3   Physico-chemical results for the six classifying determinand parameters in the Artificial Water Bodies (AWB) that contain Grand Canal sites for each quarter in 2023.

No determinand breaches were reported for the Milltown Feeder (GCMF_1, one site) in 2023 (Figure 2.4 and Appendix II). The Naas Line (GCNL_09, one site), however, breached the TON threshold in Q1 and the *E.coli* threshold in Q4 of this year (Figure 2.4). The Barrow Line AWB (GCBL_14, 4 sites) breached for Ammonia in Q2, resulting from breaches for this determinand at three of the four sites on this sampling occasion.
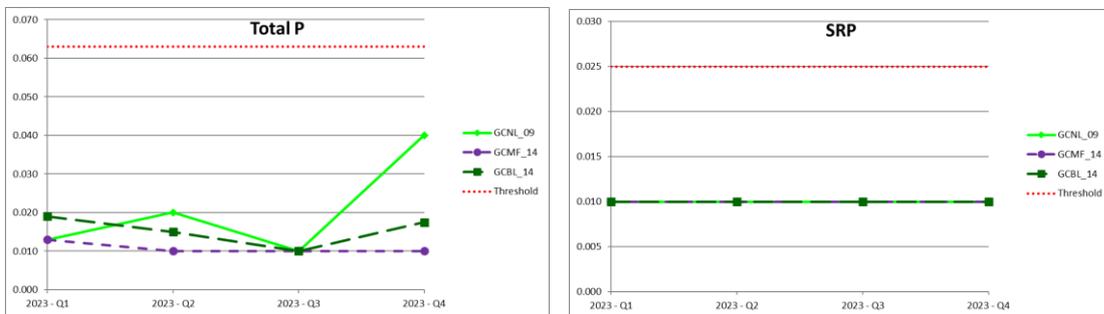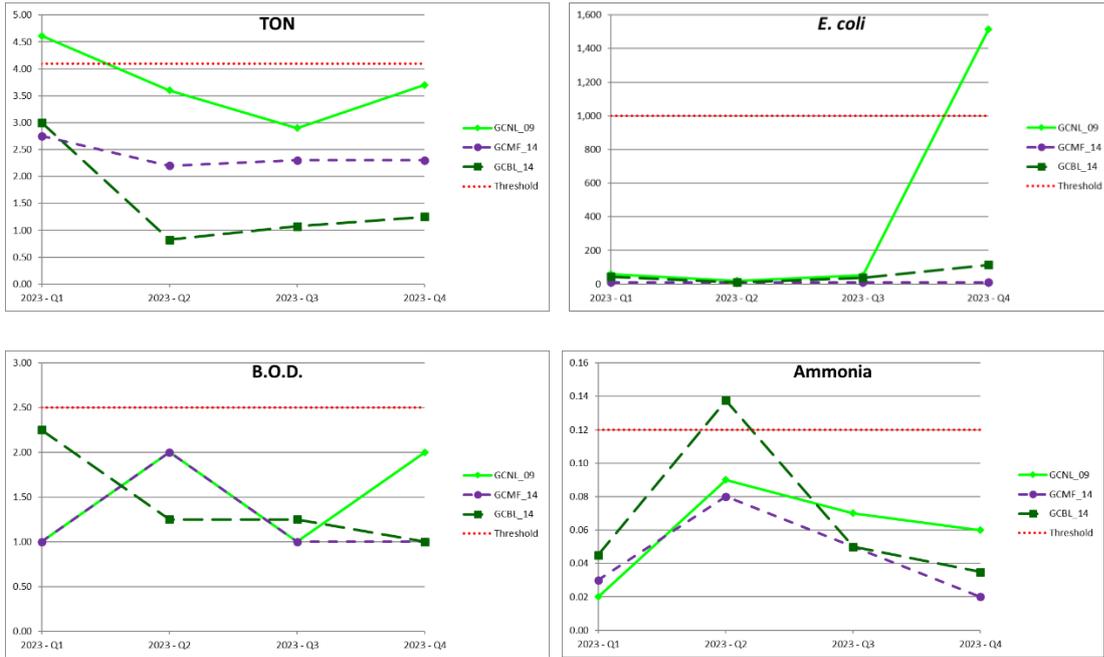
Figure 2.4   Physico-chemical results for the six classifying determinand parameters in the Artificial Water Bodies (AWB) that contain Naas Line, Milltown feeder and Barrow Line sites for each quarter in 2023.
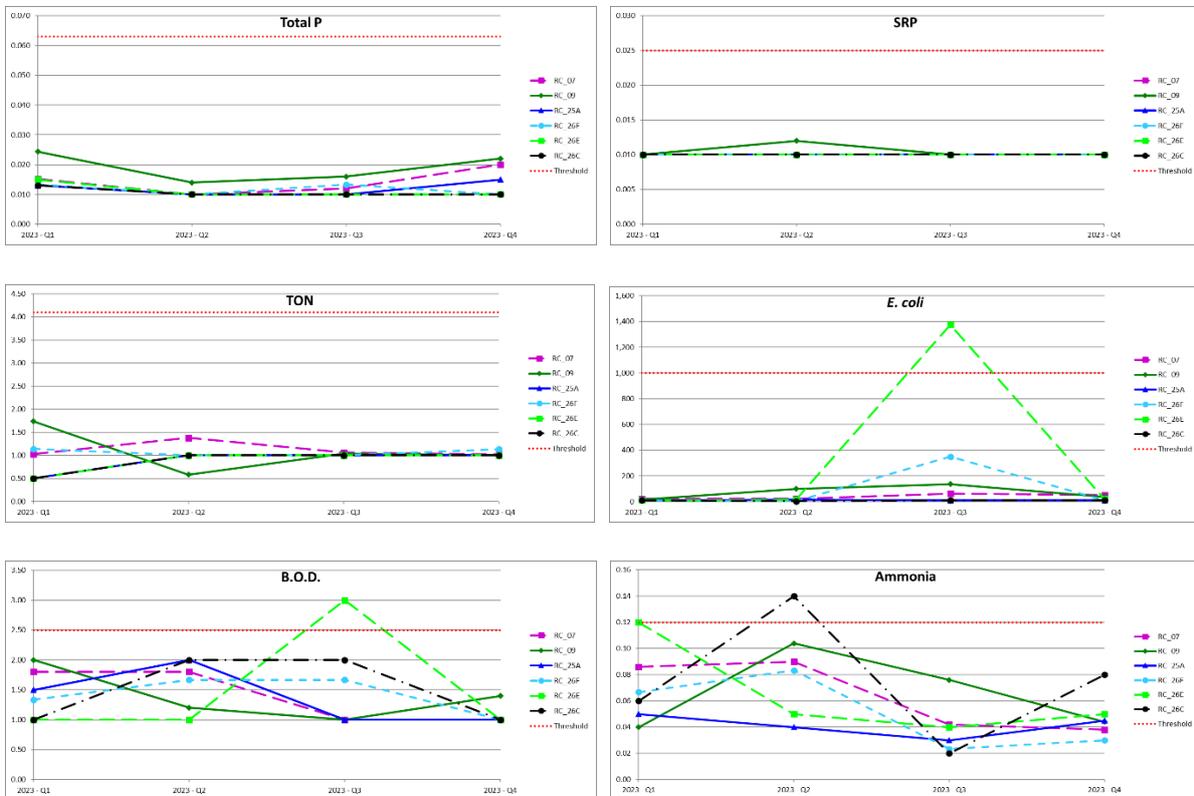
Figure 2.5   Physico-chemical results for the six classifying determinand parameters in Artificial Water Bodies (AWB) that contain the Royal Canal sites for each quarter in 2023.

Six of the 15 AWBs contain WFD monitoring sites on the Royal Canal (RC_07 - 5 sites, RC_09 - 5 sites, RC_25A - 2 sites, RC_26F - 3 site, RC_26E - 1 site and RC_26C - 1 site). Four of these AWBs achieved Good indicative eco-potential on all four sampling occasions in 2023. These were RC_07, RC_09, RC_25A and RC_26F (see Appendix II). RC_26C, with just a single site, breached for Ammonia in Q2, while RC_26E, also with just one site, breached for Ammonia in Q1 and for BOD and *E. coli* in Q3 (Figure 2.5).

The Shannon-Erne Waterway AWB (SE_26A) was at Moderate in Q3 as a result of high readings for TP in SE40 and BOD in SE42 (see Appendix II).

Fourteen of the 15 AWBs were assigned Good indicative eco-potential based on the combined results from physico-chemical sampling between Q1 and Q4 2023 (Table 2.4). This compares with 14 and 11 in 2022 and 2021, respectively. As in 2022, the one AWB that was at Moderate indicative eco-potential in 2023 was GC_14W, which breached for the determinand parameter BOD. This AWB contains two sites, GCEW8 (east of Rhode) and GCW12 (west of Daingean), and each contributed to the breach of threshold recorded. In Q1, a very high reading of 9mg/l O_2 was reported at GCW8, while elevated and high readings were reported on each sampling occasion at GCW12 (see Appendix II).

Table 2.4   Indicative ecological potential of the Artificial Water Bodies on the Grand & Royal Canals, the Shannon-Erne Waterway and the Grand Canal Basin, based on results from physico-chemical analysis for classifying determinands during Q1 to Q4 2023, combined.

AWB	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	2023	0.017	0.010	1.493	130.042	1.375	0.066	Good
GCNL_09	2023	0.021	0.010	3.703	411.750	1.500	0.060	Good
GCMF_14	2023	0.011	0.010	2.388	10.000	1.250	0.045	Good
GCBL_14	2023	0.015	0.010	1.538	51.500	1.438	0.067	Good
GC_14E	2023	0.011	0.010	1.493	21.875	1.375	0.060	Good
GC_14W	2023	0.033	0.011	1.418	25.625	**2.750**	0.065	**Moderate**
GC_07	2023	0.011	0.010	1.210	11.875	1.500	0.039	Good
GC_25A	2023	0.020	0.010	1.262	53.000	1.833	0.043	Good
GCB*	2023	0.036	0.015	1.315	**3,126.625**	1.375	0.095	**Moderate**
RC_07	2023	0.014	0.010	1.121	38.950	1.400	0.064	Good
RC_09	2023	0.019	0.011	1.089	71.950	1.400	0.066	Good
RC_25A	2023	0.012	0.010	0.875	11.750	1.375	0.041	Good
RC_26F	2023	0.012	0.010	1.068	93.500	1.417	0.051	Good
RC_26E	2023	0.011	0.010	0.875	355.500	1.500	0.065	Good
RC_26C	2023	0.011	0.010	0.875	8.250	1.500	0.075	Good
SE_26A	2023	0.051	0.013	0.875	114.125	2.000	0.051	Good

* Grand Canal Basin is not a designated AWB

2.3.4. Physico-chemistry and Indicative Ecological Potential of Sites on Grand Canal Basin

Grand Canal Basin is an important amenity in the heart of Dublin City and is used by the general public for a variety of water-based activities. A Dublin City Council (DCC) urban wastewater outfall is located in the inner basin (Figures 2.1 and 2.2). This pipe is used to carry storm water overflow but, on occasion, sewage contamination is discharged to the basin *via* this outfall.

A major fish kill occurred in the basin in November 2004 (Caffrey *et al*. 2006) and an intensive water sampling programme was implemented for several years after this episode. This monitoring programme revealed intermittent (and occasionally serious) breaches of Total and Faecal coliform threshold limits over the years, particularly in the vicinity of the DCC outfall in the inner basin.

In order to monitor this situation more thoroughly, Waterways Ireland (WI) and DCC have, in recent years, conducted regular bacteriological sampling, for *E. coli* and *Enterococci.* This sampling programme has been in addition to the quarterly water sampling programme operated by INVAS at two sites in the Grand Canal Basin (GCB4 and GCB7), as part of the annual WFD Canals Surveillance Monitoring Programme. The WI and DCC sampling has taken place at up to 11 sites in the basin (three in the inner basin, eight in the outer basin) and two in the adjacent Grand Canal. Between early 2022 and late March 2023, five samples for bacteriological analysis (rather than 13) were collected and analysed on a roughly fortnightly basis. These were taken from the 1st level of the Grand Canal's Circular Line before it enters the basin (GCB8), two sites in the inner (GCB4 and GCB5) and two sites in the outer basin (GCB6 and GCB7) (Figure 2.2). Between late March and mid-May 2023, when the last set of results from WI/DCC was received by INVAS, a sixth sampling site (GCB6B in Figure 2.2), located in the middle of the outer basin, was included in the sampling programme. As part of this analytical programme, breaches in acceptable limits for *E. coli* (>900 per 100ml) and *Enterococci* (>250 per 100ml) are recorded.

2.3.4.1.   Results from Quarterly Sampling conducted by INVAS Biosecurity Ltd.

Results from physico-chemical analysis in the Grand Canal Basin at GCB4 (inner basin) were good in 2023, with readings for all parameters well within acceptable limits on all sampling occasions. There was only one elevated Ammonia reading, at 0.1mg/l N, recorded in Q2. This compares favourably with results for 2022 where levels recorded for Ammonia were high on each sampling occasion, with three breaches for this determinand reported, in Q1, Q3 and Q4. The highest reading on this occasion was 0.14mg/l N. When the results for Q1 – Q4 2023 were assessed, this site was assigned Good indicative eco-potential (Table 2.3).

Results for GCB7 (outer basin) were less than satisfactory and breaches in determinand threshold limits were recorded in Q1, Q2 and Q4 (see Appendix I). A very high TP reading of 0.11mg/l P was reported in Q4, on the same occasion that a very significant breach in the *E. coli* threshold was recorded. The threshold limits for SRP and Ammonia were also breached on this sampling occasion (see Appendix I). When sampling took place in Q4, there was no indication of any disturbance to the water or of any obvious contaminant to it. However, these results indicate that water quality conditions in the outer basin were poor on this sampling occasion, even though conditions in the inner basin on the same day were good. High Ammonia levels were recorded in Q1, Q2 and Q4 at

this site, and BOD levels were also elevated in Q1, Q2 and Q4. When results for Q1 – Q4 2023 were assessed, GCB7 was assigned Moderate indicative eco-potential due to breaches in *E. coli* and Ammonia (Table 2.3). When the data for the two sites in Grand Canal Basin for Q1 - Q4 were combined, this artificial waterbody was assigned Moderate indicative eco-potential (Table 2.4), reflecting the extremely high *E. coli* count recorded at GCB7 in Q4 2023.

Results for Q1 to Q4 2023, particularly for GCB7, show that polluted water continues to access the basin and compromise the quality of the water in this high-profile recreational area. What is surprising is the fact that these poor water quality conditions were not picked up during contemporaneous sampling on the inner basin (GCB4).

2.3.4.2. Results from WI/DCC Bacteriological Sampling

Twenty sets of samples for bacteriological analysis (*E. coli* and *Enterococci*) were taken by WI/DCC in and immediately upstream of the Grand Canal Basin between January and May 2023 (Table 2.5). Up to 27th March, sampling was conducted at five sites – one in the Grand Canal immediately upstream of the basin and two in each of the inner and outer basins. From 27th March, of the 14 sets of samples taken, four were taken from the original five site locations, while the remaining ten included a sixth site, located in the middle of the outer basin. Hence, on these latter sampling occasions, water was taken from one site on the Grand Canal, two in the inner basin and three in the outer basin.

A total of 16 breach events involving *E. coli* and *Enterococci* were reported from the water samples taken between January and May 2023 and analysed by DCC (Table 2.5). Three were recorded in the Grand Canal before it entered the basin, all reporting high *Enterococci* counts. One of the counts was particularly high, at 2,100 per 100ml (the threshold limit is 250 per 100ml), and, interestingly, did not correspond to a high rainfall event in the Dublin area.

In the inner basin, six breaches were reported, with two for *E. coli* and four for *Enterococci*. The counts for *Enterococci* reported on 26th April 2023 were very high, at 570 and 770 per 100ml. It is notable that, while there was little or no rain recorded at the Phoenix Park on 25th or 26th, a significant rainfall event was recorded on 24th April. In the outer basin, of the seven breaches reported, just one was for *E. coli*. This was recorded on 21st March, the same date that a high *Enterococci* count was recorded at the same site. On 10th May 2023, breaches of the *Enterococci* threshold limit were recorded at the three sites sampled in the outer basin. Breaches for this parameter were also recorded on this date in the inner basin, at one site, and in the Grand Canal upstream of the basin (Table 6). Light rainfall was recorded in the Dublin area on the 10th, but also in the days preceding this.

E. coli counts reported by WI/DCC on 16th May and by INVAS on 17th May for sites in the inner and outer basins were very similar and all below 50 counts per 100ml.

Table 2.5. Number of sites that breached acceptable limits for *E. coli* (>900 counts per 100ml) and *Enterococci* (>250 counts per 100ml) in water samples taken by Waterways Ireland and analysed by Dublin City Council in Level 1 of the Grand Canal (1 site) and in the inner (2 sites) and outer (2 sites) Grand Canal Basins between January and May 2023.

DATE	CANAL	CANAL	INNER	INNER	OUTER	OUTER
	E coli	*Enterococci*	*E coli*	*Enterococci*	*E coli*	*Enterococci*
10.1.23	0	0	0	0	0	1
24.1.23	0	0	0	0	0	0
7.2.23	0	0	0	0	0	0
21.2.23	0	0	0	0	0	0
7.3.23	0	0	0	0	0	0
21.3.23	0	0	0	0	1	1
27.3.23	0	0	1	1	0	0
29.3.23	0	0	1	0	0	0
3.4.23	0	0	0	0	0	0
4.4.23	0	0	0	0	0	0
12.4.23	0	0	0	0	0	0
17.4.23	0	0	0	0	0	0
18.4.23	0	1	0	0	0	0
24.4.23	0	1	0	0	0	0
26.4.23	0	0	0	2	0	1
2.5.23	0	0	0	0	0	0
8.5.23	0	0	0	0	0	0
10.5.23	0	1	0	1	0	3
15.5.23	0	0	0	0	0	0
16.5.23	0	0	0	0	0	0

2.3.5.   Physico-chemistry and Indicative Ecological Potential of Canal Feeders and Drains

Results for physico-chemical analysis of water samples from the five feeders/drains that discharge to the canals for the four quarters of 2023 are presented in Appendices III to VII.

Poor water quality conditions have been reported for the Monread drain (GCE5.1) in 2018, 2019, 2021 and 2022, indicating that contaminated water was being discharged to the Grand Canal *via* this drain. The year 2020 was the exception, where results for most parameters were low on all four sampling occasions. Results for nutrient parameters in water from the Monread drain in 2023 were generally good, although a very high TP reading of 0.09mg/l P was reported in Q4. Notably, readings for MRP and SRP (and nitrogen) were very low on this occasion (see Appendix III and VII). Very high *E. coli* counts were recorded in Q2, Q3 and Q4 this year, all in breach of the threshold limit for this determinand, with a high of 3,448 per 100ml reported in Q4. An elevated BOD reading of 2mg/l O_2 was also reported at this time. The bacteriological counts for the last three quarters of 2023 clearly indicate that deleterious matter is continuing to be discharged to the Grand Canal through the Monread drain and this represents an ongoing serious water quality issue for the receiving Grand Canal system. It is imperative that Kildare County Council takes immediate action to identify and

eliminate the source(s) of this pollution to the canal. Because of significant breaches in the *E. coli* threshold limit recorded in Q2, Q3 and Q4, this site was at Moderate indicative eco-potential when figures for 2023 were averaged (Table 2.6).

Both the Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeders discharge to the main line of the Grand Canal, west of Daingean, and both have exhibited very poor water quality conditions in the past. In 2023, water quality conditions in the Ballymullen feeder were reasonably good and only one threshold breach event was recorded, for SRP in Q1 (see Appendix III). In addition, some elevated readings that were within threshold limits were reported during the year, including TP of 0.05mg/l P in Q3 and Q4, *E. coli* of 687 counts per 100ml in Q2 and BOD of 2mg/l O_2 in Q1. Based on these results, this site was at Good indicative eco-potential when results for the four quarters were assessed (Table 2.6), as was the case in 2022. In 2021, however, this site was assigned Moderate status when the results for Q1 – Q4 were combined, having significantly breached threshold limits for TP, SRP, *E. coli* and Ammonia.

Plate 2.5: YSI multimeter probe sampling water from the Ballymullen feeder (GCW12.1) in February 2023.

Phosphorus levels in the adjacent Ballylennon feeder stream in 2023 were relatively high, with three of the four TP readings for the year $\geq$0.05mg/l P and that for SRP in Q1 in breach of the threshold limit (see Appendix III). Total coliform and *E. coli* counts were particularly low throughout the year, with the highest *E. coli* count of 52 per 100ml in Q3 and Q4. Ammonia levels were high in Q1 and Q4 but very low in Q2 and Q3. A very high BOD reading of 7mg/l O_2 was recorded here in Q1, followed by two elevated readings of 2mg/l O_2 in Q2 and Q3. Resulting from these high BOD results, this site was assigned Moderate indicative eco-potential for 2023 (Table 2.6). The site was also at Moderate in 2022, for breaching BOD limits, and in 2021, for breaching BOD and SRP limits. Following a survey of the Ballymullen and Ballylennon feeders in 2022 by Inland Fisheries Ireland (IFI), it was recommended that the landowner, through whose land the Ballymullen stream passes,

be requested to block bovine access to the stream close to the canal and that Offaly County Council be informed of the continuing poor water quality of both feeders. It is not clear if any efforts have been made to address the ongoing problems for water quality on these feeders in 2023.

Plate 2.6: Using the YSI water logger to collect on-site measurement at Kilcock Harbour drain (RCE16.1) on 16th February 2023.

The water from the Athy drain (BL15.1) was assigned Moderate indicative eco-potential in each quarter of 2023 based on often significant breaches in determinand threshold limits (see Appendix III). In Q1, a TON reading of 6.2mg/l N was responsible, in Q2 a high Ammonia reading was the culprit. In Q3, the threshold limits for four of the six determinands were breached, with very high readings recorded for *E. coli* (14,830 per 100ml) and Ammonia (0.58mg/l N), while in Q4, the limit for *E. coli* was again breached (see Appendix III). The combination of these results meant that this site was assigned Moderate end-of-year status, with breaches for TON, *E. coli* and Ammonia (Table 2.6). This drain was also at Moderate status at the end of 2022, resulting from significant breaches in the TP and Ammonia threshold limits. The drain achieved Good status at the end of 2021, even though a very high *E. coli* count of 3,448 per 100ml was recorded in Q4 of that year. The unacceptably high phosphorus, nitrogen and *E. coli* levels that are regularly reported in water passing through this drain indicate that highly deleterious matter is regularly, if not constantly, being discharged to the Barrow Canal, and to the nearby River Barrow, *via* this drain. Offaly County Council must address this issue as a matter of urgency as it is already having adverse consequences for the ecology of the receiving canal.

Table 2.6 **The indicative ecological potential of the five feeders/drains monitored as part of the WFD surveillance monitoring programme, based on the physico-chemical results for Q1 to Q4 2023, combined.**

			Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Monread	GCE5.1	2023	0.041	0.013	2.738	**1,732**	1.250	0.043	**Moderate**
Ballymullen	GCW12.1	2023	0.043	0.018	2.363	303	1.250	0.053	**Good**
Ballylennon	GCW13.1	2023	0.049	0.023	1.545	40	**3.000**	0.090	**Moderate**
Athy	BL15.1	2023	0.045	0.010	**4.280**	**4,293**	2.000	**0.220**	**Moderate**
Kilcock Harbour	RCE16.1	2023	0.038	0.010	1.455	605	1.500	0.075	**Good**

The Kilcock Harbour drain discharges directly into Kilcock Harbour and has been responsible for releasing sewage-contaminated surface water into the harbour in the past. In Q1 to Q3 2023, water quality conditions in water discharging from the drain were reasonably good, although elevated BOD readings were recorded in Q1 and Q2, and elevated Ammonia readings were recorded in Q2 and Q3 (see Appendix III). In Q4, following heavy rainfall in the days before sampling, breaches in the TP and *E. coli* threshold limits were recorded, with the latter reporting 2,143 counts per 100ml. This high count follows on from very high *E. coli* (to 30,000 per 100ml) and *Enterococci* (to 620 per 100ml) counts recorded from WI sampling in the Royal Canal close to the discharge point of the drain on 19th September 2023. These results indicate that deleterious matter, containing sewage and/or animal waste contamination, is continuing to be discharged to the Royal Canal *via* the Kilcock Harbour drain. Efforts must be redoubled by Kildare County Council to identify the source(s) of this pollution and to take immediate action to eliminate it. While this drain was assigned Moderate rather than Good indicative eco-potential in Q4, it had remained at Good status from Q1 through Q3 (see Appendix III). This is reflected in the fact that the drain was assigned Good status when physico-chemical results for Q1 - Q4 2023 were assessed (Table 2.6).

3. Macrophyte Monitoring

3.1. Introduction

Macrophytes, in the context of the present report, comprise aquatic (submerged, floating-leaved and free-floating) and emergent species, the latter more commonly associated with the canal marginal and riparian zones.

Macrophyte sampling was carried out at the 41 WFD monitoring sites on the Royal and Grand Canals between 4th July and 9th August 2023. In previous years, macrophyte monitoring on the Shannon-Erne Waterway had been conducted but, in 2020, it was decided to omit this Waterway from macrophyte (and macroinvertebrate) sampling as it's hydromorphology is not conducive to the establishment and growth of diverse macrophyte communities and it is, thus, incapable of achieving Maximum eco-potential.

3.2. Materials and Methods

The survey area at each site consists of a 150m-long canal reach that is divided into ten roughly equidistant sampling points. At each point aquatic macrophytes are collected using a standardised, 8-pronged grapnel with a 7m-long rope attachment. Samples are collected by standing at the edge of the canal and throwing the grapnel as far as possible across the channel towards the opposite bank. The grapnel is permitted to settle on the canal bed before being slowly retrieved. Each grapnel sample is allowed to drip for *circa* 1 minute before being weighed. All aquatic macrophyte species retrieved by the grapnel are identified and recorded. An estimate of the percentage cover (see below) occupied by each aquatic plant species is made using a combination of the grapnel sample and a visual assessment of the plant species present in the canal at each sampling point. The figures presented in the report are those recorded on the date of sampling and do not take into account prior weed cutting operations at these sites. The width of the reed fringe (emergent species) on both banks at each sampling point is measured, or estimated, and an assessment of the relative cover (see below) occupied by each species is made.

Cover for aquatic macrophyte species is assessed relative to the area of water between the two banks and expressed on a version of the DAFOR scale:

- D – Dominant (>70% cover)

- A – Abundant (31-70% cover)

- F – Frequent (11-30% cover)

- O – Occasional (3-10% cover)

- R – Rare (<3% cover).

For the purposes of quantifying percentage cover, the DAFOR scores are converted to a numerical scale of 1 to 5 (Dominant = 5; Abundant = 4; Frequent = 3; Occasional = 2; Rare = 1). Results for the ten grapnel samples at each site are averaged to give an overall value for each aquatic macrophyte species. The overall percentage cover for each emergent plant species that occupies

both margins along the 150m-long canal site is assigned by carrying out a visual assessment of the canal reach.

To assess the ecological potential of a site using macrophyte data, a number of metrics are calculated:

- Aquatic Plant Biomass (APB) (based on grapnel samples)

- Number of BMWP (Biological Monitoring Working Party) scoring aquatic plant taxa (N_AQUA)

- Macrophyte Fertility Index (MFI)

- Number of BMWP (Biological Monitoring Working Party) scoring emergent taxa (N_EMERG)

- Relative extent of emergent vegetation (REL_EMERG).

The MFI represents a cover-weighted index score for a site based on a set of fertility ranks for different macrophyte species. Most scores lie in the range 6 – 8.5 for canals, the higher values indicating greater fertility. Not all macrophyte species recorded on our Irish canals are included in the MFI list provided by SNIFFER and, in such instances, the species that is deemed to be most ecologically similar from the list is scored (e.g., *Chara curta* and *C. hispida* are scored as *Chara* sp., *Nitella translucens* is scored as *Nitella flexilis* (agg.), *Potamogeton coloratus* is scored as *P. lucens*, *Equisetum arvense* is scored as *E. fluviatile*). The REL_EMERG metric represents the proportion of channel occupied by emergent plants, with values ranging from 0 (no fringing vegetation) to 1 (the entire channel margin is occupied by emergent macrophytes).

The classification involves calculating an Ecological Quality Index (EQI) for each metric based on the ratio of 'observed value : expected value'. The expected value is based on reference conditions using alkalinity, boat traffic and channel type data. For the purpose of standardisation, each EQI value is converted to an Ecological Quality Ratio (EQR), which ranges from 0 – 1, with class boundaries at intervals of 0.2 (1 - 0.8 = Maximum, 0.79 - 0.6 = Good, 0.59 - 0.4 = Moderate, 0.39 - 0.2 = Poor, 0.19 – 0 = Bad).

The overall EQR for a site is determined by calculating the average value from three groups of metrics: (i) EQR_{MFI} (reflecting water quality), (ii) EQR_{APB} and EQR_{N_AQUA} (reflecting in-channel disturbance) and (iii) EQR_{N_EMERG} and EQR_{REL_EMERG} (reflecting bank-related disturbance). To calculate the overall EQR for an AWB, EQR values are averaged across all sites in that AWB. The presence of invasive plant species (see Section 5) at a site will automatically result in a lowering of ecological potential for the macrophyte quality element (e.g., from Maximum to Good or from Good to Moderate).

The histograms that present results from annual macrophyte sampling (Figures 3.1 to 3.3) use the ten most commonly recorded species in that canal systems in that year. Thus, the ten macrophyte species that were most commonly recorded across the Naas Line, Milltown Feeder and the Barrow Line in 2023 are presented in Figure 3.1, even though the species presented may not include species that were particularly abundant at individual sites.
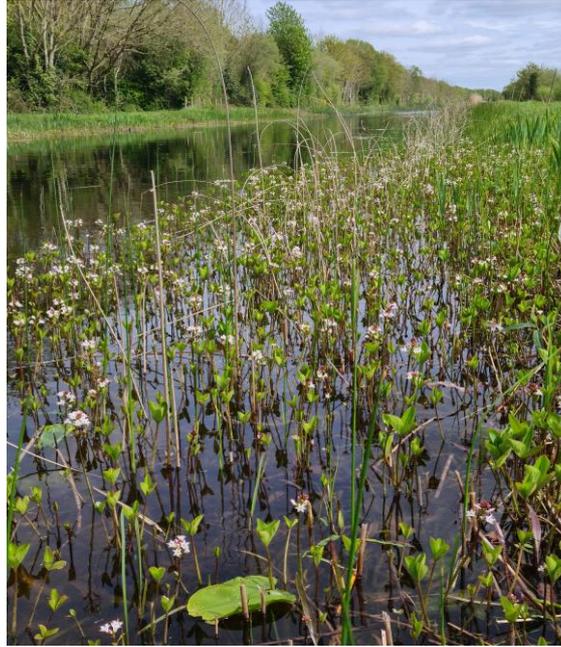
Plate 3.1: Stands of flowering Menyanthes trifoliata (Bogbean) adorn the margins of the Grand Canal east of Armstrong Bridge (GCW24) in May 2023.

3.3. Results

The results from macrophyte sampling conducted during summer 2023, including macrophyte species, communities and status at individual canal sites, are presented below.

The macrophyte species that were most widespread at monitoring sites on the canals in 2023 were *Glyceria maxima* (Reed Sweet-grass)*, Iris pseudacorus* (Yellow Iris), *Nuphar lutea* (Yellow Water-lily), *Alisma plantago-aquatica* (Water-plantain) and *Elodea nuttallii* (Nuttall's Pondweed), present at 37, 37, 34, 34 and 32 of the 41 monitoring sites, respectively (Figures 3.1, 3.2 and 3.3). The most uncommon species recorded across the WFD monitoring sites on the canals system were *Utricularia vulgaris* (Greater Bladderwort)*, Potamogeton coloratus (Fen Pondweed)* and *Oenanthe fistulosa* (Tubular Water-dropwort), which were each recorded at just a single site (Tables 3.1, 3.2 and 3.3).

3.3.1. Macrophyte Species and Assemblages in the Milltown Feeder

A steady flow of crystal clear water occupied the narrow channel of the Milltown Feeder (MF1) when it was sampled in mid-July 2023. Dense vegetation occupied the channel width and filled the water column in places, indicating that no mechanical cutting had taken place in recent weeks. Some 20 macrophyte species were recorded at this site, 12 of which were aquatic and ten emergent, with two species (*Schoenoplectus lacustris*, Common Club-rush and *Sagittaria sagittifolia*, Arrowhead) being common to both categories (Table 3.1 and Figure 3.1).

The aquatic flora at this site was dominated by the grassy species *S. lacustris* and the cushion-forming, highly invasive species *Crassula helmsii* (New Zealand Pigmyweed). The long leaves of the former species trailed in the moderate flow and, in places, occupied the full water column. This

species was recorded with abundance in each of the ten grapnel samples. The invasive *C. helmsii* carpeted much of the channel bed at this site (Plate 3.2) and was recorded with a cover abundance of 5 (>70%) in five of the nine grapnel hauls from which it was taken. This highly invasive species is living up to its 'aggressive' reputation and has continued to expand its range in the Milltown Feeder in recent years. In 2021, this submerged and densely stand-forming species was recorded here with a cover abundance of 1 (<3%). This rose significantly to a cover abundance of 4 (31-70%) in 2022 and to 5 (>70%) in 2023. The continued aggressive spread of *C. helmsii* at this site is reflected in the lower channel where it has been noted to form large, often discrete stands. The potential adverse impact of its continued spread on the ecology and functionality of the Grand and Barrow Canals is significant, and it is recommended that action, possibly localised dredging, is taken to limit its further downstream spread.

Plate 3.2: Lush stands of the highly invasive species Crassula helmsii (New Zealand Pigmyweed) carpet the channel of the Milltown Feeder (MF1) in July 2023.

The charophyte *Chara hispida* (Bristly Stonewort) continued to form localised, dense stands on the canal bed, growing alongside the ever expanding, light green cushions of *C. helmsii* and beneath the trailing leaves of *S. lacustris*. This year the cover abundance of *C. hispida* was significantly lower than was recorded in 2021 and 2022, probably reflecting the competition it is experiencing with *C. helmsii* for available space in the channel. Other submerged macrophytes that were recorded with moderate vegetative abundance included the trailing species *Juncus bulbosus* var *fluitans* (Aquatic Bulbous-rush) and *Eleogiton fluitans* (Floating Club-rush), and the broad-leaved *Potamogeton coloratus* (Fen Pondweed). (The latter species is recorded as *Potamogeton lucens,* Shining Pondweed, in Table 3.1 as it is not listed among the qualifying species provided by SNIFFER for eco-potential scoring purposes.) These species are managing to hold their place in the channel in the face of serious competition for space with *C. helmsii*. No *Elodea canadensis* (Canadian Pondweed) or *E. nuttallii* (Nuttall's Pondweed) were recorded in any of the grapnel hauls taken at this monitoring

site in 2023 (Table 3.1), while small stands of the former had been present here in each of the last few years. It is noteworthy that no specimens of *E. nuttallii* have been seen here since 2020.

The dense shrubs and tall reedy vegetation that previously characterised the off-bank at this site was severely cut back in early 2022, allowing much more light to access the channel. The vegetation along this and the tow-bank continued to be dominated by tall, alternating and often monodominant stands of *S. lacustris, Phragmites australis* (Common Reed) and, to a lesser extent, *Phalaris arundinacea* (Reed Canary-grass). Occasional, dense stands of the light green *Glyceria maxima* (Reed Sweet-grass) and *Iris pseudacorus* (Yellow Iris) occupied the wetter margins, alongside tall stands of *Alisma plantago-aquatica* (Water-plantain) and *Equisetum fluviatile* (Water Horsetail) (Table 3.1).

3.3.2. *Macrophyte Species and Assemblages in the Naas Line of the Grand Canal*

For the last year the water in this section of the Naas Canal was distinctly opaque and grey-coloured, for no obvious reason. However, on the occasion of the current sampling the water was clear, and visibility extended to the bed of the canal. The vegetation had not been recently cut and the water column was filled with lush vegetation. Seventeen macrophyte species were present at NL1 when sampled in early July 2023, with 13 aquatic and four emergent species.

The dominant aquatic plant present was *Callitriche obtusangula* (Blunt-fruited Water-starwort) (Table 3.1), which was recorded with a cover abundance of 5 (>70%) in seven of the ten grapnel hauls. (Because of the difficulty in accurately identifying *Callitriche* species, specimens from NL1 were sent to Richard Lansdown, author of the BSBI Handbook on 'Water-starwort *Callitriche* of Europe', who confirmed the identity as *C. obtusangula*.) The lush, light green stands of this submerged macrophyte occupied much of the channel and grew over and amongst much of the other submerged species. The level of growth observed on this sampling occasion was significantly greater than that recorded in 2022 or 2021, possibly reflecting the fact that the weed had not been recently cut when sampled in 2023 or may have resulted from the reduced amount of incident light reaching the canal bed through the grey-coloured water in previous years.

Another species that was better represented at NL1 in 2023 than in 2021 or 2022 was *Elodea nuttallii* (Table 3.1), which was recorded from all ten grapnel samples and mostly with a cover abundance of 4 (31-70%). This is a species that can grow in relatively low light conditions and continued to grow with abundance beneath the taller *C. obtusangula*. In parts of the channel, particularly where the latter species was less abundant, localised dense stands of *Oenanthe fluviatile* (River Water-dropwort) and *Hippuris vulgaris* (Marestail) were present. Some floating-leaved stands of *Sparganium emersum* (Unbranched burreed) were present in the slightly deeper water close to the lock gates at the end of the stretch. While filamentous green algae were retrieved on most grapnel hauls, it was never abundant and nowhere near as abundant as it was at this site in 2022.
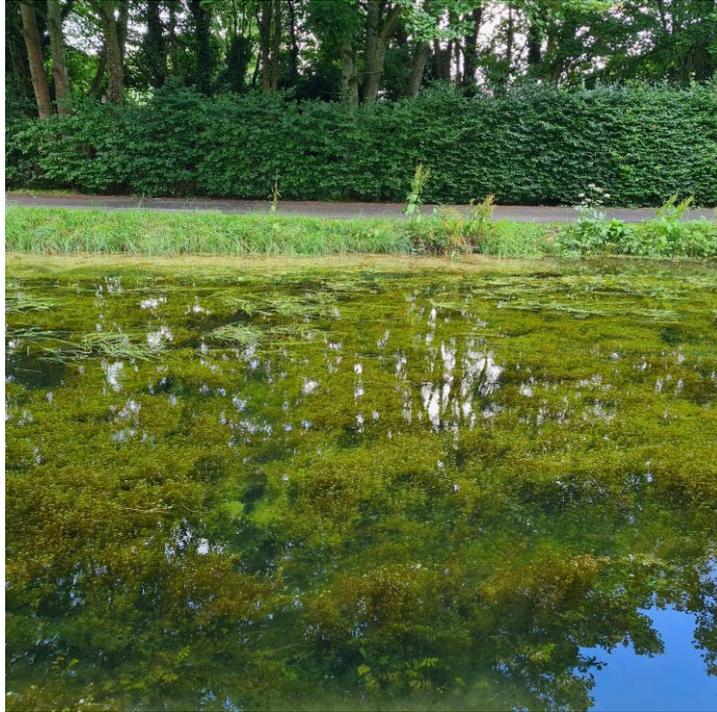
Plate 3.3: Dense stands of Callitriche obtusangula (Blunt-fruited Water-starwort) fill the water column of the Naas Canal at NL1 in July 2023.

A single stem of the highly invasive species *Crassula helmsii* was retrieved on one of the grapnel hauls from NL1. This was the first time that this species was recorded from the Naas Canal, although it is known to be present at Robertstown (GCE1) on the Grand Canal. Close examination of the margins and further grapnel hauls, however, failed to locate any further specimens. The plant retrieved had roots and was obviously growing at the site. It will be important to examine this site, and the entire Naas Canal, closely in 2024 to ascertain the status of this unwanted and highly invasive macrophyte species and to set in place measures to limit its spread within this section of canal and the receiving Grand Canal.

As in previous years, *Glyceria maxima* clearly dominated the tall, emergent, reedy vegetation along both banksides at NL1 (Table 3.1 and Figure 3.1). Occasional, though localised stands of *Phalaris arundinacea* and *Phragmites australis* were interspersed amongst this vegetation. Small stands of *Mentha aquatica* (Water Mint) were present at the water's edge.

3.3.3. Macrophyte Species and Assemblages in the Barrow Line (Grand Canal)

Water levels at the four monitoring sites on the Barrow Line during macrophyte sampling were normal or just below normal for the time of year and the water was clear at all but the site at Athy (BL15), which was turbid. The bankside works at Umeras (BL6) were almost complete when the sampling took place and the bankside vegetation was growing vigorously. The weed in the central channel had recently been cut in most sections of the Barrow Canal.

A total of 33 macrophyte species was recorded at the four Barrow Line monitoring sites in 2023, comprising 20 aquatic and 15 emergent species (*Schoenoplectus lacustris* and *Sagittaria sagittifolia*

were common to both categories). Among the aquatic species, none were present at all four sites and only *Nuphar lutea* (Yellow Water-lily) was present at three sites (Table 3.1). The most abundant aquatic species at all but BL15 were the trailing, grassy plants ((*S. lacustris, S. sagittifolia* and *Sparganium emersum*), all three of which were represented at Umeras (BL6). Among the emergent species, *Alisma plantago-aquatica* (Water-plantain)*, Glyceria maxima* (Reed Sweet-grass) and *Iris pseudacorus* (Yellow Iris) were recorded at all four monitoring sites (Figure 3.1). *Elodea nuttallii* was recorded, with relatively low abundance, at one site (Umeras) in 2023, while it had not been recorded at any of the four sites in 2022.
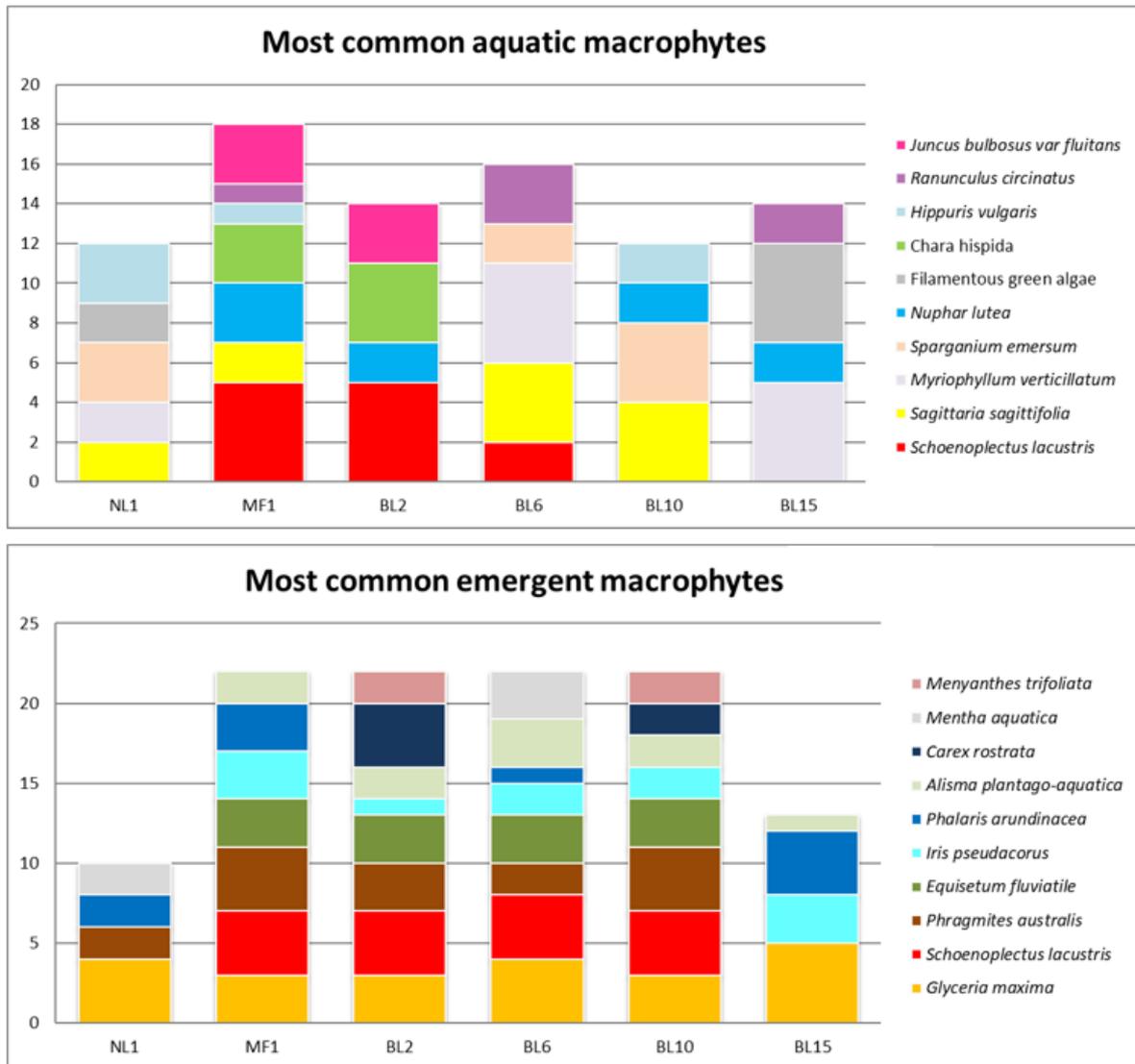
Figure 3.1   Relative representations, based on DAFOR abundance, of the ten most commonly recorded aquatic and emergent macrophyte species at WFD sites in the Milltown feeder, Naas Line and Barrow Line in 2023. (The figures presented are those recorded on the date of sampling and do not take into account prior weed cutting operations at these sites.)

Dense trailing stands of *S. lacustris* continued to dominate the aquatic flora at the site downstream of Lock 20 (BL2), even after mechanical cutting. The growth of this species has been very vigorous

at this site for the past number of years and its blanketing growth has obviously had an impact on the colonisation and establishment of other macrophyte species. This is reflected in the small number of aquatic species recorded here in recent years – 5, 5 and 6 in 2023, 2022 and 2021, respectively. This site has consistently had the lowest diversity of aquatic species of those on the Barrow Line in recent years and may be compared with Umeras, which has reported 11, 7 and 12 species in 2023, 2022 and 2021, respectively. Low-growing and dense, coarse stands of *Chara hispida* were present across the channel, growing beneath the trailing *Schoenoplectus* leaves. Closer to the margins and in slightly shallower water, moderate stands of another trailing-leaved species *Juncus bulbosus* var *fluitans* were recorded. The only other aquatic species recorded here in 2023 were floating-leaved forms – *Nuphar lutea* and *Persicaria amphibia* (Amphibious Bistort) (Table 3.1).

As in previous years, dense and continuous stands of tall, emergent *S. lacustris* continued to dominate both banksides when sampled in 2023 (Table 3.1 and Figure 3.1), even though this vegetation had been severely cut earlier in the year. Very tall, monodominant stands of *Phragmites australis* were also present along this section of canal. Closer to the wetted margins, stands of *Carex* sp. (cf. *rostrata*) grew alongside occasionally dense stands of *Equisetum fluviatile* (Water Horsetail)*, Glyceria maxima* and *Alisma plantago-aquatica*. A small stand of *Baldellia ranunculoides* (Lesser Water-plantain), a species that is rare in Irish canal systems, was recorded along the shallow margins at this site.

The aquatic flora at Umeras (BL6) was dominated by stands of *Myriophyllum verticillatum* (Whorled Water-milfoil) and *S. sagittifolia* that filled much of the water column, particularly closer to the margins where the mechanical weed cutters had less access. In 2023, *M. verticillatum* was recorded with a cover abundance of 5 (>70%) at this site while, in recent years, it had been recorded growing with less abundance in this section of canal. Four *Potamogeton* species (this includes *Stuckenia pectinata*) were recorded here in 2023, mostly with relatively low abundance, although *P. perfoliatus* (Perfoliate Pondweed) was present across the channel in moderate quantity (Table 3.1). Isolated stands of *Elodea canadensis* were also present, although none of the large stands that had been observed in 2021 were recorded. In the shallower margins, moderate stands of *Ranunculus circinatus* (Fan-leaved Water-crowfoot) were recorded. This species had not been reported here in 2021 or 2022. No charophyte species were recorded at this site since 2021, although the conditions at the site would appear to be conducive to its growth.

Along the wet margins on both banksides, tall stands of *S. lacustris, A. plantago-aquatica* and *G. maxima* dominated the emergent flora (Table 3.1 and Figure 3.1). Other tall species including *I. pseudacorus* and *E. fluviatile* were also present in this tall mass of greenery. Amongst this tall vegetation, the more low-growing fringing herb species *Mentha aquatica* (Water Mint) and *Nasturtium officinale* (Water-cress) were recorded. A number of small patches of *B. ranunculoides*, not previously recorded at this site, were found growing in the shallow margins.

As in previous years, the trailing and grassy submerged leaves of *S. emersum* and *S. sagittifolia* dominated the aquatic flora across the channel at the monitoring site upstream of Vicarstown (BL10)

(Table 3.1). The only truly submerged species recorded from the ten grapnel hauls were the low-growing *Fontinalis antipyretica* (Greater Water-moss) and *Hippuris vulgaris*. No specimens of *Potamogeton praelongus* (Long-stalked Pondweed), recorded here in 2021 and 2022, were retrieved during sampling, nor were any charophyte species recorded. The low species diversity among the aquatic species may be accounted for by the density of the trailing submerged vegetation across the channel.

The tow-bank continued to be densely overgrown with brambles, bushes and small trees. Closer to the margins of the channel, tall, monodominant and commonly alternating stands of *Phragmites australis* and *S. lacustris* dominated the banksides. In the shallow water at the margin's edge, dense stands of *Carex acutiformis* (Lesser Pond-sedge) were prominent (Table 3.1). Smaller stands of another sedge, *Carex rostrata* (Bottle Sedge), were also present here. Other emergent species recorded growing along these wet margins included *A. plantago-aquatica, I. pseudacorus, E. fluviatile and G. maxima* (Table 3.1).

Plate 3.4: Tangled masses of submerged filamentous green algae dominated the macrophyte flora in the Barrow Canal at Athy (BL15) in July 2023.

The aquatic vegetation in the Athy section of the Barrow Canal (BL15) was totally carpeted with long, deep green and trailing plumes of filamentous algae (Table 3.1). Few surface scums were evident but much of the water column was filled with the slimy algae. A similar scenario was evident during sampling in 2021, although the coverage with algae was less obvious during the summer of 2022. The profusion of filamentous algae on this sampling occasion presumably reflects the poor quality of the water being discharged to the channel *via* the Athy drain (BL15.1) (see Section 2.3.4). Although draped with filamentous algae, large stands of *M. verticillatum*, mixed with lesser stands of *M. spicatum* (Spiked Water-milfoil), continued to grow vigorously and occupied much of the channel width. Small stands of *Stuckenia pectinata* and *R. circinatus* were present along the

shallower margins. One strand of *Utricularia vulgaris* (Greater Bladderwort) was recovered on one of the grapnel hauls. In 2019 and 2020, the rather rare charophyte *Tolypella intricata* was recorded from this section. No specimens of this species have been recorded here since.

Table 3.1   Abundance values for aquatic and emergent macrophyte species in Grand Canal sites east of the summit (GCE), the Naas Line, Milltown feeder and Barrow Line in summer 2023. Abundance values - Dominant (>70%) = 5; Abundant (31 – 70%) = 4; Frequent (11 – 30%) = 3; Occasional (3 – 10) = 2; Rare (< 3%) = 1

Name	GCE1	GCE4	GCE6	GCE8	GCE10	GCE12	GCE14	NL1	MF1	BL2	BL6	BL10	BL15
Submerged													
Berula erecta								1	2				
Callitriche obtusangula								5			2		2
Callitriche platycarpa		2											
Chara curta					1								
Chara hispida	2			5	2					3	4		
Chara sp.	1		3	3	3	2							
Crassula helmsii	1					3	1	5					
Eleogiton fluitans	1					1		3					
Elodea canadensis	1	2				4	2						
Elodea nuttallii	3	5	4	1	3	3	2	4			2		
Filamentous green algae	3	3	2			3	4	2					5
Fontinalis antipyretica			2					1				3	
Hippuris vulgaris	1	3	3				1	3	1			2	
Juncus bulbosus var *fluitans*	3									3	3		
Lemna minor		2											
Lemna trisulca	1		4	3		2	2	1					
Myriophyllum spicatum													2
Myriophyllum verticillatum	2							2			5		5
Nuphar lutea	2	2	3	3			3		3	2		2	2
Oenanthe fluviatilis	3	2			3	2		3					
Persicaria amphibia	1									2			
Potamogeton berchtoldii											1		
Potamogeton lucens	2		3						2				
Potamogeton natans	1								2				
Potamogeton perfoliatus											3		
Potamogeton praelongus											2		
Ranunculus circinatus			2						1		3		2
Sagittaria sagittifolia	5	5	4	5	5	5	3	2	2		4	4	
Schoenoplectus lacustris	2		1						5	5	2		
Sparganium emersum	3	3					3				2	4	
Stuckenia pectinata		2									2		2
Utricularia vulgaris s.l.													1
Emergent													
Alisma plantago-aquatica	2		1			1			2	2	3	2	1
Baldellia ranunculoides										1	2		
Berula erecta			1						1				
Butomus umbellatus					2	1	1						
Carex acutiformis	2			3	2							4	
Carex rostrata										4		2	
Carex sp.							2						
Equisetum fluviatile	1		2	1	3					3	3	3	3
Glyceria maxima	3	3	5	4	3		4	4	3	3	4	3	5
Helosciadium nodiflorum							1						
Iris pseudacorus	3	1	3	2	3	2	2		3	1	2	2	3
Juncus inflexus	1			2									
Mentha aquatica		1			1		2	2			3		
Menyanthes trifoliata							2			2		2	
Nasturtium officinale									1		1		
Phalaris arundinacea	2	1	2	3	1	1		2	3		1		4
Phragmites australis	4	4		3	5	2	2		4	3	2	4	
Ranunculus lingua											2		
Sagittaria sagittifolia	3	3		5	4	4	2		1		2	2	
Schoenoplectus lacustris	3		2	2					4	4	4	4	
Sparganium emersum							1						
Sparganium erectum	2	3	2	1	4	3	2						
Typha latifolia				2									

The emergent flora along the water margins at BL15 was totally dominated by monospecific stands of *G. maxima*. Farther up the bank, isolated and occasionally dense stands of P. *arundinacea* were also present (Table 3.1).

3.3.4. Macrophyte Species and Assemblages on the Grand Canal

A total of 50 macrophyte species, including 29 aquatic and 24 emergent species, were recorded from the 18 WFD monitoring sites on the Grand Canal during 2023 (*S. lacustris, S. sagittifolia* and *S. emersum* were common to both categories). Grand Canal East (GCE) and Grand Canal West (GCW) supported 41 and 47 species, respectively (Tables 3.1 and 3.2).

Just two macrophyte species were present in any of the seven GCE monitoring sites but not recorded from any of the 11 GCW sites. These were *Callitriche platycarpa* (Various-leaved Water-starwort) and *Butomus umbellatus* (Flowering Rush). Seven species were present in WFD monitoring sites in GCW but were not recorded in any GCE sites. Four of these were *Potamogeton* species – *P. berchtoldii* (Small Pondweed), *P. obtusifolius* (Blunt-leaved Pondweed), *P. perfoliatus* (Perfoliate Pondweed) and *P. praelongus* (Long-stalked Pondweed), and the others were *Ranunculus lingua* (Greater Spearwort), *Equisetum variegatum* (Variegated Horsetail) and Juncus *articulatus* (jointed Rush). (*Equisetum variegatum* does not appear in Table 3.2 as it is not on the MFI species list.)

As in 2022, only *S. sagittifolia* was recorded at all 18 WFD sites in 2023, while *I. pseudacorus* and *E. nuttallii* were present at 17 of the monitoring sites on the Grand Canal (Tables 3.1, 3.2 and Figure 3.2). Four species were present at all seven GCE sites (*E. nuttallii, S. sagittifolia, I. pseudacorus* and *Sparganium erectum* (Branched Burreed)), while *S. sagittifolia, A. plantago-aquatica* and *Schoenoplectus lacustris* were recorded at the 11 sites on GCW (Tables 3.1, 3.2 and Figure 3.2).

In 2021 and 2022, the submerged and floating-leaved forms of *S. sagittifolia* and *S. lacustris* often combined at monitoring sites to dominate the aquatic flora of the Grand Canal, particularly in GCW. (These are among the most problematic of the macrophyte species for those managing the canal navigations because of the difficulty in effectively cutting their streamlined leaves.) In 2023, *S. lacustris* was present at fewer sites and with less vegetative abundance in GCW, although it continued to be the dominant grassy species at GCW1 (Bond Bridge) (Table 3.2). *Sagittaria sagittifolia*, in its submerged form, was clearly the dominant aquatic species in both sections of the Grand Canal in 2023, supporting a cover abundance score of 5 (>70%) at five of the seven sites in GCE and of $\geq$4 (31-70%) at seven of the 11 sites in GCW (Tables 3.1, 3.2 and Plate 3.5). Growing with this level of abundance, it is probable that this species blocks light from other, smaller submerged macrophyte species, as well as competing with them for the limited amount of space that is available in these overgrown channels.

In 2023, *E. nuttallii* was recorded from 17 of the monitoring sites on the Grand Canal. (Up to 2021, *Elodea nuttallii* had been categorised as an invasive species for WFD canal classification purposes but, as it now widespread throughout the canals and as no mitigation measures will bring about its removal or eradication, it had been removed from the invasive species list.) This species is continuing

to spread within this canal system, having been recorded at 13 sites in 2020, 15 in 2021 and 16 in 2022. This year the species was a dominant feature of the aquatic flora at four site – GCE4 (Sallins), GCE6 (Ponsonby Bridge), GCW18 (Ballycowan) and GCW20 (Cornalaur). One interesting observation this year was the relative decrease in cover abundance of *E. nuttallii* compared to that of *E. canadensis* at GCE14 (Baggot Street). In 2022 both species were recorded with an abundance of 3 at this site, while this year the abundance of *E. canadensis* had increased to 4 while that of *E. nuttallii* had decreased to 2 (Table 3.1).
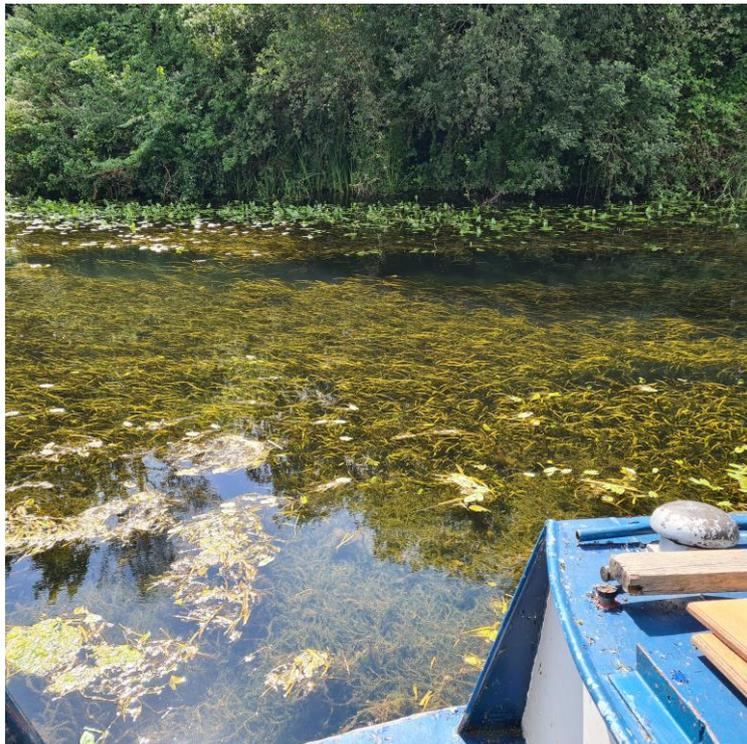
Plate 3.5: Very dense growth of Arrowhead (Sagittaria sagittifolia) in the Grand Canal west of Sallins Bridge (GCE4) in July 2023.

The invasive submerged macrophyte *Crassula helmsii* (New Zealand Pigmyweed) has not expanded its range in the Grand Canal since last year and continues to be recorded from six sites, two in GCE and four in GCW (Tables 3.1 and 3.2). Nor has there been any increase in overall vegetative abundance at these sites, although there was a slight decrease in abundance from 2 in 2022 to 1 in 2023 at GCE1 (Robertstown).

Potamogeton species (to include *Stuckenia pectinata*) continued to be poorly represented at WFD monitoring sites on GCE, with only *P. lucens, P. natans* and *Stuckenia pectinata* recorded in 2023, and all with relatively low abundance (Table 3.1). Seven *Potamogeton* species were recorded at GCW sites in 2023, with the broad-leaved *P. lucens* being the most abundant species at the seven sites from which it was recorded. The floating-leaved *P. natans* was present at eight sites, but with relatively low abundance at all (Table 3.2).
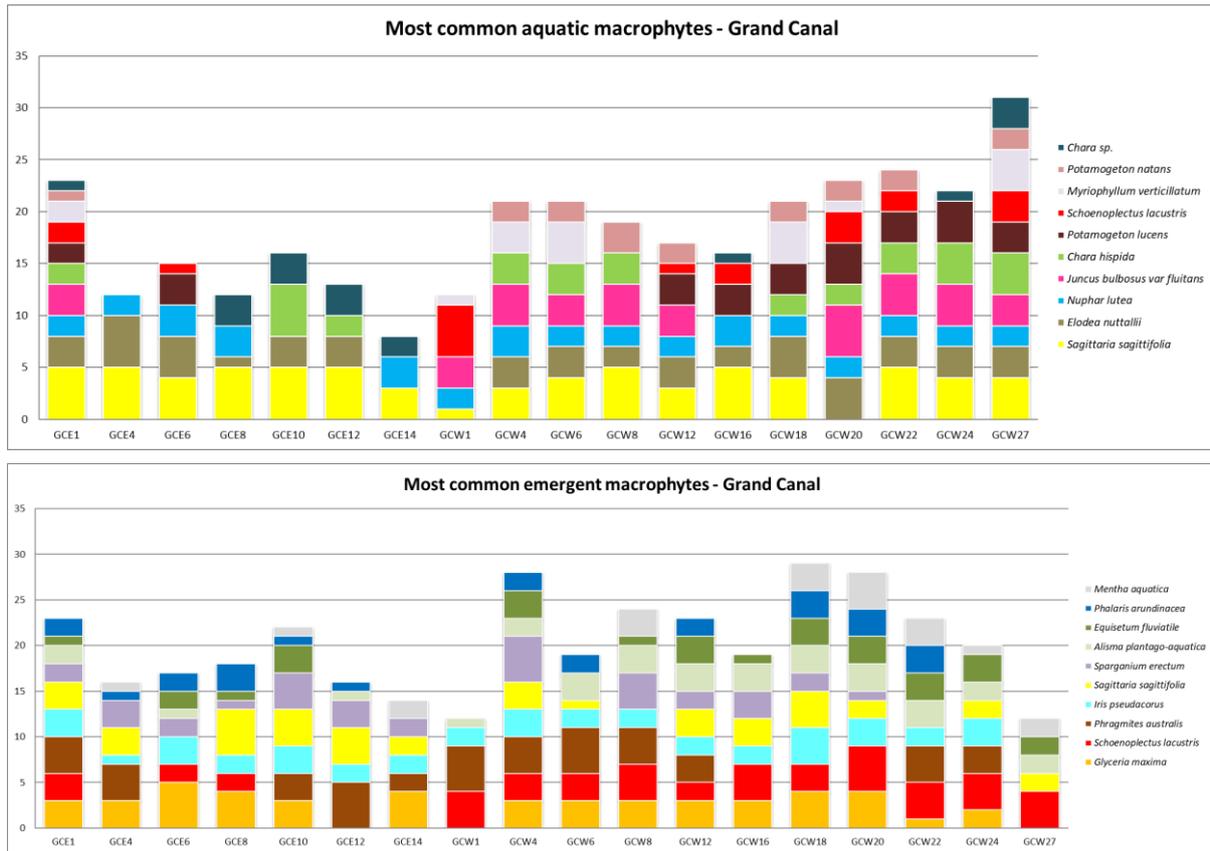
Figure 3.2   Relative representations, based on DAFOR abundance, of the ten most commonly recorded aquatic and emergent macrophytes at WFD sites in the Grand Canal in 2023. (The figures presented are those recorded on the date of sampling and do not take into account prior weed cutting operations at these sites.)

Three charophyte species were recorded at WFD sites in GCE and GCW. These were *Chara hispida, C. curta* and *C*. sp. (cf. *vulgaris*). All three were recorded together at just two sites – GCE12 (Blackhorse) and GCW27 (L'Estrange Bridge). *Chara hispida* (Bristly Stonewort) was the most common species, being recorded at 11 sites. It reached its best vegetative expression at GCE10 (Clondalkin) where dense clumps of the coarse stonewort were retrieved in each of the ten grapnel hauls. It also grew very vigorously and carpeted significant areas of canal bed at GCW24 (east of Armstrong Bridge) and GCW27 (L'Estrange Bridge) (Tables 3.1 and 3.2). *Chara* sp. (cf. *vulgaris*) was also well represented, particularly at sites to the east in GCE.

Myriophyllum verticillatum is a submerged macrophyte species that, in previous years, caused considerable problems for navigation in the Grand Canal. In recent years, however, its status as a problematic species in the canals has significantly diminished and, in 2023, the species was only recorded at one GCE site (GCE1), with low abundance, and at six GCW sites. At only three of the latter did this submerged species grew abundantly and represent a significant component of the aquatic flora (Table 3.2).

Table 3.2   Abundance values for aquatic and emergent macrophyte species in the Grand Canal West of the summit (GCW) in summer 2023. Abundance values - Dominant (>70%) = 5; Abundant (31 – 70%) = 4; Frequent (11 – 30%) = 3; Occasional (3 – 10%) = 2; Rare (<3%) = 1

Name	GCW1	GCW4	GCW6	GCW8	GCW12	GCW16	GCW18	GCW20	GCW22	GCW24	GCW27
Submerged											
Chara curta											2
Chara hispida		3	3	3			2	2	3	4	4
Chara sp.						1				1	3
Crassula helmsii	2	4	3	3							
Eleogiton fluitans		3	2								
Elodea canadensis										1	
Elodea nuttallii		3	3	2	3	2	4	4	3	3	3
Fontinalis antipyretica				4		2	2	4		1	
Hippuris vulgaris											2
Juncus bulbosus var *fluitans*	3	4	3	4	3			5	4	4	3
Lemna minor					1						
Lemna trisulca						1					
Myriophyllum spicatum			2				1				
Myriophyllum verticillatum	1	3	4				4	1			4
Nuphar lutea	2	3	2	2	2	3	2	2	2	2	2
Oenanthe fluviatilis	1										
Persicaria amphibia	1	1				1	2				1
Potamogeton berchtoldii				1	3		1				
Potamogeton lucens					3	3	3	4	3	4	3
Potamogeton natans		2	2	3	2		2	2	2		2
Potamogeton obtusifolius						1					
Potamogeton perfoliatus		2	1	1							
Potamogeton praelongus		1									
Ranunculus circinatus		2	2		2	2		1	3	2	
Sagittaria sagittifolia	1	3	4	5	3	5	4		5	4	4
Schoenoplectus lacustris	5				1	2		3	2		3
Sparganium emersum					2	3					
Stuckenia pectinata			1					2	2		
Emergent											
Alisma plantago-aquatica	1	2	3	3	3	3	3	3	3	2	2
Berula erecta		2			1	1					
Carex acutiformis		1				2					
Carex rostrata										1	3
Carex sp.		2	2						2	1	
Equisetum fluviatile		3		1	3	1	3	3	3	3	2
Glyceria maxima		3	3	3	3	3	4	4	1	2	
Helosciadium nodiflorum									1		
Iris pseudacorus	2	3	2	2	2	2	4	3	2	3	
Juncus articulatus									2		
Juncus inflexus				2	2	1					3
Mentha aquatica				3			3	4	3	1	2
Menyanthes trifoliata		2		2	1					2	1
Phalaris arundinacea		2	2		2		3	3	3		
Phragmites australis	5	4	5	4	3				4	3	
Ranunculus lingua									2	3	
Sagittaria sagittifolia		3	1		3	3	4	2		2	2
Schoenoplectus lacustris	4	3	3	4	2	4	3	5	4	4	4
Sparganium emersum						2					
Sparganium erectum		5		4	2	3	2	1			
Typha latifolia		2		3			3		2		

Dense carpets of filamentous green algae were recorded at only one site on the Grand Canal in 2023 and that was at GCE14 (Baggot Street) in Dublin city (Table 3.1). Here, the algae covered the canal bed and coated the other resident aquatic macrophytes. Moderate growths of filamentous algae were also recorded at GCE1 (Robertstown) and GCE4 (Sallins), both sections of canal that also support permanently moored cruisers. It is noteworthy that no plumes of algae were recovered on grapnel hauls, nor were they evident on the water surface, at GCE8 (Hazelhatch), an area of canal that also supports a large number of permanently moored craft.

Glyceria maxima and *Iris pseudacorus* were the most prominent emergent species to grow along the lower margins of the Grand Canal banksides in 2023, as in previous years. The former produced more or less continuous light green stands that were occasionally interrupted by tall, clumped stands of *Iris.* In the water along these margins, large and robust stands of *Sparganium erectum* (Branched Burreed) were a feature at 13 of the 18 monitoring sites (Tables 3.1 and 3.2). Significant stands were present at GCE10 (Clondalkin), GCW4 (Lock 20) and GCW8 (east of Rhode). Also growing in the water along these margins at 14 of the 18 sites was the very characteristic *S. sagittifolia*. The emergent leaves of this plant formed a continuous band along the margins and were particularly prominent at GCE8 (Hazelhatch), GCE10 (Clondalkin) and GCE12 (Blackhorse) (Table 3.1). At all 11 monitoring sites in GCW, isolated stands of *A. plantago-aquatica* were recorded, while these tall and elegant plants were only present at three of the GCE sites (Tables 3.1 and 3.2). Few fringing herbs, such as *Helosciadium nodiflorum, Berula erecta, Mentha aquatica* or *Nasturtium officinale*, were present along these margins at Grand Canal monitoring sites.

Farther up the banksides, growing in drier and firmer soil, the emergent flora was dominated by a combination of tall reed, rush and grass species. *Schoenoplectus lacustris* was recorded at all 11 monitoring sites in GCW but only in three of the seven GCE sites. This tall, spear-shaped rush also grew far more abundantly in GCW sites, where it was recorded with a cover abundance of $\geq$4 at seven of the 11 sites. At these sites, this tall plant commonly dominated the physiognomy of the banksides, although at some sites, equally tall and dense stands of *Phragmites australis* were also present. It is interesting that, at most sites where the two plants were recorded together, the latter grew more abundantly (Tables 3.1 and 3.2). These two species were rarely recorded growing in mixed assemblage.

3.3.5. Macrophyte Species and Assemblages on the Royal Canal

A total of 46 macrophyte species was recorded at the 17 WFD monitoring sites on the Royal Canal in 2023. These comprised 28 aquatic and 21 emergent species ((*S. lacustris, S. sagittifolia* and *S. emersum* were common to both categories). At sites on Royal Canal East (RCE), some 25 aquatic and 19 emergent species were recorded, while west of the summit on Royal Canal West (RCW), some 21 aquatic and 15 emergent species were present (Table 3.3).

Species that were recorded at monitoring sites in RCE but not at sites in RCW in 2022 were – *Berula erecta* (Lesser Water-parsnip)*,* an unidentified *Carex* species*, Ceratophyllum demersum* (Rigid Hornwort), *Chara curta*, an unidentified *Chara* species, *Hippuris vulgaris, Menyanthes trifoliata*

(Bogbean), *Tolypella intricata (*in Table 3.3 as *Nitella translucens* because *T. intricata* is not included in the scoring Macrophyte Fertility Index)*, Oenanthe fistulosa* (Tubular Water-dropwort), while those species recorded at RCW sites but not at RCE sites were – *Carex paniculata* (Greater Tussock-sedge), *Juncus bulbosus* var *fluitans* (Aquatic Bulbous-rush), *Juncus effusus* (Sofr-rush), *Stuckenia pectinata* and *P. perfoliatus* (Table 3.3). No macrophyte species was recorded from all 17 WFD monitoring sites on the Royal Canal in 2023, although *G. maxima, I. pseudacorus* and *A. plantago-aquatica* were present at 16, 15 and 15 of the sites (Table 3.3 and Figure 3.3).

Elodea nuttallii, previously categorised as an invasive species in Irish canals, was present at 14 of the 17 monitoring sites, where it had been recorded at all 17 in 2022. The species had been recorded with low abundance at RCE19 (Louisa Bridge), RCE22 (Castleknock) and RCW5 (Kildallan) in 2022 and it is possible that it could have been missed here during grapnel sampling in 2023. In RCE, the species was recorded with cover abundance of $\geq$4 at four of the ten sites, while in RCW it was far more abundant and was recorded an abundance score of $\geq$4 at six of the seven sites and a score of 5 (>70%) at three of these sites (Plate 3.6). It is interesting that, even growing with such vegetative abundance at these sites, *E. nuttallii* was not always the dominant aquatic species and vied for dominance with the low-growing *Fontinalis antipyretica* (Willow Moss) at seven sites (Table 3.3). *Fontinalis* is not well represented in the Grand or Barrow Canal systems, although it does grow abundantly at a few sites (e.g., GCW8 – east of Rhode and GCW20 – Cornalaur) (Table 3.2). *Elodea canadensis* was recorded growing alongside *E. nuttallii* at nine RCE sites but was only recorded, with low abundance, at two RCW sites (Table 3.3).

Plate 3.6: Healthy and dense growths of Elodea nuttallii (Nuttall's Waterweed) dominated the aquatic flora in the Royal Canal at Belmont (RCW3) in August 2023.

Myriophyllum verticillatum is a species that previously was regarded as highly problematic in the Royal Canal, posing problems for navigation, angling and even free movement of water. In 2021, the species was present at all 17 monitoring sites, with an abundance level of $\geq$ 4 at four sites. In 2022, it was recorded from 11 sites (six on RCE and five on RCW), with an abundance level of $\geq$ 4

at three sites. In 2023, *M. verticillatum* was present at only nine sites and with an abundance of ≥ 4 at only three sites. The closely related and less problematic *M. spicatum* was poorly represented in the Royal Canal at all but one site – RCW5 (Kildallan) Table 3.3).

In 2021 and 2022, the trailing and grassy-leaved plant *Sparganium emersum* (Unbranched Bur-reed) grew abundantly at monitoring sites in the Royal Canal, particularly at sites in RCE. Here, it posed problems for navigation and for canal maintenance crews, as it can be difficult to effectively cut. In 2023, however, the species was recorded from just six sites, again mostly in RCE, and at only four of these with an abundance of ≥ 4 (Table 3.3 and Plates 3.7 and 3.8). During sampling, it was observed that the aquatic weed in a number of Royal Canal sections had been deeply cut and this may account for the poorer representation of this species at monitoring sites. It is noteworthy that, in the Grand Canal system, the grassy-leaved species that pose most problems for navigation is *S. sagittifolia* and that *S. emersum* is present at relatively few sites (Tables 3.1 and 3.2).

Plate 3.7: Sparganium emersum (Unbranched Burreed) occupied practically the full channel width at Hill of Down (RCE8) in early August 2023.

Five *Potamogeton* species (to include *Stuckenia*) were recorded from WFD sites on the Royal Canal in 2023, one less than was recorded in 2021 and 2022. The missing species in 2023 was *P. crispus* (Curled Pondweed), a species that had only been encountered at one location in RCE25 (Croke Park). During sampling this year, works were ongoing along the towpath at this site and the water level had been lowered significantly. This restricted access to the full length of the monitoring site during sampling and probably resulted in this species being missed. *Potamogeton praelongus* (Long-stalked Pondweed) was present at five of the monitoring sites, with four on RCW. This is a species that was recorded at just one site on the Grand Canal system (GCW4 – Lock 20) and at one site on the Barrow Line (BL6 – Umeras).
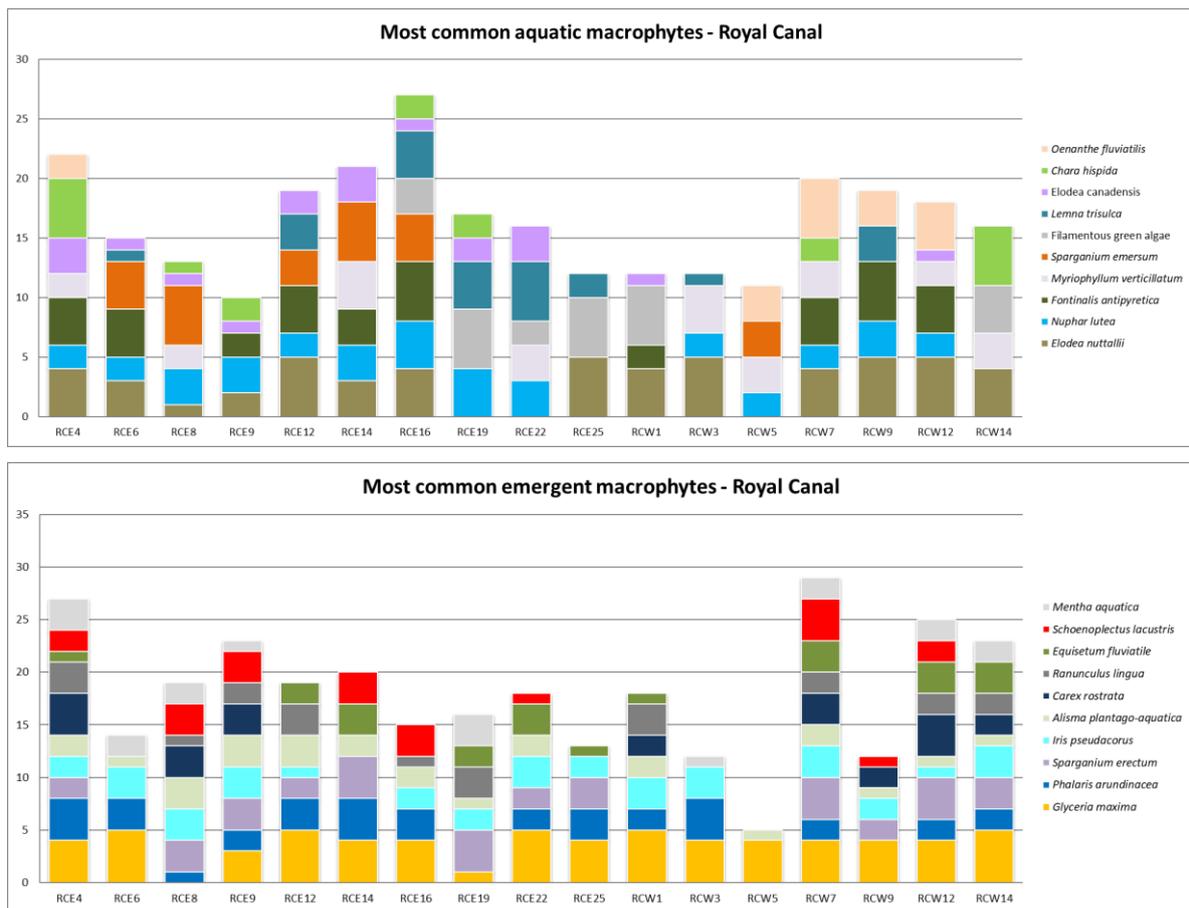
Figure 3.3   Relative representations, based on DAFOR abundance, of the ten most commonly recorded aquatic and emergent macrophytes at WFD sites in the Royal Canal in 2023. (The figures presented are those recorded on the date of sampling and do not take into account prior weed cutting operations at these sites.)

Four charophyte species were recorded at monitoring sites on the Royal Canal, with most recorded at sites in RCE (Table 3.3). While most sites supported one or two species, two sites supported three species. Dense low-growing charophyte stands dominated the aquatic flora at three sites – RCE4 (McNead's Bridge) and RCW14 (Ballydrum Bridge), where *C. hispida* was the main species, and RCE9 (Moyvalley), where *C.* sp. (cf. *vulgaris)* produced extensive stands of coarse vegetation on the canal bed. Small samples of the rare charophyte *Tolypella intricata*, recorded in 2021 and 2022, were retrieved in grapnel hauls at RCE22 (Castleknock) in 2023. (This species is scored as *Nitella translucens* in Table 3.3.)

Dense stands of filamentous green algae were recorded at only a small number of monitoring sites on the Royal Canal in 2023, as was the case in 2021 and 2022. The most abundant growths were recorded at RCE19 (Louisa Bridge), RCE25 (Croke Park) and RCW1 (Mullingar), where algae carpeted the canal bed and aquatic vegetation but also presented extensive surface scums. At RCE25, the water level had been artificially lowered over the past few months to facilitate Greenway works along the towpath and this provided ideal conditions for the algae to proliferate. At RCE19, large beds of

algal scum have been observed here throughout the summer and autumn months, although the reason for this excessive algal growth is unknown as water quality conditions have been satisfactory through 2023 (see Section 2.3.1). Likewise, water quality at RCW1 has been good in recent months and the reason for the proliferation of the filamentous algae is unclear.

Table 3.3   Abundance values for aquatic and emergent macrophyte species for the Royal Canal (east and west of the summit) in summer 2023. Abundance values - Dominant (>70%) = 5; Abundant (31 – 70%) = 4; Frequent (11 – 30%) = 3; Occasional (3 – 10%) = 2; Rare (<3%) = 1.

Name	RCE4	RCE6	RCE8	RCE9	RCE12	RCE14	RCE16	RCE19	RCE22	RCE25	RCW1	RCW3	RCW5	RCW7	RCW9	RCW12	RCW14
Submerged																	
Ceratophyllum demersum										1							
Chara curta				3													
Chara globularis	3	2															3
Chara hispida	5		1	2			2	2						2			5
Chara sp.	2	2	2	5													
Elodea canadensis	3	1	1	1	2	3	1	2	3		1					1	
Elodea nuttallii	4	3	1	2	5	3	4			5	4	5		4	5	5	4
Filamentous green algae							3	5	2	5	5						4
Fontinalis antipyretica	4	4		2	4	3	5				2			4	5	4	
Juncus bulbosus var *fluitans*													3	3		4	
Hippuris vulgaris		2				3		3	3								
Lemna trisulca		1			3		4	4	5	2		1			3		
Myriophyllum spicatum	1										1	4	2				1
Myriophyllum verticillatum	2		2			4			3			4	3	3		2	3
Nitella translucens									2								
Nuphar lutea	2	2	3	3	2	3	4	4	3			2	2	2	3	2	
Oenanthe fluviatilis	2												3	5	3	4	
Persicaria amphibia	1		1	1			1			2	2	1					2
Potamogeton lucens			3	4													4
Potamogeton natans	2	1	2		1			4							1	3	1
Stuckenia pectinata														2			
Potamogeton perfoliatus															2		
Potamogeton praelongus		2									2	1	3	2			
Ranunculus circinatus		1	1		3		2						1	3	1		
Sagittaria sagittifolia	5		1				1				1		2				
Schoenoplectus lacustris				3													
Sparganium emersum		4	5		3	5	4						3				
Emergent																	
Alisma plantago-aquatica	2	1	3	3	3	2	2	1	2		2		1	2	1	1	1
Berula erecta		2		1													
Carex acutiformis					3	1	2						4		4		1
Carex paniculata																1	
Carex rostrata	4		3	3							2			3	2	4	2
Carex sp.	1		1														
Equisetum fluviatile	1				2	3		2	3	1	1			3		3	3
Glyceria maxima	4	5		3	5	4	4	1	5	4	5	4	4	4	4	4	5
Iris pseudacorus	2	3	3	3	1		2	2	3	2	3	3		3	2	1	3
Juncus effusus																1	3
Juncus inflexus	2	1	3	2												3	3
Mentha aquatica	3	2	2	1				3					1	2		2	2
Menyanthes trifoliata				1													
Oenanthe fistulosa	1																
Phalaris arundinacea	4	3	1	2	3	4	3		2	3	2	4		2		2	2
Ranunculus lingua	3		1	2	3		1	3			3			2		2	2
Sagittaria sagittifolia	4		1			2											
Schoenoplectus lacustris	2		3	3		3	3		1					4	1	2	
Sparganium emersum								2									
Sparganium erectum	2		3	3	2	4		4	2	3				4	2	4	3
Typha latifolia	3		3	1								3				3	1

Continuous and often uninterrupted stands of the light green *Glyceria maxima* characterise the margins of the Royal and Grand Canals. This species was recorded at almost every monitoring site along the canals and its lush and abundant vegetation, at the water's edge, provides shelter for an abundance of wildlife and protection for the banksides from the erosive effects caused by cruisers. Other species that occupy a similar habitat and that are also widespread along the canals include *I. pseudacorus* and *A. plantago-aquatica* (Tables 3.1, 3.2 and 3.3). *Ranunculus lingua* (Greater Spearwort) is another species that prefers this marginal habitat and adds considerable character and colour to these margins during the summer months. This species is significantly more common in the Royal Canal than in the Grand or Barrow Canals and was present at ten of the 18 WFD monitoring sites in 2023. Another species that thrives along the water's edge in the Royal and Grand Canals is *Sparganium erectum*, recorded at 12 of the 18 sites on the former canal system in 2023 (Table 3.3).

Plate 3.8: Stands of Sparganium emersum (Unbranched Burreed) rise to water surface level in the Royal Canal, east of Kilcock (RCE16) in August 2023.

Farther up the banksides, the most prominent reed species present at monitoring sites on the Royal Canal was *Phalaris arundinacea* (Reed Canary-grass) (Table 3.3). While this species was also a regular feature on the Grand and Barrow Canals, the physiognomy of these canal systems was dominated by tall, continuous and often alternating stands of *P. australis* and *S. lacustris.* It is noteworthy that no stands of the former species were recorded at monitoring sites on the Royal Canal in 2023.

3.4. Ecological Potential of WFD Monitoring Sites and AWBs

Thirty-nine of the 41 WFD monitoring sites on the Royal, Grand and Barrow Canals, including the Naas Line and Milltown Feeder, were assigned Maximum ecological potential based on results from

macrophyte sampling in summer 2023 (Table 3.4). This compared with 40 and 41 sites in 2021 and 2022, respectively. The sites that were assigned Good rather than Maximum eco-potential were RCE25 (Croke Park) and RCW3 (Belmont Bridge).

The water level at the Croke Park monitoring site had been artificially lowered since early summer to facilitate Greenway construction in this area and, when sampled for macrophyte status, a depth of only *c.* 0.5m of water was present. The water was concentrated in the central channel and the canal margins were fully exposed (Plate 3.10). In the water, dense and tangled stands of filamentous green algae carpeted not only the canal bed but also the dense cushions of *E. nuttallii* that occupied this disturbed section of canal. The reduced floral diversity in this artificially disturbed channel and on the dewatered banksides, in addition to the high abundance of filamentous algae and *E. nuttallii* (see Table 3.3), resulted in this site being at Good rather than Maximum eco-potential. At RCW3, the submerged *E. nuttallii* grew much more abundantly than in 2021 or 2022 and impacted diversity among the resident aquatic plant species. This is reflected in the fact that some species that were present in 2022 were either not recorded or recorded with significantly reduced vegetative abundance in 2023 (e.g., *Potamogeton natans, P. pectinatus, P. praelongus, S. emersum*). This probably explains the site being assigned Good rather than Maximum eco-potential.

Plate 3.9: Emergent and floating-leaved stands of Sparganium emersum (Unbranched Burreed) below Louisa Bridge (RCE19) in July 2023.

Table 3.4 **Ecological potential and Ecological Quality Ratio (EQR) value awarded to each of the 41 WFD monitoring sites on the Grand and Royal Canals in 2023, based on the macrophyte quality element.** (EQR scores: 1-0.8 = Maximum, 0.79-0.6 = Good, 0.59-0.4 = Moderate, 0.39-0.2 = Poor, 0.19–0 = Bad)

Canal	Site Code	Year	EQR	Macrophyte Eco-potential
Grand Canal	GCE4	2023	0.90	Max
	GCE6	2023	0.99	Max
	GCE8	2023	0.88	Max
	GCE10	2023	0.86	Max
	GCE12	2023	0.88	Max
	GCE14	2023	0.94	Max
	NL1	2023	0.86	Max
	MF1	2023	0.99	Max
	BL2	2023	0.92	Max
	BL6	2023	0.96	Max
	BL10	2023	0.92	Max
	BL15	2023	0.86	Max
	GCE1	2023	0.99	Max
	GCW1	2023	0.85	Max
	GCW8	2023	1.00	Max
	GCW12	2023	0.95	Max
	GCW4	2023	1.00	Max
	GCW6	2023	0.98	Max
	GCW16	2023	0.95	Max
	GCW18	2023	1.00	Max
	GCW20	2023	0.99	Max
	GCW22	2023	1.00	Max
	GCW24	2023	0.99	Max
	GCW27	2023	0.99	Max
Royal Canal	RCE4	2023	0.98	Max
	RCE6	2023	0.97	Max
	RCE8	2023	0.96	Max
	RCE9	2023	0.94	Max
	RCE12	2023	0.95	Max
	RCE14	2023	0.92	Max
	RCE16	2023	0.98	Max
	RCE19	2023	0.91	Max
	RCE22	2023	0.91	Max
	RCE25	2023	0.71	Good
	RCW1	2023	0.87	Max
	RCW3	2023	0.72	Good
	RCW5	2023	0.84	Max
	RCW7	2023	0.99	Max
	RCW9	2023	0.99	Max
	RCW12	2023	0.96	Max
	RCW14	2023	0.97	Max

When the EQRs for the macrophytes at monitoring sites sampled in each of the AWBs in 2023 were combined, 13 of the 14 AWBs were assigned Maximum ecological potential (Table 3.5). The only AWB whose EQR fell below 0.8, at 0.78, was RC_25A, which contains just two sites (RCW1 and

RCW3), the latter which was assigned Moderate rather than Good eco-potential based on its restricted macrophyte composition.

Table 3.5   Ecological potential of the 14 WFD Artificial Water Bodies (AWB) on the Grand and Royal Canals in 2023, based on the macrophyte quality element.

Canal	AWB	EQR	Macrophyte Eco-potential
Grand Canal	GCE_09	0.90	Max
	GCNL_09	0.86	Max
	GCMF_14	0.99	Max
	GCBL_14	0.91	Max
	GC_14E	0.92	Max
	GC_14W	0.98	Max
	GC_07	0.99	Max
	GC_25A	0.99	Max
Royal Canal	RC_07	0.96	Max
	RC_09	0.88	Max
	RC_25A	0.78	Good
	RC_26F	0.94	Max
	RC_26E	0.96	Max
	RC_26C	0.97	Max
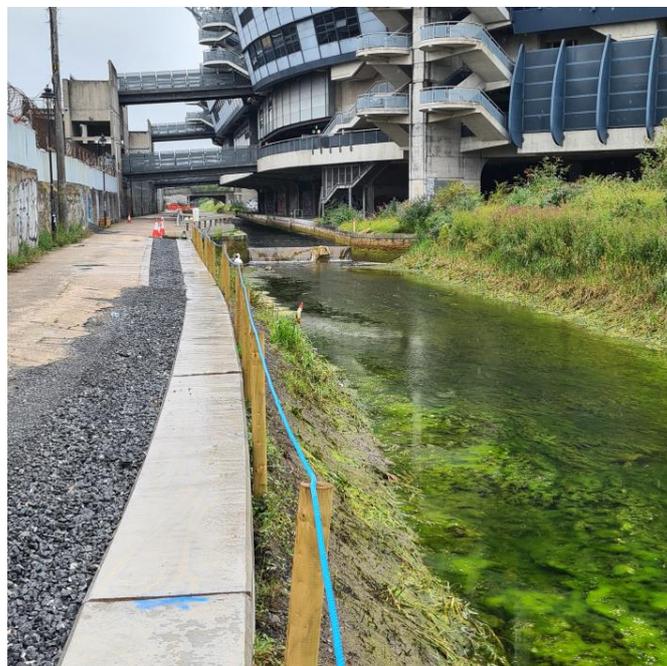
Plate 3.10: Dense carpets of filamentous green algae present in Royal Canal at Croke Park (RCE25) where water level was lowered during summer 2023 to facilitate Greenway construction.

4. Aquatic Macroinvertebrate Monitoring

4.1. Introduction

Aquatic macroinvertebrate sampling at the remaining 13 WFD monitoring sites on the Royal and Grand Canals was carried out between 27th April and 3rd May 2023 for the purposes of assessing the ecological potential of these canal sites in respect of the macroinvertebrate quality element. This is the third and final sampling event in the current three-year cycle (2021 – 2023).

4.2. Materials and Methods

Sampling involves a 3-minute semi-continuous handnet sweep of the canal margin along a 10m stretch of channel. Macroinvertebrates are collected from emergent and aquatic plants, as well as from exposed sediments along the 10m stretch. Samples are stored in labelled plastic bags and preserved in 70% ethanol. Processing of macroinvertebrate samples involves washing each sample through a 0.5mm sieve and sorting by hand. Identification is carried out to family level using keys presented in Section 7.

A system for classifying British and Irish Canals (Willby, 2012) is used to assess the ecological potential of WFD sites based on their macroinvertebrate composition. Macroinvertebrates are recorded according to log_{10} abundance categories (0 = absent; 1–9 = 1; 10-99 = 2; 100-999 = 3). A number of macroinvertebrate metrics are calculated:

- Number of families (N_FAM)

- Average Score Per Taxon (ASPT) (based on BMWP scores for 81 families)

- Number of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) families (N_EPT)

- Number of Mollusc (snail, mussel and limpet) and Odonata (damselfly and dragonfly) families (N_MOLL+ODON)

- Number of Coleoptera (beetle) and Hemiptera (water bug) families (N_COL+BUGS).

The metrics ASPT and EPT are sensitive to water quality pressures, while N_FAM, N_MOLL+ODON and N_COL+BUGS reflect hydromorphological pressures, i.e., the quality and diversity of physical habitats in the canal. The classification involves calculating (for each site) an Ecological Quality Index (EQI) for each metric based on the ratio of 'observed value : expected value'. The expected value is based on reference conditions using alkalinity, boat traffic, channel type, particle size and altitude data for each site. For the purpose of standardisation, each EQI value is then converted to an Ecological Quality Ratio (EQR), ranging from 0 – 1, with class boundaries at intervals of 0.2: 0.8 – 1 = Maximum; 0.6 – 0.79 = Good; 0.4 – 0.59 = Moderate; 0.2 – 0.39 = Poor; 0 – 0.19 = Bad.

The overall EQR for a site is determined by the lowest of the water quality component (i.e., EQR_{ASPT} and EQR_{N_EPT}) and the hydromorphological component (i.e., EQR_{N_FAM}, $EQR_{N\_COL+BUG}$ and $EQR_{N\_MOLL+ODON}$). To get the overall EQR for an artificial water body (AWB), EQR values are averaged

across all sites in each AWB. Any site or AWB containing the invasive *Dreissena polymorpha* (Zebra mussel), or any other designated invasive macroinvertebrate species, cannot achieve Maximum Ecological Potential (MEP) and must be assigned, at best, Good Ecological Potential (GEP).

4.3. Results

4.3.1. *Macroinvertebrate Assemblages at WFD Monitoring Sites*

The 13 WFD sites sampled in 2023 included six on the Grand Canal (MF1, BL2, GCW27, GCW24, GCW22, GCW20) and seven on the Royal Canal (RCW14, RCW12, RCW9, RCW7, RCW5, RCE6, RCE4). All of these sites had previously been sampled in 2017 and again in 2020.

A total of 34 aquatic macroinvertebrate families were recorded from the 13 monitoring sites in 2023 (Table 4.1). The numbers of taxa ranged from 21 at GCW20 (Cornalaur) to 15 at MF1 (Milltown Feeder), with an average of 18 taxa across the sites. The molluscs followed by bugs and beetles had the highest numbers of families, followed by crustaceans, mayflies, caddisflies, trueflies, damsel/dragonflies and others. In terms of numbers of individuals, Asellidae (crustaceans), Crangonyctidae (crustaceans) and Bithynidae (snails) were generally the most abundant (Table 4.1). (While Amphipod nomenclature is very complex, it is considered that Gammaridae in Table 4.1 should be Crangonyctidae.)

Plate 4.1: Larvae from some of the variety of Caddisfly species recorded at sites on the canals during spring 2023.

A total of 44 aquatic macroinvertebrate families were recorded from the Royal and Grand Canals during the current 3-year reporting cycle (2021-2023). Thirty-eight families were recorded from the Grand Canal, including the Naas Line, Barrow Line and the Milltown Feeder, while 41 families were recorded from the Royal Canal. The average number of taxa across all canal sites was 17, with the highest number (25) recorded from RCW3 (Belmont) and the lowest number (9) from NL1 (Naas

Line). The most widely distributed taxa across sites were the snails, mussels and crustaceans, followed by bugs, caddisflies, damsel/dragonflies and true flies. The two non-native species recorded at canal monitoring sites were both amphipod crustaceans, the North American *Crangonyx pseudogracilis* (widespread and abundant) and the Ponto-Caspian *Corophium curvispinum,* which is localized and rare. The former is unlikely to influence macroinvertebrate communities and is deemed to be fairly benign, while the latter is too rare to have much ecological influence at the moment. However, increases in non-native species should be monitored for adverse effects, such as competition or habitat modification.

The macroinvertebrate community was most diverse at RCW12 and GCW12, similar to the previous sampling cycle (Figure 4.1 and see 2020 report). There were low diversity values at sites GCE1, GCE4, GCE6, GCE8, GCE10, GCE12, GCE14, RCE25 and particularly NL1 as compared to most other sites (Figure 4.1), with these overall trends matching those that emerged from the 2018-2020 cycle. Indeed, the Grand Canal sites were more variable and had lower diversity values, as compared to the more consistent and higher scores for the Royal Canal, but with a noticeable dip in diversity at RCE25 (Croke Park) (Figure 4.1). Sites with the lowest diversity occurred mainly in urban areas and tended to have proportionally higher numbers of the more pollution tolerant taxa, particularly crustaceans and snails. Overall, however, the diversity of macroinvertebrates at surveillance monitoring sites, plus the families occurring there, are indicative of generally good water quality and diverse habitat across sites, although sites with long-term trends of low diversity, plus short-term declines, should warrant research effort to ascribe causes to these patterns.
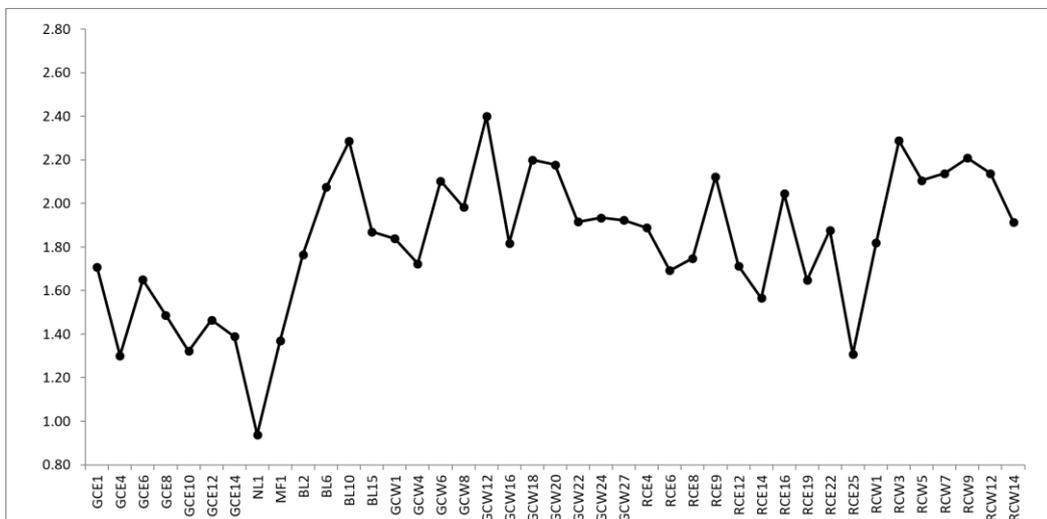
Table 4.1   Shannon-Weiner diversity values for macroinvertebrate families for the 41 monitoring sites on the Grand and Royal Canals during the current monitoring cycle (2021-2023).

The macroinvertebrate species present in the monitoring sites on the Royal and Grand Canals are consistent with those present in high quality rivers and lakes, although different water types (lakes *versus* rivers *versus* canals) will differ in species composition due to their habitat requirements. For example, many crustaceans are missing in the more erosive higher order streams of river systems due to lack of calcium for exoskeleton development. Further, highest species richness often comes

from "intermediate disturbance" regimes (e.g., where there is some artificial enrichment of water, movement of water due to boat traffic, cutting of reeds/weeds, and other disturbance). This is because low disturbance can lead to a proliferation of competitively dominant species, reducing species richness, while high disturbance can lead to local species extinction as the environment is too stressful. Hence, intermediate levels of disturbance, as is experienced in the canal systems currently being monitored, can actually maintain high species richness. As the canals will clearly vary in disturbance regimes, some research on the influence of this would help interpret species richness patterns that may often be independent of water quality.

Table 4.1   Abundance of aquatic macroinvertebrate families recorded from the 41 Royal and Grand Canal sites monitored in 2021, 2022 and 2023.

Family	Common name	GCE1	GCE4	GCE6	GCE8	GCE10	GCE12	GCE14	NL1	MF1	BL2	BL6	BL10	BL15	GCW1	GCW4	GCW6	GCW8	GCW12	GCW16	GCW18	GCW20	GCW22	GCW24	GCW27	RCE4	RCE6	RCE8	RCE9	RCE12	RCE14	RCE16	RCE19	RCE22	RCE25	RCW1	RCW3	RCW5	RCW7	RCW9	RCW12	RCW14
Neritidae	Snails							9																																		
Valvatidae	Snails																			5		6							2											2		
Lymnaeidae	Snails	1	10	9	27	2		7	2	2	3	18	6	7		1	4	7	10	3		2	7	3	5	5	6	4	1	13	6	2	10	1	1	2	2	13	1	7	11	1
Physidae	Snails	16	5					29	1		17	5	7			9	16	18			1							1		5			19	3	12	22	41	24	15	6		1
Planorbidae	Snails	10	10	30	1	9	3	39	44	9	10	9	11	13	1		9	4	1	18	1		15	11	78	20	4	17	4	4	14	4	20	7	21	43	48	7	1		6	20	40
Bithyniidae	Snails	130	24	19	250	506	178	566	12	169	4	20	33	105	26	8		25	18	192	27	95			13	9	83	87	6	33	157	63	97	230	77	615	81	83	6	4	23	96	149
Ancylidae	Limpets				4	12									1											2	6	2												1		
Unionidae	Mussels																																			1						
Sphaeriidae	Mussels	16	6	1	24	12	20	80		11		43	20	41	2		13	3	14	93	24	62	8	21	3		10	33	6	18	5	26	8	28	15	30		3	5	3	25	13
Oligochaeta	Worms																				1																					
Glossiphoniidae	Leeches	1		1	1	1		2																				2	1									1				
Asellidae	Crustaceans	196	64	197	93	357	107	241	374	551	43	116	20	300	53	24	24	35	50	89	90	25	6	18	6	118	258	168	51	373	339	198	213	141	159	107	86	24	30	63	58	15
Corophiidae	Crustaceans																																							3	1	
Gammaridae *	Crustaceans	54	372	153	165	55	9	93	635	223	59	158	56	98	26	51	62	73	42	61	40	28	11	3	7	27	51	30	72	190		55	44	70	24	183	51	8	12	22	24	15
Siphlonuridae	Mayflies																																							9		
Baetidae	Mayflies					2	1				138				101	40	9						1	1			1			21	3						11	9	72	24	6		2
Leptophlebiidae	Mayflies																																					9	1			
Ephemerellidae	Mayflies																					1																				
Caenidae	Mayflies										2	2								8			4	3	1					2		2		277	3				5		1	1
Coenagriidae	Damselflies	8			8	6					9	202	21	5	44	23	71	29	46	7	4	8			50	107	81	19	2	31	22	7	12	80	8	2	13	1	61	58	50	26	34	14
Aeshnidae	Dragonflies								1	1		3			1	1	1			1	2		2		1		1				1	3			1		1	4	2			
Gerridae	Bugs																			1	1						1								1						
Nepidae	Bugs																						1																1		
Notonectidae	Bugs	2	4	9	3	3	1		6	2			1	4	2	1	2		1	1	7	4	1	1		2		1	4	1	3	6	1	14		1	3	1	1			1
Pleidae	Bugs	8	44	124	1		1	3	2																		3		2	12						1	4	11	2	9		
Corixidae	Bugs			12	1	1	17	14			4	1	9	9		12	3	4	2	3	2		10	1	4		5	3	1	1	18	1	1	2	1	2	4	13				
Haliplidae	Beetles	1					2								3	2		8	6	7	10	2	3	3	1		1		5		2			2			3	5	2			
Hygrobiidae	Beetles																	1																			1	1			
Dytiscidae	Beetles	1		2		2	2				2	6			1		2			2	5	4				1				2						9	1			4	3	14
Gyrinidae	Beetles												1	2		2				1	1							1								1						
Hydrophilidae	Beetles												3						2																							
Dryopidae	Beetles																																							1		
Noteridae	Beetles												1	4		5						5								2				1	4	1						
Sialidae	Alderflies	1				2				4						4					2	2	1			5		4	2	3												
Polycentropidae	Caddisflies						1							1										1		7	2	1		1	5				1				2	1		
Limnephilidae	Caddisflies	17	1	3	2	8	5	1		46	46	101	14	83	19	17	40	20	33			47	24		13	34	46	43	99	29	70	77	155	11	48	10	9	32	34	24	27	45
Leptoceridae	Caddisflies	4		2		6	2	1	1		4	2	3	3			1	2	2	2	11	2	3	5	3	3		1	1		3	10	1	9		1			2			
Tipulidae	Trueflies																						1																1			
Chironomidae	Trueflies	1	6	5	1		3	3		3	1	15	2	9	1	1	1	2	5	3	17			3	2		1	1	2	9	22	3	3	6	2	5	9	2	4	6	2	8
Limoniidae	Trueflies																					2							1	1		1					1				
Ceratopogonidae	Trueflies												1								1									1									2		
Cybaeidae	Spiders			1		2			1	1			2				1	2		1			1						1	1		1	1	1	1	1	1	2		3	2	
Pyralidae	Moths																							1						1	1										
Hydracarina	Mites	2	4		2	1					13			1	1	1	1	2		5	20	6	1	2	2		2			5	1	4				3	3	9	2		10	13

Further, the range of feeding strategies represented by the macroinvertebrate species present in these canals is also encouraging, with most functional feeding groups present - grazers, filterers, collector/gatherers and predators. In addition, the low occurrence of invasive alien species is good as this can skew species richness for a number of reasons, including predation (e.g., by Killer shrimp, *Dikerogammarus villosus*). A widespread, non-native species that was present in the sites monitored was *Crangonyx pseudogracilis* (Northern River Crangonyctid) which, while not entirely benign, does not negatively affect any of the native species to the point of extinction (as can happen with other invaders, such as *Dikerogammarus villosus*). Hence, there are likely no detectable effects on other macroinvertebrates caused by *C. pseudogracilis* and no distortion of macroinvertebrate indices due to non-native species. In 2023, small numbers of the non-native *Corophium curvispinum* (Caspian

mud shrimp) were recorded at sites RCW7 and RCW9, where they were also found in previous monitoring cycles (see 2020 Report).

No Zebra mussels were collected in the current sampling cycle, a fact that likely reflects the sampling method being unlikely to capture such species. However, with the advent of the Quagga mussel (*Dreissena bugensis*) and Asian clam (*Corbicula fluminea*), alongside Zebra mussel, in Ireland, it is recommended that bespoke sampling (such as dredge sampling) is utilized to detect and track such invaders. Finally, no vulnerable or red list species were noted during the current sampling cycle.

4.3.2. *Ecological Potential of WFD Monitoring Sites and AWBs*

Of the 13 WFD monitoring sites examined in 2023, nine were at Maximum eco-potential, based on results from macroinvertebrate sampling. Four sites were at Good and one was at Moderate eco-potential (Table 4.2).

At the individual site level, nine of the 13 sites monitored in 2023 retained the Maximum eco-potential they had been assigned in 2020. However, two sites (RCE6 - Thomastown and RCW7-Kelly's Bridge) changed from Maximum to Good, one site (MF1 – Milltown Feeder) changed from Maximum to Moderate, and one site (GCW22 - west of Pollagh) changed from Good to Maximum. Comparing results from 2017 with those from 2023, seven sites retained Maximum eco-potential ratings and one site retained its Good rating, while 3 sites changed from a lower to a higher eco-potential rating, and only 2 sites moved from higher to lower ratings.

Just two of the WFD monitoring sites examined in 2022 were at Maximum eco-potential, based on results from macroinvertebrate sampling. Eight sites were at Good, while two sites each were assigned Moderate and Poor eco-potential (Table 4.2). The Ecological Quality Ratio (EQR) scores for the sites monitored in 2022 showed that, of the 12 Grand Canal sites scored, 10 had declined in value, one was the same score and 1 score was up, compared with those recorded for these sites in 2019. In particular, GCE4 (Sallins) and NL1 (Naas Line) had both moved from Good to Poor. Of the two Royal Canal sites, one changed from Maximum to Good and the other was at Maximum in both years.

Of the two sites at Poor in 2022 (GCE4 and NL1), the latter reported the lowest number of taxa of any site sampled that year, at just nine (Table 4.1). This reduced biodiversity among macroinvertebrates could possibly reflect the impact of high Total Oxidised Nitrogen (TON) and Nitrate levels in this section of canal over the past few seasons. In addition, during water and macrophyte sampling here in 2022, the canal bed was densely carpeted beneath tangled stands of filamentous green algae. This made macroinvertebrate sampling difficult, and the tangled mats of algae probably obscured some macroinvertebrate organisms during sampling. It had also been noted that the water in this section of canal had displayed an opaqueness on recent sampling occasions, a factor that might also render the habitat less suitable to a wider diversity of macroinvertebrate species. The site at GCE4 has become very popular with cruisers and, currently, a large number are permanently moored along the towpath. In fact, the full length of the WFD monitoring site is currently occupied by moored cruisers and it was deemed necessary to move the traditional monitoring site a further 600m westward and away from any moored craft. While the water quality

in this section of canal has been moderately good in the recent past, it is possible that deleterious matter from these craft may be entering the canal and adversely impacting the macroinvertebrate community here, resulting in a lower eco-potential ranking than would be expected for this site. Additionally, because of the number of cruisers and their proximity to one another along this monitoring site, it was necessary to take handnet sweep samples from two relatively confined spaces, between moored boats, in order to achieve the 10m-long section that is required to collect macroinvertebrate samples for WFD assessment purposes. It is probable that the presence (and movement) of the cruisers along this section of canal has adversely impacted local living conditions (e.g., by increased shading, turbidity and physical disturbance of the marginal flora and substrate) for the resident macroinvertebrates fauna and that this was reflected in the Poor eco-potential rating achieved.

The difference in numbers of scoring macroinvertebrate taxa between the two sampling years (i.e., 2019 and 2022) that drove the change in eco-potential from Good to Poor at GCE4 involved six taxa (Valvatidae, Acroloxidae, Corophiidae, Baetidae, Coenagridae and Hydrobiidae) (Table 4.1). The first four of these taxa were present in very low numbers in 2019 (1,2,1 and 1 individuals, respectively) and were absent in 2022. The last two taxa (Coenagridae and Hydrobiidae) were present in large numbers in 2019 (44 and 179, respectively) but absent in 2022. The scoring system is based on a number of metrics, such as presence of families and numbers of Molluscs and Damselflies (see Section 4.2), and thus a reduction from 19 families in 2019 to 13 families in 2022, plus the absence of Valvatidae (Mollusc) and Coenagridae (Damselfly) in 2022, can substantially reduce the scores generated. Similar arguments to those above can be applied to the site at NL1, with 17 taxa present in 2019 but only nine taxa recorded in 2022. Further, however, the scores for the sites in 2017 were very similar to the scores for 2022, suggesting that, while water quality may appear to have declined i.e., since 2019, it is more likely that the water quality has remained consistent, with alterations in local habitat conditions at these two particular sites affecting the macroinvertebrate fauna.

Of the 14 WFD monitoring sites monitored in 2021, nine were at Maximum eco-potential, based on results from macroinvertebrate sampling, four were at Good and just one was at Moderate eco-potential (Table 4.2).

Table 4.2   Ecological potential of WFD monitoring sites on the Grand and Royal Canals based on macroinvertebrate sampling conducted in 2021, 2022 and 2023.

Canal	AWB	Site	Year	EQR	Macroinvetebrate Eco-potential
Grand Canal	GC_09	GCE4	2022	0.38	Poor
		GCE6	2022	0.71	Good
		GCE8	2022	0.51	Moderate
		GCE10	2022	0.68	Good
		GCE12	2022	0.78	Good
		GCE14	2022	0.62	Good
	GCNL_09	NL1	2022	0.36	Poor
	GCMF_14	MF1	2023	0.47	Moderate
	GCBL_14	BL2	2023	0.80	Max
		BL6	2021	0.86	Max
		BL10	2021	0.85	Max
		BL15	2021	0.64	Good
	GC_14E	GCE1	2022	0.66	Good
		GCW1	2022	0.53	Moderate
	GC_14W	GCW8	2022	0.82	Max
		GCW12	2021	0.87	Max
	GC_07	GCW4	2022	0.66	Good
		GCW6	2022	0.77	Good
	GC_25A	GCW16	2021	0.45	Moderate
		GCW18	2021	0.91	Max
		GCW20	2023	0.96	Max
		GCW22	2023	0.82	Max
		GCW24	2023	0.90	Max
		GCW27	2023	0.84	Max
Royal Canal	RC_07	RCE4	2023	0.83	Max
		RCE6	2023	0.71	Good
		RCE8	2021	0.90	Max
		RCE9	2021	0.87	Max
		RCE12	2021	0.84	Max
	RC_09	RCE14	2021	0.78	Good
		RCE16	2021	0.88	Max
		RCE19	2021	0.79	Good
		RCE22	2021	0.62	Good
		RCE25	2021	0.84	Max
	RC_25A	RCW1	2022	0.68	Good
		RCW3	2022	0.89	Max
	RC_26F	RCW5	2023	0.86	Max
		RCW7	2023	0.74	Good
		RCW9	2023	0.81	Max
	RC_26E	RCW12	2023	0.86	Max
	RC_26C	RCW14	2023	0.83	Max

At the AWB level, six of the 14 AWBs were at Maximum eco-potential based on the macroinvertebrate quality element at the end of the 2021-2023 monitoring cycle. Five AWBs were at Good, two at Moderate and just one at Poor post this monitoring period (Table 4.3). Five AWBs retained Maximum eco-potential between 2020 (the end of the 2018-2020 monitoring cycle) and 2023, one AWB (GCBL_14) retained Good status and one AWB (GCMF_14) changed from Maximum to Moderate status. Comparing 2017 (end of the 2015-2017 monitoring cycle) with 2023, six AWBs retained or moved into the next higher eco-potential rating, while only one (GCMF_14) changed from Good to Moderate. Overall, therefore, the environmental quality of the habitat occupied by the macroinvertebrates, as measured by macroinvertebrate assemblages, is consistently high, although some individual sites may experience some form of transient issues that require further investigation and mitigation.

Table 4.3   Ecological potential of the 14 Artificial Water Bodies (AWB) on the Grand and Royal Canals between 2021 and 2023, based on the macroinvertebrate quality element at the 41 monitoring sites.

Canal	AWB	EQR	Macroinvetebrate Eco-potential
Grand Canal	GC_09	0.61	Good
	GCNL_09	0.36	Poor
	GCMF_14	0.47	Moderate
	GCBL_14	0.79	Good
	GC_14E	0.59	Moderate
	GC_14W	0.85	Max
	GC_07	0.72	Good
	GC_25A	0.81	Max
Royal Canal	RC_07	0.83	Max
	RC_09	0.78	Good
	RC_25A	0.78	Good
	RC_26F	0.81	Max
	RC_26E	0.86	Max
	RC_26C	0.83	Max

5. Invasive Plant Species Monitoring

5.1. Introduction

Sampling for invasive plant species was conducted at the 41 WFD surveillance monitoring sites between 4th July and 9th August 2023, in conjunction with macrophyte sampling.

For the ecological classification of WFD monitoring sites and AWBs, the presence of invasive macrophyte or macroinvertebrate species at a site will automatically result in a change of ecological potential for that quality element (e.g., from Maximum to Good or from Good to Moderate).

Until 2021, the submerged elodeid *Elodea nuttallii* (Nuttall's Pondweed) was categorised as an invasive species for WFD canal classification purposes. However, as this species is now both widespread and abundant in the Royal, Grand and Barrow Canals (currently present in 33 of the 41 sites monitored) and as no mitigation measures will bring about its effective control or eradication, it was agreed with EPA to remove it from the invasive species list for Irish canals. It remains a listed invasive species in Irish (S.I. 477/2011) and European (1143/2014) legislation.

5.2. Materials and Methods

The survey area at each WFD monitoring site consists of a 150m canal reach that is sampled at ten roughly equidistant locations. At each location submerged, floating-leaved and free-floating aquatic macrophytes are collected using a standardised, 8-pronged grapnel with a 7m-long rope attachment. Every grapnel haul is examined for the presence of invasive plant species, but particularly for those listed in the tender document provided by Waterways Ireland for WFD Surveillance Monitoring. Although it is not required for a determination of ecological potential, it is deemed useful to estimate the percentage cover (see Section 3.2) occupied by each invasive plant species at each sampling location. Results for the ten grapnel samples are averaged to give an overall abundance/cover value for each invasive plant species at each WFD site.

5.3. Results

Only one listed invasive plant species (*Crassula helmsii* – New Zealand Pigmyweed) and no listed invasive animal species was recorded during sampling at the 41 WFD monitoring sites on the canals in 2023.

Two listed terrestrial invasive plant species have been recorded on the canals in recent years, but neither at any of the 41 WFD monitoring sites. These are *Reynoutria japonica* (Japanese knotweed) and *Allium triquetrum* (Three-cornered Garlic). The former species has been subject to herbicidal control by WI staff for several years and its presence is now very limited along these waterways. The latter species was first recorded on the Circular Line of the Grand Canal in 2018 and specimens remain present at this location. An examination of WFD monitoring sites in spring 2023, when *Allium triquetrum* would be in flower and most visible, did not record any specimens of this invasive species, although its presence at other canal locations was not examined. It will be important to monitor the distribution of this plant on the canals as it has the potential to spread very rapidly in suitable habitats and is becoming more widespread in Ireland.

During regular water and biological sampling on the canals in 2023, the increased presence of *Buddleja davidii* (Buddleja) and *Crocosmia x crocosmiiflora* (Montbretia) (Plate 5.1) has been noted. While these are beautiful plants to look at, they are non-native and potentially highly invasive species in Ireland. Because of their known capacity to spread very rapidly and to adversely impact biodiversity, planting of these species along the banksides of the canals should be actively discouraged and it is recommended that existing stands of these species should be treated and removed.

Plate 5.1: Buddleja davidii (Buddleja) in flower along the bank of the Grand Canal at Baggot Street (GCE14) (left) and Crocosmia x crocosmiifolia (Montbretia) growing along the towpath at a permanently moored craft at Sallins (GCE4) (right) in 2023.

Two non-native macroinvertebrate species recorded at canal monitoring sites in 2023 were both amphipod crustaceans, the North American *Crangonyx pseudogracilis* (widespread and abundant) and the Ponto-Caspian *Corophium curvispinum,* which is localized and rare. The former is unlikely to influence macroinvertebrate communities and is deemed to be fairly benign, while the latter is too rare to have much ecological influence at the moment. However, increases in non-native species should be monitored for adverse effects, such as competition or habitat modification.

5.3.1. Status of Aquatic Invasive Plant Species at WFD Monitoring Sites

In 2021 and 2022, the highly invasive *Crassula helmsii* was recorded at the same seven WFD monitoring sites – two on Grand Canal East (GCE1 - Robertstown and GCE14 - Baggot Street), four on Grand Canal West (GCW1 - Bond Bridge, GCW4 - Lock 20, GCW6 - George's Bridge and GCW8 - east of Rhode) and at MF1 (Milltown Feeder). In 2023, this invasive species was again recorded at these seven canal monitoring sites but, in addition, a small specimen of the plant was recorded during macrophyte sampling on NL1 (Naas Line), an eighth site among the 41 canal monitoring sites. A detailed examination of the site at that time, visually and using the grapnel, failed to uncover any further specimens. However, it will be important to closely monitor this site, and the length of Naas Line, for the presence of stands of this species and to physically remove them as soon as they

are located. No *C. helmsii* has yet been recorded from any WFD monitoring site on the Royal Canal or Barrow Line.

It is noteworthy that the vegetative abundance of this aggressive invasive species has actually decreased at GCE1, where it was recorded with a cover abundance of 2 (3 – 10%) in 2021 and 2022 but at 1 (<3%) in 2023. On the latter sampling occasion, only small strands of the plant were recovered from three of the ten grapnel hauls. At five of the sites from which *C. helmsii* was previously recorded, its vegetative abundance remained roughly the same in 2022 and 2023. These sites were GCE14 (Baggot Street), GCW1 (Bond Bridge), GCW4 (Lock 20), GCW6 (George's Bridge) and GCW8 (east of Rhode). These results suggest that this highly invasive species is not spreading at canal sites where it has become established as aggressively as might have been expected, for reasons that are unclear. One possible explanation might be that, at a number of these sites, particularly on GCW, the water levels in 2021 and 2022 were lower than normal during the spring and summer months. As a consequence, much more of the wetted and muddy canal margins were exposed. This is a favoured habitat for *C. helmsii*, where it can grow and expand by clonal growth along those margins that would normally be submerged.

Plate 5.2: Dense stand of Crassula helmsii (New Zealand Pigmyweed) growing along the margins of the Milltown Feeder (left) and a dense clump of the plant retrieved on a grapnel (right), in July 2023.

The expansion of *C. helmsii* at MF1 (Milltown Feeder) is more typical of what would be expected for this invasive species. In 2021, the plant was recorded at this monitoring site with a cover abundance of 1 (<3% cover) and was present, with low abundance, in three of the ten grapnel hauls taken at that time. In 2022, the abundance score for this site increased to 4 (31 – 70% cover) and dense clumps of the plant were recovered from eight of the ten grapnel hauls. It was now among the most dominant of the aquatic species at the site. In 2023, *C. helmsii* was by far the dominant macrophyte in the site and occupied large areas of river bed, to the total exclusion of previously resident,

indigenous macrophyte species (Plate 5.2, left). Dense clumps of the plant were recovered on nine of the ten grapnel hauls (Plate 5.2, right).

As was the case in 2022, large and localised stands of *C. helmsii* were present in the Milltown feeder stream downstream of MF1. Because of the speed with which this species is expanding in this important feeder, it is clear that it represents a real threat not only to the stream itself and also to the receiving waters of the Grand and Barrow Canals. Therefore, as urged in last year's report, it is strongly recommended that a particular focus be applied to removing as much of this invasive weed as possible from this feeder in the coming season. It may even be a case where bankside weed cutters are used to target large stands of this species, ensuring the removal of its stems, leaves and roots.

Plate 5.3:   A continuous carpet of the invasive Crassula helmsii (New Zealand Pigmyweed) covers the canal at Ticknevin Bridge, just upstream of GCW4 (Lock 20) in July 2023.

5.3.2.   Ecological Potential of WFD Monitoring Sites based on Invasive Plant Species

The eco-potential of the eight WFD sites at which the invasive species *C. helmsii* was recorded in 2023 had their eco-potential changed from Maximum to Good (Table 5.1) by virtue of the fact a listed invasive species was recorded at these sites.

Table 5.1 **Ecological potential of the 41 WFD monitoring sites on the Grand and Royal Canals sampled in 2023, based on the invasive plant species quality element. (Maximum (Max) indicates that no invasive plant species were present.)**

Site Code	Year	Ecological Potential - Site
GCE4	2023	Max
GCE6	2023	Max
GCE8	2023	Max
GCE10	2023	Max
GCE12	2023	Max
GCE14	2023	Good
NL1	2023	Good
MF1	2023	Good
BL2	2023	Max
BL6	2023	Max
BL10	2023	Max
BL15	2023	Max
GCE1	2023	Good
GCW1	2023	Good
GCW8	2023	Good
GCW12	2023	Max
GCW4	2023	Good
GCW6	2023	Good
GCW16	2023	Max
GCW18	2023	Max
GCW20	2023	Max
GCW22	2023	Max
GCW24	2023	Max
GCW27	2023	Max
RCE4	2023	Max
RCE6	2023	Max
RCE8	2023	Max
RCE9	2023	Max
RCE12	2023	Max
RCE14	2023	Max
RCE16	2023	Max
RCE19	2023	Max
RCE22	2023	Max
RCE25	2023	Max
RCW1	2023	Max
RCW3	2023	Max
RCW5	2023	Max
RCW7	2023	Max
RCW9	2023	Max
RCW12	2023	Max
RCW14	2023	Max

Because of the one-out-all-out rule whereby the lowest eco-potential value determines the overall eco-potential for an AWB, six of the 14 AWBs (not 15, as it was agreed with EPA not to sample sites on the Shannon-Erne Waterway – SE_26A for macrophytes or macroinvertebrates) were assigned Good rather than Maximum status (Table 5.2), based on the invasive species quality element.

Table 5.2   Ecological potential of the 14 Artificial Water Bodies on the Grand and Royal Canals in 2023, based on the invasive plant species quality element.

AWB	Year	Ecological Potential - AWB
GC_09	2023	Good
GCNL_09	2023	Good
GCMF_14	2023	Good
GCBL_14	2023	Max
GC_14E	2023	Good
GC_14W	2023	Good
GC_07	2023	Good
GC_25A	2023	Max
RC_07	2023	Max
RC_09	2023	Max
RC_25A	2023	Max
RC_26F	2023	Max
RC_26E	2023	Max
RC_26C	2023	Max

6. Combined Ecological Potential

In 2023, 33 of the 41 WFD surveillance monitoring sites on the canals were assessed at Good ecological potential when physico-chemical, macrophyte, macroinvertebrate (2021-2023), invasive species and hydromorphological quality elements were assessed to determine their combined eco-potential (Table 6.1). (The Shannon-Erne Waterway AWB is assessed solely for the physico-chemical quality element.) This compared with 33 sites that were at Good eco-potential in 2022 and 36 in 2021. Six sites were at Moderate and two at Poor eco-potential following assessment in 2023 (Table 6.1).

The two sites that were at Poor eco-potential at the end of the 2021-2023 surveillance monitoring programme were GCE4 (Sallins) and NL1 on the Naas Line, and both were assigned this status based on the results from the macroinvertebrate quality element alone (Table 6.1). The site on the Naas Line reported a very low macroinvertebrate biodiversity when surveyed in 2022, possibly reflecting the high levels of TON and Nitrate that have been recorded at this site in recent years, in addition to the dense carpets of filamentous green algae that occupied the bed of the canal for much of that year. The site at Sallins had witnessed a burgeoning number of cruisers taking permanent mooring spaces along the towpath, and these now occupy the full length of the WFD monitoring site and beyond. (As a consequence, it was deemed necessary to permanently move the monitoring site a further 600m west to enable water and biological samples to be collected without interference from boats.) It is probable that the presence of these craft and the direct disturbance they caused to the margins of the canal, where the macroinvertebrate samples were taken, had adversely impacted living conditions for this faunal community and resulted in the low eco-potential rating assigned. The six sites at Moderate eco-potential were GCE8, MF1, GCW1, GCW8, GCW16 and GCW20.

The eco-potential of six canal sites changed from 2022 to 2023, with three changing from Moderate to Good and three from Good to Moderate. Those that showed an improvement in eco-potential rating from Moderate to Good were GCE6 (Ponsonby Bridge), GCW12 (west of Daingean) and RCE8 (Hill of Down), and all reflecting improved water quality conditions in 2023. Those that changed from Good to Moderate were MF1 (Milltown Feeder), GCW8 (east of Rhode) and GCW20 (Cornalaur), the latter two reflecting poorer water quality conditions and the former was assigned a Moderate eco-potential based on the macroinvertebrate quality element in 2023. The reasons why sites were assigned specific eco-potential ratings are presented in Sections 2, 3, 4 and 5 of this report.

Of the two Shannon-Erne Waterway sites examined as part of the WFD surveillance monitoring programme, SE40 (upstream of Leitrim) changed from Moderate to Good between 2022 and 2023, reflecting an improvement in water quality conditions at this site in 2023 (Table 6.1). This site was also at Moderate in 2021. SE42 (Leitrim village and marina) was at Good eco-potential in 2023 and 2022, and at Moderate in 2021.

Table 6.1 **Ecological potential of the 41 WFD monitoring sites on the Grand Canal and Royal Canal based on the combined physico-chemistry, macrophyte, macroinvertebrate (2021-2023), invasive species and hydromorphology quality elements in 2023. The ecological potential of the sites on the Shannon-Erne Waterway AWB and the Grand Canal Basin is based on physico-chemistry results alone.**

Canal	Site	Macrophytes	Macro-invertebrates	Physico-Chemistry	Hydro-morphology	Invasive Species	ECOLOGICAL POTENTIAL - SITE
Grand Canal	GCE4	Max	Poor	Good	Max	Max	Poor
	GCE6	Max	Good	Good	Max	Max	Good
	GCE8	Max	Moderate	Good	Max	Max	Moderate
	GCE10	Max	Good	Good	Max	Max	Good
	GCE12	Max	Good	Good	Max	Max	Good
	GCE14	Max	Good	Good	Max	Good	Good
	NL1	Max	Poor	Good	Max	Good	Poor
	MF1	Max	Moderate	Good	Max	Good	Moderate
	BL2	Max	Max	Good	Max	Max	Good
	BL6	Max	Max	Good	Max	Max	Good
	BL10	Max	Max	Good	Max	Max	Good
	BL15	Max	Good	Good	Max	Max	Good
	GCE1	Max	Good	Good	Max	Good	Good
	GCW1	Max	Moderate	Good	Max	Good	Moderate
	GCW8	Max	Max	Moderate	Max	Good	Moderate
	GCW12	Max	Max	Good	Max	Max	Good
	GCW4	Max	Good	Good	Max	Good	Good
	GCW6	Max	Good	Good	Max	Good	Good
	GCW16	Max	Moderate	Good	Max	Max	Moderate
	GCW18	Max	Max	Good	Max	Max	Good
	GCW20	Max	Max	Moderate	Max	Max	Moderate
	GCW22	Max	Max	Good	Max	Max	Good
	GCW24	Max	Max	Good	Max	Max	Good
	GCW27	Max	Max	Good	Max	Max	Good
	GCB4	-	-	Good	-	-	Good
	GCB7	-	-	Moderate	-	-	Moderate
Royal Canal	RCE4	Max	Max	Good	Max	Max	Good
	RCE6	Max	Good	Good	Max	Max	Good
	RCE8	Max	Max	Good	Max	Max	Good
	RCE9	Max	Max	Good	Max	Max	Good
	RCE12	Max	Max	Good	Max	Max	Good
	RCE14	Max	Good	Good	Max	Max	Good
	RCE16	Max	Max	Good	Max	Max	Good
	RCE19	Max	Good	Good	Max	Max	Good
	RCE22	Max	Good	Good	Max	Max	Good
	RCE25	Good	Max	Good	Max	Max	Good
	RCW1	Max	Good	Good	Max	Max	Good
	RCW3	Good	Max	Good	Max	Max	Good
	RCW5	Max	Max	Good	Max	Max	Good
	RCW7	Max	Good	Good	Max	Max	Good
	RCW9	Max	Max	Good	Max	Max	Good
	RCW12	Max	Max	Good	Max	Max	Good
	RCW14	Max	Max	Good	Max	Max	Good
Shannon Erne	SE40	-	-	Good	-	-	Good
	SE42	-	-	Good	-	-	Good

*Grand Canal Basin is not a designated AWB

The monitoring site GCB4 (inner basin) on the Grand Canal Basin changed from Moderate to Good between 2022 and 2023, reflecting an improvement in water quality conditions (Table 6.1). It was also at Good status in 2021. The site on the outer basin (GCB7) was assigned Moderate eco-potential in 2023 and 2022 but was at Good status in 2021.

The eco-potential of the 14 AWBs based on the combined macroinvertebrate (2021–2023), macrophyte, invasive species, physico-chemical and hydromorphological quality elements in 2023, are presented in Table 6.2. Ten AWBs achieved Good eco-potential, three achieved Moderate and one was assigned Poor eco-potential. This compares with 12 at Good and two at Moderate eco-potential in 2020 (when all of the sites for the macroinvertebrate quality element, 2018–2020) had been assessed.

The Shannon-Erne Waterway AWB (SE_26A) was at Good eco-potential (based solely on the physico-chemical quality element) at the end of 2023 (Table 6.2), as it was at the end of 2022. This was an improvement on 2021, where it was assigned Moderate eco-potential.

The Grand Canal Basin was at Moderate eco-potential (based solely on the physico-chemical quality element) at the end of 2023 (Table 6.2), as it was at the end of 2022. It was assigned Good eco-potential in 2021.

Table 6.2   Ecological potential of the 14 Artificial Water Bodies on the Grand Canal and Royal Canal based on the combined macrophyte, macroinvertebrate (2021–2023), physico-chemistry, hydromorphology and invasive species quality elements in 2023. The ecological potential of the Shannon-Erne Waterway AWB and the Grand Canal Basin is based on physico-chemistry results alone.

AWB	Macrophytes	Macro-invertebrates	Physico-Chemistry	Hydro-morphology	Invasive Species	ECOLOGICAL POTENTIAL - AWB
GC_09	Max	Good	Good	Max	Good	Good
GCNL_09	Max	Poor	Good	Max	Good	Poor
GCMF_14	Max	Moderate	Good	Max	Good	Moderate
GCBL_14	Max	Good	Good	Max	Max	Good
GC_14E	Max	Moderate	Good	Max	Good	Moderate
GC_14W	Max	Max	Moderate	Max	Good	Moderate
GC_07	Max	Good	Good	Max	Good	Good
GC_25A	Max	Max	Good	Max	Max	Good
GCB	-	-	Moderate	-	-	Moderate
RC_07	Max	Max	Good	Max	Max	Good
RC_09	Max	Good	Good	Max	Max	Good
RC_25A	Good	Good	Good	Max	Max	Good
RC_26F	Max	Max	Good	Max	Max	Good
RC_26E	Max	Max	Good	Max	Max	Good
RC_26C	Max	Max	Good	Max	Max	Good
SE_26A	-	-	Good	-	-	Good

*Grand Canal Basin is not a designated AWB

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Appendices

Appendix I. Physico-chemical results and indicative ecological potential for the six classifying determinands on a site-by-site basis in the 15 Artificial Water Bodies (AWBs) on the Grand & Royal Canals and the Shannon-Erne Waterway for Q1, Q2, Q3 and Q4 in 2023. (Results for the Grand Canal Basin are included.)

AWB		Site Code	Quarter	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100 ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GC_09	GCE4_Q1	GCE4	Q1	0.017	0.010	2.61	97	2.00	0.030	Good
	GCE4_Q2		Q2	0.03	0.020	2.00	1,162	1.00	0.170	Moderate
	GCE4_Q3		Q3	0.02	0.010	1.80	31	1.00	0.150	Moderate
	GCE4_Q4		Q4	0.03	0.010	1.50	727	1.00	0.030	Good
	GCE6_Q1	GCE6	Q1	0.018	0.01	2.51	10	2.00	0.030	Good
	GCE6_Q2		Q2	0.01	0.01	1.50	10	1.00	0.070	Good
	GCE6_Q3		Q3	0.01	0.01	1.40	10	1.00	0.060	Good
	GCE6_Q4		Q4	0.03	0.01	1.70	213	1.00	0.050	Good
	GCE8_Q1	GCE8	Q1	0.016	0.01	2.20	10	3.00	0.040	Moderate
	GCE8_Q2		Q2	0.01	0.01	1.20	74	1.00	0.050	Good
	GCE8_Q3		Q3	0.02	0.01	1.40	20	1.00	0.130	Moderate
	GCE8_Q4		Q4	0.02	0.01	1.80	52	1.00	0.020	Good
	GCE10_Q1	GCE10	Q1	0.017	0.01	2.12	10	2.00	0.030	Good
	GCE10_Q2		Q2	0.01	0.01	0.9	10	1.00	0.070	Good
	GCE10_Q3		Q3	0.01	0.01	1	10	1.00	0.060	Good
	GCE10_Q4		Q4	0.01	0.01	1.4	86	1.00	0.030	Good
	GCE12_Q1	GCE12	Q1	0.013	0.01	1.93	10	2.00	0.030	Good
	GCE12_Q2		Q2	0.01	0.01	0.60	175	2.00	0.120	Moderate
	GCE12_Q3		Q3	0.01	0.01	1.00	292	1.00	0.080	Good
	GCE12_Q4		Q4	0.02	0.01	1.00	52	1.00	0.030	Good
	GCE14_Q1	GCE14	Q1	0.018	0.01	1.77	10	2.00	0.040	Good
	GCE14_Q2		Q2	0.02	0.01	0.50	20	2.00	0.120	Moderate
	GCE14_Q3		Q3	0.02	0.01	1.00	20	1.00	0.040	Good
	GCE14_Q4		Q4	0.03	0.01	1.00	10	1.00	0.110	Good
GCNL_09	NL1_Q1	NL1	Q1	0.013	0.01	4.61	60	1.00	0.020	Moderate
	NL1_Q2		Q2	0.02	0.01	3.60	20	2.00	0.090	Good
	NL1_Q3		Q3	0.01	0.01	2.90	52	1.00	0.070	Good
	NL1_Q4		Q4	0.04	0.01	3.70	1515	2.00	0.060	Moderate
GCMF_14	MF1_Q1	MF1	Q1	0.013	0.01	2.75	10	1.00	0.030	Good
	MF1_Q2		Q2	0.01	0.01	2.20	10	2.00	0.080	Good
	MF1_Q3		Q3	0.01	0.01	2.30	10	1.00	0.050	Good
	MF1_Q4		Q4	0.01	0.01	2.30	10	1.00	0.020	Good

GCBL_14	BL2_Q1	BL2	Q1	0.019	0.01	1.39	10	2.00	0.050	Good
	BL2_Q2		Q2	0.01	0.01	0.50	10	1.00	**0.130**	**Moderate**
	BL2_Q3		Q3	0.01	0.01	1.00	100	1.00	0.050	Good
	BL2_Q4		Q4	0.01	0.01	1.00	10	1.00	0.050	Good
	BL6_Q1	BL6	Q1	0.017	0.01	2.45	10	**3.00**	0.030	**Moderate**
	BL6_Q2		Q2	0.01	0.01	1.80	10	1.00	0.090	Good
	BL6_Q3		Q3	0.01	0.01	1.30	31	1.00	0.040	Good
	BL6_Q4		Q4	0.01	0.01	1.80	10	1.00	0.020	Good
	BL10_Q1	BL10	Q1	0.02	0.01	**4.88**	10	2.00	0.040	**Moderate**
	BL10_Q2		Q2	0.02	0.01	0.50	10	1.00	**0.190**	**Moderate**
	BL10_Q3		Q3	0.01	0.01	1.00	10	1.00	0.060	Good
	BL10_Q4		Q4	0.02	0.01	1.10	10	1.00	0.030	Good
	BL15_Q1	BL15	Q1	0.02	0.01	3.29	145	2.00	0.060	Good
	BL15_Q2		Q2	0.02	0.01	0.50	10	2.00	**0.140**	**Moderate**
	BL15_Q3		Q3	0.01	0.01	1.00	10	2.00	0.050	Good
	BL15_Q4		Q4	0.03	0.01	1.10	428	1.00	0.040	Good
GC_14E	GCE1_Q1	GCE1	Q1	0.013	0.010	2.40	10	1.00	0.030	Good
	GCE1_Q2		Q2	0.010	0.010	1.50	31	2.00	0.100	Good
	GCE1_Q3		Q3	0.010	0.010	1.00	10	1.00	0.100	Good
	GCE1_Q4		Q4	0.010	0.010	1.00	10	1.00	0.100	Good
	GCW1_Q1	GCW1	Q1	0.013	0.01	2.24	10	2.00	0.020	Good
	GCW1_Q2		Q2	0.01	0.01	1.20	10	2.00	0.060	Good
	GCW1_Q3		Q3	0.01	0.01	1.10	10	1.00	0.050	Good
	GCW1_Q4		Q4	0.01	0.01	1.50	84	1.00	0.020	Good
GC_14W	GCW8_Q1	GCW8	Q1	0.026	0.01	1.37	10	**9.00**	**0.120**	**Moderate**
	GCW8_Q2		Q2	0.01	0.01	1.00	3	1.00	0.050	Good
	GCW8_Q3		Q3	0.02	0.01	1.00	10	1.00	0.020	Good
	GCW8_Q4		Q4	0.05	0.01	1.70	31	2.00	0.060	Good
	GCW12_Q1	GCW12	Q1	0.035	0.01	2.17	10	2.00	0.090	Good
	GCW12_Q2		Q2	0.02	0.01	1.00	11	2.00	0.040	Good
	GCW12_Q3		Q3	0.04	0.01	1.00	10	**3.00**	0.020	**Moderate**
	GCW12_Q4		Q4	0.06	0.02	2.10	120	2.00	**0.120**	**Moderate**
GC_07	GCW4_Q1	GCW4	Q1	0.013	0.01	1.81	10	2.00	0.040	Good
	GCW4_Q2		Q2	0.01	0.01	1.00	3	2.00	0.040	Good
	GCW4_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	Good
	GCW4_Q4		Q4	0.01	0.01	1.40	41	1.00	0.050	Good
	GCW6_Q1	GCW6	Q1	0.013	0.01	1.17	10	2.00	0.060	Good
	GCW6_Q2		Q2	0.01	0.01	1.00	1	2.00	0.040	Good
	GCW6_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	Good
	GCW6_Q4		Q4	0.01	0.01	1.30	10	1.00	0.040	Good

GC_25A	GCW16_Q1	GCW16	Q1	0.022	0.01	1.74	10	2.00	0.030	**Good**
	GCW16_Q2		Q2	0.01	0.01	1.00	15	2.00	0.030	**Good**
	GCW16_Q3		Q3	0.01	0.01	1.00	10	1.00	0.030	**Good**
	GCW16_Q4		Q4	0.04	0.01	1.70	10	2.00	0.060	**Good**
	GCW18_Q1	GCW18	Q1	0.02	0.01	1.79	10	**4.00**	0.060	**Moderate**
	GCW18_Q2		Q2	0.01	0.01	1.00	51	2.00	0.060	**Good**
	GCW18_Q3		Q3	0.02	0.01	1.00	243	2.00	0.020	**Good**
	GCW18_Q4		Q4	0.02	0.01	1.50	41	1.00	0.020	**Good**
	GCW20_Q1	GCW20	Q1	0.015	0.01	2.47	10	**6.00**	0.060	**Moderate**
	GCW20_Q2		Q2	0.01	0.01	1.00	687	2.00	0.030	**Good**
	GCW20_Q3		Q3	0.02	0.01	1.00	10	1.00	0.030	**Good**
	GCW20_Q4		Q4	0.02	0.01	1.20	52	1.00	0.060	**Good**
	GCW22_Q1	GCW22	Q1	0.015	0.01	2.15	10	2.00	0.060	**Good**
	GCW22_Q2		Q2	0.01	0.01	1.00	0	2.00	0.050	**Good**
	GCW22_Q3		Q3	**0.13**	0.01	1.00	10	1.00	0.020	**Moderate**
	GCW22_Q4		Q4	0.01	0.01	1.30	10	1.00	0.060	**Good**
	GCW24_Q1	GCW24	Q1	0.013	0.01	1.93	10	2.00	0.060	**Good**
	GCW24_Q2		Q2	0.01	0.01	1.00	0	2.00	0.060	**Good**
	GCW24_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	**Good**
	GCW24_Q4		Q4	0.01	0.01	1.00	10	1.00	0.030	**Good**
	GCW27_Q1	GCW27	Q1	0.013	0.01	0.50	10	2.00	0.100	**Good**
	GCW27_Q2		Q2	0.01	0.01	1.00	2	2.00	0.030	**Good**
	GCW27_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	**Good**
	GCW27_Q4		Q4	0.01	0.01	1.00	41	1.00	0.030	**Good**
GCB*	GCB4*_Q1	GCB4*	Q1	0.026	0.01	2.31	10	1.00	0.050	**Good**
	GCB4*_Q2		Q2	0.01	0.01	1.10	41	1.00	0.100	**Good**
	GCB4*_Q3		Q3	0.02	0.01	1.00	100	1.00	0.090	**Good**
	GCB4*_Q4		Q4	0.05	0.01	1.00	75	1.00	0.040	**Good**
	GCB7*_Q1	GCB7*	Q1	0.021	0.01	2.31	495	2.00	**0.120**	**Moderate**
	GCB7*_Q2		Q2	0.03	**0.03**	0.80	10	2.00	**0.170**	**Moderate**
	GCB7*_Q3		Q3	0.02	0.01	1.00	86	1.00	0.070	**Good**
	GCB7*_Q4		Q4	**0.11**	**0.03**	1.00	**24196**	2.00	**0.120**	**Moderate**

RC_07	RCE4_Q1	RCE4	Q1	0.013	0.01	0.50	10	2.00	**0.140**	**Moderate**
	RCE4_Q2		Q2	0.01	0.01	1.00	4	2.00	0.080	**Good**
	RCE4_Q3		Q3	0.01	0.01	1.00	10	1.00	0.030	**Good**
	RCE4_Q4		Q4	0.03	0.01	1.00	10	1.00	0.050	**Good**
	RCE6_Q1	RCE6	Q1	0.013	0.01	1.28	10	1.00	0.080	**Good**
	RCE6_Q2		Q2	0.01	0.01	2.50	65	1.00	0.090	**Good**
	RCE6_Q3		Q3	0.02	0.01	1.00	10	1.00	0.040	**Good**
	RCE6_Q4		Q4	0.01	0.01	1.00	20	1.00	0.040	**Good**
	RCE8_Q1	RCE8	Q1	0.018	0.01	0.50	10	2.00	0.100	**Good**
	RCE8_Q2		Q2	0.01	0.01	2.20	12	2.00	0.060	**Good**
	RCE8_Q3		Q3	0.01	0.01	1.00	269	1.00	0.040	**Good**
	RCE8_Q4		Q4	0.01	0.01	1.10	109	1.00	0.040	**Good**
	RCE9_Q1	RCE9	Q1	0.017	0.01	0.50	10	2.00	0.060	**Good**
	RCE9_Q2		Q2	0.01	0.01	0.50	10	2.00	0.110	**Good**
	RCE9_Q3		Q3	0.01	0.01	1.00	10	1.00	0.060	**Good**
	RCE9_Q4		Q4	0.02	0.01	1.00	86	1.00	0.020	**Good**
	RCE12_Q1	RCE12	Q1	0.015	0.01	2.34	63	2.00	0.050	**Good**
	RCE12_Q2		Q2	0.01	0.01	0.70	20	2.00	0.110	**Good**
	RCE12_Q3		Q3	0.01	0.01	1.30	10	1.00	0.040	**Good**
	RCE12_Q4		Q4	0.03	0.01	1.00	31	1.00	0.040	**Good**
RC_09	RCE14_Q1	RCE14	Q1	0.017	0.01	1.70	10	2.00	0.040	**Good**
	RCE14_Q2		Q2	0.01	0.01	0.60	20	1.00	0.100	**Good**
	RCE14_Q3		Q3	0.01	0.01	1.00	10	1.00	0.050	**Good**
	RCE14_Q4		Q4	0.02	0.01	1.00	10	1.00	0.040	**Good**
	RCE16_Q1	RCE16	Q1	0.021	0.01	2.33	10	2.00	0.030	**Good**
	RCE16_Q2		Q2	0.02	0.01	0.70	10	1.00	0.080	**Good**
	RCE16_Q3		Q3	0.01	0.01	1.00	100	1.00	0.060	**Good**
	RCE16_Q4		Q4	0.02	0.01	1.00	10	2.00	0.030	**Good**
	RCE19_Q1	RCE19	Q1	0.013	0.01	2.16	10	1.00	0.050	**Good**
	RCE19_Q2		Q2	0.01	0.01	0.50	10	1.00	0.110	**Good**
	RCE19_Q3		Q3	0.01	0.01	1.00	10	1.00	0.050	**Good**
	RCE19_Q4		Q4	0.02	0.01	1.00	121	2.00	0.020	**Good**
	RCE22_Q1	RCE22	Q1	0.017	0.01	1.10	31	2.00	0.050	**Good**
	RCE22_Q2		Q2	0.01	0.01	0.60	355	1.00	0.110	**Good**
	RCE22_Q3		Q3	0.02	0.01	1.20	479	1.00	0.090	**Good**
	RCE22_Q4		Q4	0.03	0.01	1.00	30	1.00	0.110	**Good**
	RCE25_Q1	RCE25	Q1	0.054	0.01	1.39	10	**3.00**	0.030	**Moderate**
	RCE25_Q2		Q2	0.02	0.02	0.50	98	2.00	**0.120**	**Moderate**
	RCE25_Q3		Q3	0.03	0.01	1.00	85	1.00	**0.130**	**Moderate**
	RCE25_Q4		Q4	0.02	0.01	1.00	20	1.00	0.020	**Good**

RC_25A	RCW1_Q1	RCW1	Q1	0.013	0.01	0.50	10	1.00	0.040	Good
	RCW1_Q2		Q2	0.01	0.01	1.00	34	2.00	0.050	Good
	RCW1_Q3		Q3	0.01	0.01	1.00	10	1.00	0.040	Good
	RCW1_Q4		Q4	0.01	0.01	1.00	10	1.00	0.040	Good
	RCW3_Q1	RCW3	Q1	0.013	0.01	0.50	10	2.00	0.060	Good
	RCW3_Q2		Q2	0.01	0.01	1.00	0	2.00	0.030	Good
	RCW3_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	Good
	RCW3_Q4		Q4	0.02	0.01	1.00	10	1.00	0.050	Good
RC_26F	RCW5_Q1	RCW5	Q1	0.014	0.01	0.89	10	2.00	0.070	Good
	RCW5_Q2		Q2	0.01	0.01	1.00	2	2.00	0.060	Good
	RCW5_Q3		Q3	0.01	0.01	1.00	10	1.00	0.020	Good
	RCW5_Q4		Q4	0.01	0.01	1.00	10	1.00	0.020	Good
	RCW7_Q1	RCW7	Q1	0.013	0.01	1.19	10	1.00	0.060	Good
	RCW7_Q2		Q2	0.01	0.01	1.00	5	1.00	0.060	Good
	RCW7_Q3		Q3	0.01	0.01	1.00	882	1.00	0.030	Good
	RCW7_Q4		Q4	0.01	0.01	1.40	10	1.00	0.030	Good
	RCW9_Q1	RCW9	Q1	0.013	0.01	1.34	10	1.00	0.070	Good
	RCW9_Q2		Q2	0.01	0.01	1.00	5	2.00	**0.130**	Moderate
	RCW9_Q3		Q3	0.02	0.01	1.00	158	**3.00**	0.020	Moderate
	RCW9_Q4		Q4	0.01	0.01	1.00	10	1.00	0.040	Good
RC_26E	RCW12_Q1	RCW12	Q1	0.015	0.01	0.50	10	1.00	**0.120**	Moderate
	RCW12_Q2		Q2	0.01	0.01	1.00	16	1.00	0.050	Good
	RCW12_Q3		Q3	0.01	0.01	1.00	**1376**	**3.00**	0.040	Moderate
	RCW12_Q4		Q4	0.01	0.01	1.00	20	1.00	0.050	Good
RC_26C	RCW14_Q1	RCW14	Q1	0.013	0.01	0.50	10	1.00	0.060	Good
	RCW14_Q2		Q2	0.01	0.01	1.00	3	2.00	**0.140**	Moderate
	RCW14_Q3		Q3	0.01	0.01	1.00	10	2.00	0.020	Good
	RCW14_Q4		Q4	0.01	0.01	1.00	10	1.00	0.080	Good
SE_26A	SE40_Q1	SE40	Q1	0.024	0.01	0.50	10	2.00	0.080	Good
	SE40_Q2		Q2	0.03	0.01	1.00	9	2.00	0.080	Good
	SE40_Q3		Q3	**0.14**	0.01	1.00	63	2.00	0.030	Moderate
	SE40_Q4		Q4	0.04	0.01	1.00	20	1.00	0.070	Good
	SE42_Q1	SE42	Q1	0.034	0.02	0.50	10	2.00	0.050	Good
	SE42_Q2		Q2	0.02	0.01	1.00	9	1.00	0.020	Good
	SE42_Q3		Q3	0.06	0.01	1.00	161	**4.00**	0.020	Moderate
	SE42_Q4		Q4	0.06	0.02	1.00	631	2.00	0.060	Good

Appendix II. **Physico-chemical results and indicative ecological potential for the six classifying determinands in the 15 Artificial Water Bodies (AWBs) on the Grand & Royal Canals and the Shannon-Erne Waterway for Q1, Q2, Q3 and Q4 in 2023. (Results for the Grand Canal Basin are included.)**

	AWB	Quarter	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Grand Canal	GC_09	Q1	0.017	0.010	2.19	25	2.17	0.033	Good
		Q2	0.015	0.012	1.12	242	1.33	0.100	Good
		Q3	0.015	0.010	1.27	64	1.00	0.087	Good
		Q4	0.023	0.010	1.40	190	1.00	0.045	Good
	GCNL_09	Q1	0.013	0.010	**4.61**	60	1.00	0.020	Moderate
		Q2	0.020	0.010	3.60	20	2.00	0.090	Good
		Q3	0.010	0.010	2.90	52	1.00	0.070	Good
		Q4	0.040	0.010	3.70	**1,515**	2.00	0.060	Moderate
	GCMF_14	Q1	0.013	0.010	2.75	10	1.00	0.030	Good
		Q2	0.010	0.010	2.20	10	2.00	0.080	Good
		Q3	0.010	0.010	2.30	10	1.00	0.050	Good
		Q4	0.010	0.010	2.30	10	1.00	0.020	Good
	GCBL_14	Q1	0.019	0.010	3.00	44	2.25	0.045	Good
		Q2	0.015	0.010	0.83	10	1.25	**0.138**	Moderate
		Q3	0.010	0.010	1.08	38	1.25	0.050	Good
		Q4	0.018	0.010	1.25	115	1.00	0.035	Good
	GC_14E	Q1	0.013	0.010	2.32	10	1.50	0.025	Good
		Q2	0.010	0.010	1.35	21	2.00	0.080	Good
		Q3	0.010	0.010	1.05	10	1.00	0.075	Good
		Q4	0.010	0.010	1.25	47	1.00	0.060	Good
	GC_14W	Q1	0.031	0.010	1.77	10	**5.50**	0.105	Moderate
		Q2	0.015	0.010	1.00	7	1.50	0.045	Good
		Q3	0.030	0.010	1.00	10	2.00	0.020	Good
		Q4	0.055	0.015	1.90	76	2.00	0.090	Good
	GC_07	Q1	0.013	0.010	1.49	10	2.00	0.050	Good
		Q2	0.010	0.010	1.00	2	2.00	0.040	Good
		Q3	0.010	0.010	1.00	10	1.00	0.020	Good
		Q4	0.010	0.010	1.35	26	1.00	0.045	Good
	GC_25A	Q1	0.016	0.010	1.76	10	**3.00**	0.062	Moderate
		Q2	0.010	0.010	1.00	126	2.00	0.043	Good
		Q3	0.033	0.010	1.00	49	1.17	0.023	Good
		Q4	0.018	0.010	1.00	58	1.00	0.035	Good
	GCB*	Q1	0.024	0.010	2.31	253	1.50	0.085	Good
		Q2	0.020	0.020	0.95	26	1.50	**0.135**	Moderate
		Q3	0.020	0.010	1.00	93	1.00	0.080	Good
		Q4	**0.080**	0.020	1.00	**12,136**	1.50	0.080	Moderate
Royal Canal	RC_07	Q1	0.015	0.010	1.02	21	1.80	0.086	Good
		Q2	0.010	0.010	1.38	22	1.80	0.090	Good
		Q3	0.012	0.010	1.06	62	1.00	0.042	Good
		Q4	0.020	0.010	1.02	51	1.00	0.038	Good
	RC_09	Q1	0.024	0.010	1.74	14	2.00	0.040	Good
		Q2	0.014	0.012	0.58	99	1.20	0.104	Good
		Q3	0.016	0.010	1.04	137	1.00	0.076	Good
		Q4	0.022	0.010	1.00	38	1.40	0.044	Good
	RC_25A	Q1	0.013	0.010	0.50	10	1.50	0.050	Good
		Q2	0.010	0.010	1.00	17	2.00	0.040	Good
		Q3	0.010	0.010	1.00	10	1.00	0.030	Good
		Q4	0.015	0.010	1.00	10	1.00	0.045	Good
	RC_26F	Q1	0.013	0.010	1.14	10	1.33	0.067	Good
		Q2	0.010	0.010	1.00	4	1.67	0.083	Good
		Q3	0.013	0.010	1.00	350	1.67	0.023	Good
		Q4	0.010	0.010	1.13	10	1.00	0.030	Good
	RC_26E	Q1	0.015	0.010	0.50	10	1.00	**0.120**	Moderate
		Q2	0.010	0.010	1.00	16	1.00	0.050	Good
		Q3	0.010	0.010	1.00	**1,376**	**3.00**	0.040	Moderate
		Q4	0.010	0.010	1.00	20	1.00	0.050	Good
Shannon Erne	RC_26C	Q1	0.013	0.010	0.50	10	1.00	0.060	Good
		Q2	0.010	0.010	1.00	3	2.00	**0.140**	Moderate
		Q3	0.010	0.010	1.00	10	2.00	0.020	Good
		Q4	0.010	0.010	1.00	10	1.00	0.080	Good
	SE_26A	Q1	0.029	0.015	0.50	10	2.00	0.065	Good
		Q2	0.025	0.010	1.00	9	1.50	0.050	Good
		Q3	**0.100**	0.010	1.00	112	**3.00**	0.025	Moderate
		Q4	0.050	0.015	1.00	326	1.50	0.065	Good

Appendix III. Physico-chemical results and indicative ecological potential for the six classifying determinands on the five canal feeders/drains for Q1 Q2, Q3 and Q4 in 2023.

Feeders		Site Code	Quarter	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100 ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Monread Feeder	GCE5.1_Q1	GCE5.1	Q1	0.024	0.02	3.15	175	1.00	0.02	Good
	GCE5.1_Q2		Q2	0.02	0.01	3.10	1725	1.00	0.08	Moderate
	GCE5.1_Q3		Q3	0.03	0.01	3.10	1580	1.00	0.03	Moderate
	GCE5.1_Q4		Q4	0.09	0.01	1.60	3448	2.00	0.04	Moderate
Ballymullen Feeder	GCW12.1_Q1	GCW12.1	Q1	0.04	0.03	3.05	10	2.00	0.07	Moderate
	GCW12.1_Q2		Q2	0.03	0.02	2.70	687	1.00	0.04	Good
	GCW12.1_Q3		Q3	0.05	0.01	1.50	223	1.00	0.02	Good
	GCW12.1_Q4		Q4	0.05	0.01	2.20	292	1.00	0.08	Good
Ballylennon Feeder	GCW13.1_Q1	GCW13.1	Q1	0.057	0.04	1.88	10	7.00	0.16	Moderate
	GCW13.1_Q2		Q2	0.03	0.02	1.60	46	2.00	0.03	Good
	GCW13.1_Q3		Q3	0.05	0.01	1.00	52	2.00	0.02	Good
	GCW13.1_Q4		Q4	0.06	0.02	1.70	52	1.00	0.15	Moderate
Athy Drain	BL15.1_Q1	BL15.1	Q1	0.018	0.01	6.12	63	2.00	0.06	Moderate
	BL15.1_Q2		Q2	0.04	0.01	3.00	556	2.00	0.14	Moderate
	BL15.1_Q3		Q3	0.06	0.01	5.40	14830	3.00	0.58	Moderate
	BL15.1_Q4		Q4	0.06	0.01	2.60	1723	1.00	0.1	Moderate
Kilcock Harbour	RCE16.1_Q1	RCE16.1	Q1	0.032	0.01	2.02	146	2.00	0.08	Good
	RCE16.1_Q2		Q2	0.03	0.01	0.90	98	2.00	0.11	Good
	RCE16.1_Q3		Q3	0.02	0.01	1.00	31	1.00	0.09	Good
	RCE16.1_Q4		Q4	0.07	0.01	1.90	2143	1.00	0.02	Moderate

Appendix IV

Water Framework Directive Compliance Report

Physico-chemistry

First Quarter 2023

Water Framework Directive Compliance Report

Physico-chemistry

First Quarter 2023

March 2023

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Front Cover: YSI probe being used to collect field data from the Ballylennon feeder (GC13.1) in February 2023.

1. Introduction

Water Framework Directive (WFD) surveillance monitoring of the Royal and Grand Canals and the canalised section of the Shannon-Erne Waterway for Q1 2023 was carried out on 16th and 23rd February 2023.

A canal is identified as an Artificial Water Body (AWB) in the WFD and is defined as 'a body of water created by human activity'. In recognition of their navigational role, AWBs must achieve good ecological <u>potential</u> as opposed to good ecological <u>status</u>, the latter which applies to natural water bodies, such as rivers and lakes. Ecological potential is assessed using a combination of biological (native and invasive macroinvertebrate and macrophyte), physico-chemical and hydromorphological quality elements. For classification purposes, the ecological potential of a site or AWB can be Maximum, Good, Moderate, Poor or Bad. Where physico-chemistry alone is being assessed, as in this report, sites and AWBs can achieve either Good or Moderate potential only. In assigning ecological potential, the one-out-all-out rule applies, whereby the lowest value quality element determines the overall classification of the AWB. A system for classifying British and Irish canals based on macroinvertebrate, macrophyte, invasive species, physico-chemical and hydromorphological quality elements is used to assess the ecological potential of AWBs. In the current reporting period (Q1 2023), the canals are classified based on the physico-chemistry of the water during this period.

Figure 1. Artificial Water Bodies (AWBs), sites and monitored feeder streams on the Royal and Grand Canals, and the Shannon-Erne Waterway. The AWBs are grouped based on associated river catchments.
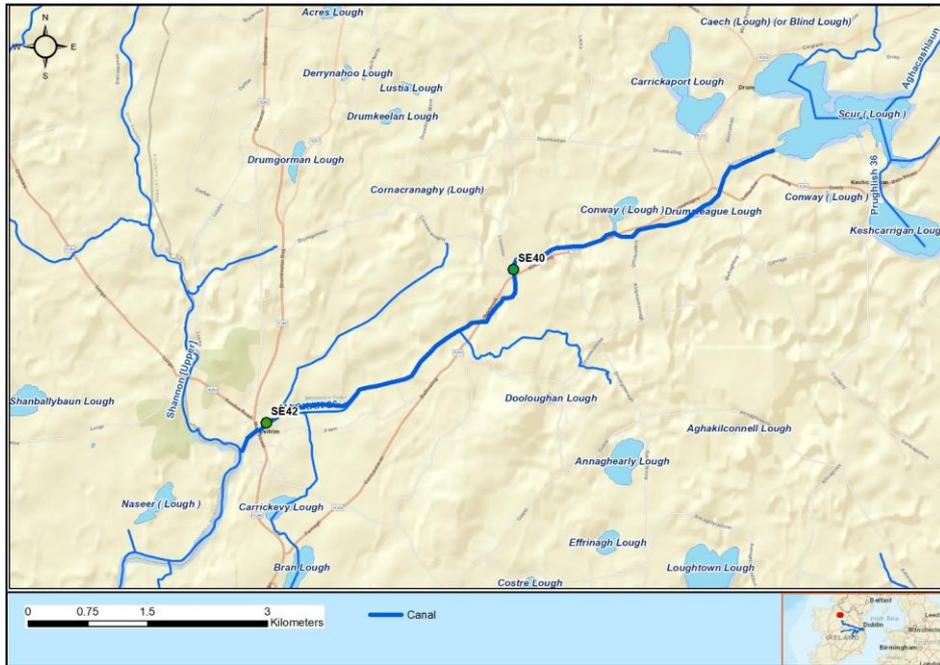
The canals are currently divided into 15 AWBs based on their locations within river catchments (Table 1). The Grand Canal supports eight AWBs (this does not include the Grand Canal Basin), the Royal Canal has six AWBs and there is just a single AWB on the Shannon-Erne Waterway. Four of the AWBs have only a single canal sampling site (Table 1), which can be potentially problematic when ecological potential for individual AWBs is being assigned. This reflects the fact that a breach in any biological or abiotic parameter can result in the AWB being changed from Good to Moderate.

For reporting purposes, a simple code has been assigned, whereby AWBs are labelled according to the river catchment in which they occur (Table 1).

Table 1. Artificial Water Bodies (AWBs) included in the WFD Monitoring Programme.

Artificial Water Body (AWB)	Catchment No	New ID Code	New Report Code	Length (km)	No of Sites
GRAND CANAL					
Grand Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_GCMLE	GC_09	41.4	6
Grand Canal Main Line East - Barrow	14	IE_14_AWB_GCMLE	GC_14E	15.7	2
Grand Canal Main Line West - Barrow	14	IE_14_AWB_GCMLW	GC_14W	12.9	2
Grand Canal Main Line - Boyne	7	IE_07_AWB_GCMLW	GC_07	14.5	2
Grand Canal Main Line - Lower Shannon	25A	IE_25A_AWB_GCMLW	GC_25A	47.0	6
Grand Canal Naas Line - Liffey and Dublin Bay	9	IE_09_AWB_GCNL	GCNL_09	11.9	1
Grand Canal Milltown Feeder - Barrow	14	IE_14_AWB_GCMF	GCMF_14	10.5	1
Grand Canal Barrow Line - Barrow	14	IE_14_AWB_GCBL	GCBL_14	50.8	4
Grand Canal Basin - Liffey and Dublin Bay	9	IE_09_AWB_GCB	GCB		2
ROYAL CANAL					
Royal Canal Main Line - Boyne Catchment	7	IE_07_AWB_RCMLE	RC_07	42.6	5
Royal Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_RCMLE	RC_09	39.4	5
Royal Canal Main Line - Lower Shannon	25A	IE_25A_AWB_RCMLW	RC_25A	13.3	2
Royal Canal Main Line - Upper Shannon	26F	IE_26F_AWB_RCMLW	RC_26F	33.8	3
Royal Canal Main Line - Upper Shannon	26E	IE_26E_AWB_RCMLW	RC_26E	3.7	1
Royal Canal Main Line - Upper Shannon	26C	IE_26C_AWB_RCMLW	RC_26C	14.2	1
SHANNON ERNE WATERWAY					
Shannon Erne Waterway - Upper Shannon	26A	IE_26A_AWB_SEW	SE_26A	25.5	2

During 2020 a second site (SE42) was included on the Shannon-Erne Waterway to better represent the water quality status of this Waterway and AWB (Table 1.1). This site is located adjacent to the marina in Leitrim village, close to where the Shannon-Erne Waterway discharges to the River Shannon (Figure 2).

Figure 2. Location of the two WFD monitoring sites (SE40 and 42) on the Shannon-Erne Waterway.
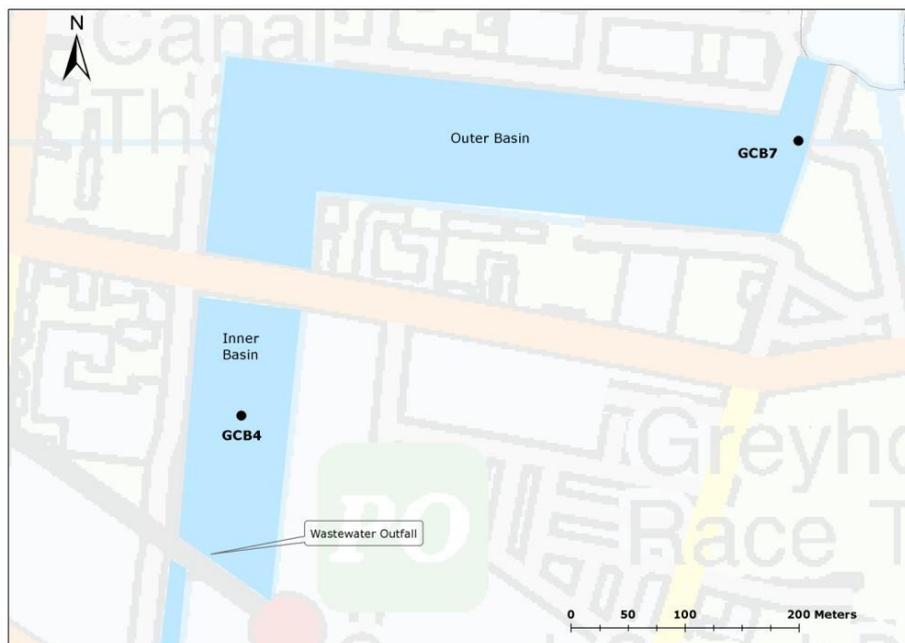

Plate 1. Water sampling at the Kilcock Harbour drain outflow pipe (RCE16.1) in February 2023.

2. Materials and Methods

2.1. *Sampling locations*

Physico-chemical sampling is conducted on a quarterly basis at 50 monitoring sites – 41 on the Royal, Grand and Barrow Canals, two on the Grand Canal Basin, two on the Shannon-Erne Waterway, and five on selected canal feeder streams/drains (see Figures 1, 2 and 3). The canal feeders/drains have been a source of elevated nutrient and coliform inputs in the past. They include the Monread drain (GCE5.1) and Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeder streams on the Grand Canal, the Athy drain (BL15.1) on the Barrow Line, and the Kilcock Harbour drain (RCE16.1) on the Royal Canal. In addition to the quarterly water samples taken by INVAS at two sites in the Grand Canal Basin as part of the WFD Canals Surveillance Programme, Waterways Ireland (WI) and Dublin City Council (DCC) conduct regular water sampling for bacteriological (*E. coli* and *Enterococci*) analysis at up to 11 sites in the Basin (three in the Inner, eight in the Outer) and two in the adjacent Grand Canal (Figure 4). In 2022 and 2023, just five samples for bacteriology have been collected and analysed on a fortnightly basis. The sampling sites were: 1st level of the Grand Canal (1), the inner basin (2 – sites 4 and 5 in Figure 4) and the outer basin (2 – sites 6 and 7 in Figure 4).
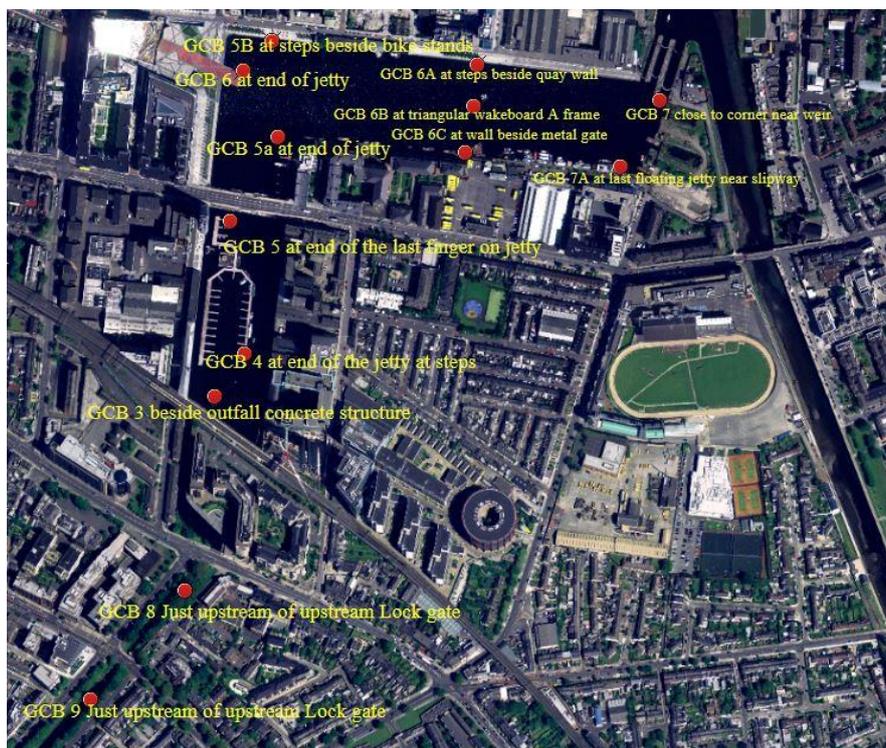

Figure 3. Grand Canal Basin (Dublin) showing the two monitoring sites (GCB4 and GCB7).

2.2. *Physico-Chemical Monitoring*

Water sampling involves the deployment of a YSI water logger at each site to measure temperature, conductivity, pH and dissolved oxygen (DO). Water samples are collected from canal sites and returned to the Independent Analytical Supplies (IAS) laboratory in Bagenalstown for analysis of a range of determinands (Table 2). A subset of these is used to assess indicative ecological potential - Total

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Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON), Ammonia, Biological Oxygen Demand (BOD) and Faecal Coliforms.

Figure 4. Grand Canal Basin (Dublin) showing the 13 sites that have been sampled in the past by Waterways Ireland and Dublin City Council for bacteriology.

Table 2. Physico-chemical determinands measured as part of WFD monitoring. (Chlorophyll monitoring has been discontinued since 2021.)

Determinand	Limit	Determinand	Limit
Total Phosphorus (TP) (mg/l P)*	0.063 mg/l P	Dissolved Oxygen (DO) (mg/l and % saturation)	>5.0 mg/l O_2
Molybdate Reactive Phosphorus (MRP) (mg/l P)	0.025 mg/l P	pH	
Soluble Reactive Phosphorus (SRP) (mg/l P)*	0.025 mg/l P	Conductivity (µS)	
Total Oxidised Nitrogen (TON) (mg/l N)*	4.1 mg/l N	Alkalinity (meq/l)	
Nitrite (mg/l)		Chlorophyll (µg/l)	
Nitrate (mg/l)		Biological Oxygen Demand (BOD) (mg/l O_2)*	<2.5 mg/l O_2
Ammonia (mg/l N)*	0.12 mg/l N	Total Coliforms (TC) (counts/100ml)	5000/100 ml
Temperature (°C)		Faecal Coliforms (counts/100ml)*	1000/100 ml

* Determinands used to assign ecological potential to the Artificial Water Bodies (AWBs)

3. Results

The full set of results from physico-chemical analysis of the water samples taken from the 50 canal, feeder/drain and Grand Canal Basin sites surveyed in Q1 2023 is presented in Appendices I and II.

3.1. *Physico-chemistry at Canal Sites*

Water sampling in Q1 2023 was conducted over two days – 16th and 23rd February 2023. February was a very dry month, with little rain in the weeks before the water sampling was conducted. Water levels in most canal sections to the east of the summit levels on both canals were close to normal, while those west of the summit levels were somewhat lower than normal for this time of year (Plate 2). The water was clear in most sections, although often stained due to water inflows from peaty areas. There was a good flow of water in most of the feeders and drains, even though there had been little rain in previous weeks. Water temperature over the sampling period varied from 6.3 to 8.7ºC and ranged from 7.0 to 8.7ºC on 16th and from 6.3 to 8.7ºC on 23rd February 2023 (see Appendix I). The highest temperature in Q1 of 8.7ºC was recorded at two sites – GCW20 (Ballycowan) and NL1 (Naas Line).

Plate 2. Low water levels on a frosty morning on the Royal Canal west of Ballydrum Bridge (RCW14) in February 2023.

The water was clear at all of the seven Grand Canal East (GCE) sites in Q1 2023 and water quality conditions were generally good. Phosphorus and nitrogen levels, including that for Ammonia, were low and well within acceptable limits. It is noteworthy that Ammonia levels were elevated at five sites in this section of canal in Q4 2022 and at three of the sites during Q1 2022 sampling. A low reading for Ammonia of 0.03mg/l N was recorded at GCE6 (Ponsonby Bridge) on this sampling occasion, where

an exceptionally high reading of 0.41mg/l N had been recorded here in Q2 2022. *E. coli* counts were also low on this sampling occasion, although an atypically high Total coliform count was recorded at GCE4 (Sallins), where it was necessary to take the water sample from between two moored cruisers. A low BOD reading of 1mg/l O_2 was recorded at only one of the seven sites (GCE1 – Robertstown). At five of these sites readings of 2mg/l O_2 were recorded, while at GCE8 (Hazelhatch) an unacceptably high reading of 3 mg/l O_2 was recorded. Because of the congestion with moored craft along the towpath on this section of canal, it was necessary to take this sample from between two craft. At the time of sampling, a thin film of oil was evident on the water surface at this site, but the water was crystal-clear and there was no sign of any discharge of deleterious matter to the canal.

As with the GCE sites, phosphorus levels at all 11 sites on Grand Canal West (GCW) were low, as were readings for TON, Nitrite and Nitrate (see Appendix I). Ammonia levels $\geq$ 0.1mg/l N were recorded at just two sites – GCW8 (east of Rhode) and GCW27 (L'Estrange Bridge) (see Appendix I). Total coliform and *E. coli* counts were very low at all sites on this sampling occasion. Particular attention during sampling in Q1 2023 was paid to GCW20 (Cornalaur) where high *E. coli* counts were recorded in Q3 and Q4 2022, and GCW1 (Bond Bridge) where relatively high counts were reported in Q2 2022. Results in Q1 2023 for all parameters at GCW1 were well within acceptable limits, while those for GCW20 were all low, except for a high BOD reading of 6mg/l O_2. Unacceptably high BOD readings (> 2.5mg/l O_2) have been recorded at sites in GCW during the last five sampling occasions. In Q1 and Q4 2022 and Q1 2023, BOD levels at 2, 4 and 3 sites, respectively, have exceeded this threshold. The sites responsible were GCW8, GCW12 (west of Daingean), GCW16 (Tullamore), GCW18 (Ballycowan), GCW20 and GCW22 (west of Pollagh). The reason(s) for the elevated BOD levels throughout this long section of the Grand Canal is not apparent and there was no evidence of organic pollution or excessive nutrient input to much of this section of canal during sampling. It is considered that contributions from the Ballymullen (GC12.1) and Ballylennon (GC13.1) feeders could have contributed somewhat to these levels, although this was unlikely to result in the elevated BOD levels recorded at sites east (upstream) of the feeders or at sites distant from them. It is possible that the decay of aquatic vegetation in the channel following weed cutting or winter decline may have contributed to the elevated BOD levels recorded. It will be important to remain vigilant during sampling on this section of canal to determine if there are any external sources of organic pollution to the waterway. In particular, it will be important to examine the sites where high BOD readings were recorded in Q1 2023 – GCW8, GCW18 and GCW20. It is interesting that readings for all parameters at GCW12, which is located close to where the Ballymullen and Ballylennon feeders enter the canal, were low on this sampling occasion and indicated good water quality conditions. This was the case even though nutrient rich water was being discharged from the feeders to this section of canal (see Section 3.3).

The water in the Naas Line at NL1 in Q1 2023 was relatively clear, although a slight opaqueness remained. Phosphorus and Ammonia levels were low on this sampling occasion, as were levels for

BOD, Total coliform and *E. coli* (see Appendix I). TON and Nitrate readings, however, were high and indicate that nitrogen-rich water continues to enter the canal, probably *via* runoff from Naas town that discharges into the harbour. While TON and Nitrate levels at this site were elevated on all sampling occasions in 2022, those recorded in Q1 2023 were the highest recently reported. Waterways Ireland should share these results with Kildare County Council to inform them that water of unacceptable quality is making its way to the canal.

Water quality conditions in the Milltown Feeder (MF1) were excellent in Q1 2023, with low values reported for most of the physico-chemical parameters measured (see Appendix I). The channel supported a good flow of crystal-clear water on this occasion.

On the Barrow Line, the levels recorded for TP, MRP, SRP, Total coliforms, *E. coli* and Ammonia were all low in Q1 2023 and well within acceptable limits (see Appendix I). The levels for TON and Nitrate were very high at BL10 (Vicarstown) and elevated at BL15 (Athy). The latter is probably explained by the very high TON and Nitrate input recorded on this sampling occasion in February from BL15.1 (Athy Drain) (see Appendix II), while that at the former site probably resulted from the Annonock stream that discharges immediately upstream and is known to support very high nitrogen levels. Again, this information should be supplied to Kildare County Council, with a request that they address the ongoing enrichment to the canal from this stream. A high BOD reading of 3mg/l O_2 was recorded at BL6 (Umeras), although the levels reported for all the other parameters measured were low. The water was relatively clear on this sampling occasion and there was no sign of any disturbance to the channel.

Water quality conditions were generally good at most sites on Royal Canal East (RCE) (see Appendix I). TP, MRP and SRP levels were very low, bar one elevated TP reading of 0.054mg/l P at RCE25 (Croke Park). It is noteworthy that this site also reported a high BOD level of 3mg/l O_2 on this occasion, the highest level recorded among the ten sites on this section of canal in February 2023. The water level at this site was somewhat lower than normal for the time of year but the water was clear and there was no evidence of any disturbance in the channel. The reason for these high readings is not obvious but the site will be examined closely on the next sampling occasion. Ammonia levels were generally low in Q1, with just two sites reporting values $\geq$ 0.1mg/l N. These were recorded at RCE4 (McNead's Bridge) and RCE8 (Hill of Down). The was no repeat of the high BOD reading of 4mg/l O_2 reported at RCE4 in Q4 2022 at this site. *E. coli* counts were very low at all sites and a count of just 63 per 100ml was recorded at RCE12 (Cloncurry), where a very high count of 2359 per 100ml was reported in Q4 2022.

Levels recorded for most parameters at the seven sites in Royal Canal West (RCW) were low and well within acceptable limits (see Appendix I) in Q1 2023. Just one high reading for Ammonia (0.12mg/l N) was recorded in February 2023, at RCW12 (Island Bridge). A high BOD level of 4mg/l O_2 was recorded at this site in Q4 2022, while the level recorded on this sampling occasion was 1mg/l O_2. No Ammonia

reading at any of the other sites exceeded 0.07mg/l N on this occasion. In Q4 2022, however, six of the seven sites on this section of the Royal Canal reported Ammonia readings $\geq$ 0.09mg/l N.

The levels for most parameters measured at monitoring site SE40 on the Shannon-Erne Waterway in Q1 2023 were low and indicative of good water quality conditions (see Appendix I). While a high BOD reading of 4mg/l O_2 was recorded at this site in Q4 2022, there was no evidence of any disturbance and a more moderate reading of 2mg/l O_2 was reported here in February 2023. While high levels of MRP, SRP and *E. coli* were reported at SE42 (Leitrim village) in October 2022, this was only repeated for MRP in Q1 2023 (see Appendix I). All other readings were low and well within acceptable limits. On this sampling occasion, there was a brisk flow of moderately turbid water in the channel but there was no sign of any discharge of deleterious matter to the waterway.

3.2. *Indicative Ecological Potential of Canal Sites and Artificial Water Bodies*

Breaches of determinand threshold limits were recorded at ten of the 43 canal and Shannon-Erne sites examined in Q1 2023, resulting in each being assigned Moderate rather than Good indicative eco-potential (Table 3 and Figure 5). This compared with 15, 8 and 12 sites, respectively, that were assigned Moderate status at the same time of year (Q1) in 2022, 2021 and 2020, and 14 sites that were at Moderate status in Q4 2022.

Nine of the ten sites that were at Moderate indicative eco-potential in Q1 2023 had threshold breaches for just one of the six determinand parameters. Five of these sites displayed breaches for BOD and two each displayed breaches for Ammonia and TON (Table 3). Just one site (GCW8) had breaches for two parameters – BOD, with a very high level of 9mg/l O_2, and Ammonia. In total, six sites breached the BOD threshold, while three breached the Ammonia and two breached the TON thresholds (Table 3). It is noteworthy that 14 sites breached the Ammonia threshold in Q1 2022.

Eleven of the 15 AWBs were assigned Good indicative eco-potential based on the physico-chemical parameters analysed in Q1 2023 (Table 4). Of the four AWBs that breached threshold limits, two breached for BOD and one each for Ammonia and TON (Table 4). Two of the four are single site AWBs (GCNL_09 and RC_26C), one is a two site AWB (GC_14W) and the remaining AWB (GC_25A) has six sites.

Table 3. Classification of the 43 canal sites in the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands for Q1 2023.

AWB	Site Code	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	GCE4	2023	0.017	0.010	2.610	97.000	2.000	0.030	Good
	GCE6	2023	0.018	0.010	2.510	10.000	2.000	0.030	Good
	GCE8	2023	0.016	0.010	2.200	10.000	3.000	0.040	Moderate
	GCE10	2023	0.017	0.010	2.120	10.000	2.000	0.030	Good
	GCE12	2023	0.013	0.010	1.930	10.000	2.000	0.030	Good
	GCE14	2023	0.018	0.010	1.770	10.000	2.000	0.040	Good
GCNL_09	NL1	2023	0.013	0.010	4.610	60.000	1.000	0.020	Moderate
GCMF_14	MF1	2023	0.013	0.010	2.750	10.000	1.000	0.030	Good
GCBL_14	BL2	2023	0.019	0.010	1.390	10.000	2.000	0.050	Good
	BL6	2023	0.017	0.010	2.450	10.000	3.000	0.030	Moderate
	BL10	2023	0.020	0.010	4.880	10.000	2.000	0.040	Moderate
	BL15	2023	0.020	0.010	3.290	145.000	2.000	0.060	Good
GC_14E	GCE1	2023	0.013	0.010	2.400	10.000	1.000	0.030	Good
	GCW1	2023	0.013	0.010	2.240	10.000	2.000	0.020	Good
GC_14W	GCW8	2023	0.026	0.010	1.370	10.000	9.000	0.120	Moderate
	GCW12	2023	0.035	0.010	2.170	10.000	2.000	0.090	Good
GC_07	GCW4	2023	0.013	0.010	1.810	10.000	2.000	0.040	Good
	GCW6	2023	0.013	0.010	1.170	10.000	2.000	0.060	Good
GC_25A	GCW16	2023	0.022	0.010	1.740	10.000	2.000	0.030	Good
	GCW18	2023	0.020	0.010	1.790	10.000	4.000	0.060	Moderate
	GCW20	2023	0.015	0.010	2.470	10.000	6.000	0.060	Moderate
	GCW22	2023	0.015	0.010	2.150	10.000	2.000	0.060	Good
	GCW24	2023	0.013	0.010	1.930	10.000	2.000	0.060	Good
	GCW27	2023	0.013	0.010	0.500	10.000	2.000	0.100	Good
GCB*	GCB4	2023	0.026	0.010	2.310	10.000	1.000	0.050	Good
	GCB7	2023	0.021	0.010	2.310	495.000	2.000	0.120	Moderate
RC_07	RCE4	2023	0.013	0.010	0.500	10.000	2.000	0.140	Moderate
	RCE6	2023	0.013	0.010	1.280	10.000	1.000	0.080	Good
	RCE8	2023	0.018	0.010	0.500	10.000	2.000	0.100	Good
	RCE9	2023	0.017	0.010	0.500	10.000	2.000	0.060	Good
	RCE12	2023	0.015	0.010	2.340	63.000	2.000	0.050	Good
RC_09	RCE14	2023	0.017	0.010	1.700	10.000	2.000	0.040	Good
	RCE16	2023	0.021	0.010	2.330	10.000	2.000	0.030	Good
	RCE19	2023	0.013	0.010	2.160	10.000	1.000	0.050	Good
	RCE22	2023	0.017	0.010	1.100	31.000	2.000	0.050	Good
	RCE25	2023	0.054	0.010	1.390	10.000	3.000	0.030	Moderate
RC_25A	RCW1	2023	0.013	0.010	0.500	10.000	1.000	0.040	Good
	RCW3	2023	0.013	0.010	0.500	10.000	2.000	0.060	Good
RC_26F	RCW5	2023	0.014	0.010	0.890	10.000	2.000	0.070	Good
	RCW7	2023	0.013	0.010	1.190	10.000	1.000	0.060	Good
	RCW9	2023	0.013	0.010	1.340	10.000	1.000	0.070	Good
RC_26E	RCW12	2023	0.015	0.010	0.500	10.000	1.000	0.120	Moderate
RC_26C	RCW14	2023	0.013	0.010	0.500	10.000	1.000	0.060	Good
SE_26A	SE40	2023	0.024	0.010	0.500	10.000	2.000	0.080	Good
	SE42	2023	0.034	0.020	0.500	10.000	2.000	0.050	Good

* The Grand Canal Basin is not a designated AWB.

Table 4. Indicative ecological potential for the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands in Q1 2023.

AWB	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	2023	0.017	0.010	2.190	24.500	2.167	0.033	Good
GCNL_09	2023	0.013	0.010	**4.610**	60.000	1.000	0.020	Moderate
GCMF_14	2023	0.013	0.010	2.750	10.000	1.000	0.030	Good
GCBL_14	2023	0.019	0.010	3.003	43.750	2.250	0.045	Good
GC_14E	2023	0.013	0.010	2.320	10.000	1.500	0.025	Good
GC_14W	2023	0.031	0.010	1.770	10.000	**5.500**	0.105	Moderate
GC_07	2023	0.013	0.010	1.490	10.000	2.000	0.050	Good
GC_25A	2023	0.016	0.010	1.763	10.000	**3.000**	0.062	Moderate
GCB*	2023	0.024	0.010	2.310	252.500	1.500	0.085	Good
RC_07	2023	0.015	0.010	1.024	20.600	1.800	0.086	Good
RC_09	2023	0.024	0.010	1.736	14.200	2.000	0.040	Good
RC_25A	2023	0.013	0.010	0.500	10.000	1.500	0.050	Good
RC_26F	2023	0.013	0.010	1.140	10.000	1.333	0.067	Good
RC_26E	2023	0.015	0.010	0.500	10.000	1.000	**0.120**	Moderate
RC_26C	2023	0.013	0.010	0.500	10.000	1.000	0.060	Good
SE_26A	2023	0.029	0.015	0.500	10.000	2.000	0.065	Good

* The Grand Canal Basin is not a designated AWB.

3.3. *Physico-chemistry and Indicative Ecological Potential of Canal Feeders/Drains*

Just two of the five feeders/drains were assigned Good indicative eco-potential based on physico-chemical sampling in Q1 2023 (see Appendix II and Figure 5). This compared with no feeders/drains at Good in Q4 2022 and only one at Good in Q1 last year.

When sampled on 16th February 2023 there was a moderate flow of grey-coloured water discharging from the Monread drain (GCE5.1) and it had a distinctive oily slick (Plate 3). The results from the physico-chemical analysis of the samples taken on that day revealed that no organic pollutants were being discharged through the drain at that time (see Appendix II) and that the oil and discolouration probably resulted from road works or road run-off somewhere along the course of the drain. On this occasion the indicative eco-potential of the drain water was Good. In Q2 and Q4 2022, the water discharging from this drain was assigned Moderate status, on both occasions for breaches in the threshold for *E. coli*, among other parameters. In Q1 2023, the *E. coli* count was low, at 175 per 100ml.

Plate 3. Oily slick on the water discharging from the Monread Feeder (GCE5.1) on 15th February 2023 (photo – Eamonn Horgan).

On 23rd February 2023 there was a moderate flow of clear water emerging from both the Ballymullen (GCW12.1) and the Ballylennon (GCW13.1) feeders. On this occasion, the MRP and SRP levels in the water from the former feeder were high, with that for SRP breaching the threshold limit (Table 5). The levels for all the other parameters examined were relatively low and indicative of at least moderate water quality conditions. This site reported high readings for BOD (5mg/l O$_2$) and *E. coli* (2098 counts per 100ml) in Q4 and Q3 2022, respectively. Levels for these parameters were significantly lower in Q1 2023 (see Appendix I and Table 5).

The physico-chemistry results from the Ballylennon feeder reported very low bacteriological counts but high phosphorus levels, particularly for MRP and SRP, the latter breaching the threshold limit (see Appendix II and Table 5). Further threshold breaches were recorded for BOD and Ammonia, with the former reporting a very high level of 7mg/l O$_2$. As a result, the site was assigned Moderate indicative eco-potential on this occasion. In Q1 2022, the water emerging from this feeder was polluted and breached five of the six threshold parameters, with *E. coli* being the only determinand parameter that was not breached. This feeder was at Good status in Q2 and Q3 of that year, before being yet again assigned Moderate status in Q4, for a breach of the SRP threshold limit. It is important that Offaly County Council continue to be informed of the water quality conditions of both feeders and particularly of the poor quality of the water discharging from the Ballylennon feeder to the canal on this sampling occasion.

The Athy drain (BL15.1) was discharging a small volume of grey-coloured water to the Barrow Canal when sampled on 16th February 2023. Phosphorus levels were very low on this occasion but nitrogen levels, particularly for TON and Nitrate, were very high, with the former breaching the threshold limit (see Appendix II and Table 5). Readings for most other parameters were at acceptable levels. It is

noteworthy that, not since Q3 2021 has the water from this drain been assigned Good indicative eco-potential, even though Kildare County Council (KCC) has been working to address the problem. It is recommended that KCC be informed of the most recent results and for an update on the status of their investigations relating to this drain.

On 16th February 2023 there was a moderate flow of clear water from the Kilcock drain (RCE16.1) to Kilcock harbour. Levels reported for most parameters measured were relatively low and indicative of moderate to good water quality conditions. For this reason, the drain was assigned Good indicative eco-potential. This drain was at Moderate status in Q1, Q3 and Q4 2022 for breaches in nutrient determinand parameters.

3.4. *Grand Canal Basin*

A Dublin City Council urban wastewater outfall is located in the inner Grand Canal Basin (see Figure 3). This outfall is used to carry storm water overflow but, on occasions, sewage contamination is discharged to the Basin *via* this outfall.

When sampled in mid-February 2023, the water level in the basin was normal for the time of year and the water was clear. Results from physico-chemical analysis of water from the inner basin (GCB4) were good, with levels for all parameters being well within acceptable limits (see Appendix I and Table 3). Levels for most parameters in the outer basin (GCB7) were also low, except for Ammonia which, at 0.12mg/l N, equalled the threshold limit for that parameter and resulted in the site being assigned Moderate indicative eco-potential (Table 3). In Q4 2022, the water sampled in both the inner and outer basins showed high levels of TP, MRP, SRP and Ammonia. However, an unacceptable high *E. coli* count of > 24,000 per 100ml was recorded in the outer basin, indicating the presence of bacteriologically contaminated water in the basin at that time. *E. coli* counts at both sites in Q1 2023 were significantly lower than those recorded in GCB7 in Q4 2023.

When the data for the two sites in Grand Canal Basin were assessed, this artificial waterbody was assigned Good status (Table 4).

No data from bacteriological sampling of the basin by WI and DCC was available for this period.

4. Issues for Waterways Ireland Resulting from Sampling in Q1 2023

During water sampling in 2022, elevated levels for TON were recorded in all four quarters at NL1 on the Naas Line but the threshold limit for this determinand parameter (4.1mg/l N) was not breached. In Q1 2023, however, a high TON reading of 4.61mg/l N was recorded at this site. It is clear that nitrogen-rich water continues to enter the Naas Line at Naas harbour, something that Kildare County Council should be made aware of.

Another site that has reported very high readings for TON over the last few years is BL10 (upstream of Vicarstown), where a level of 4.88mg/l N was recorded in Q1 2023. Clearly, nitrogen-rich water continues to be discharged to the Barrow Canal *via* the Annonock feeder, which is located immediately upstream of this site. Again, it is important that information regarding this unsatisfactory situation is made available to the appropriate local authority and that some form of mitigation is seen to be put in place.

Both the Ballymullen and Ballylennon feeders continue to discharge water of poor quality into the Grand Canal west of Daingean. SRP levels in breach of the threshold limit were recorded at both sites in Q1 2023, while unacceptably high BOD and Ammonia levels were also reported from the Ballylennon site. Although Offaly County Council has been informed about this problem on numerous occasions, WI should continue to copy them in with the results from physico-chemical analyses and urge them to acknowledge and address these ongoing issues.

The Athy drain was assigned Moderate rather than Good indicative eco-potential in Q1 2023, for the sixth sampling occasion in a row, on this occasion because of a TON reading that far exceeds the threshold limit for this parameter. While it is acknowledged that Kildare County Council has addressed some of the problems affecting water quality in this area, water of an unsatisfactory standard is continuing to access the Barrow Canal *via* the Athy drain.

Figure 5. Indicative ecological potential based on physico-chemical data for the 50 canal, Shannon-Erne Waterway and feeder/drain sites monitored in Q1 2023 (Green = Good, Yellow = Moderate).

Appendix I. Physico-chemical results and indicative ecological potential for canal (41), Shannon-Erne Waterway (2) and Grand Canal Basin (2) sites sampled in Q1 2023.

Canal	Site Code	AWB	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature	Conductivity (µS)	pH	DO %	DO (mg/L O₂)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO₃)	Indicative Physico-chemical Potential
Grand Canal	GCE1	GC_14E	Q1	16/02/2023	0.013	0.010	0.010	2.400	7.2	470	8.10	98.1	10.40	31	10	1.00	0.030	0.010	2.390	6.960	348.45	Good
Grand Canal	GCE4	GC_09	Q1	16/02/2023	0.017	0.010	0.010	2.610	8.0	467	8.19	94.0	10.06	24,196	97	2.00	0.030	0.010	2.600	6.040	302.21	Good
Grand Canal	GCE6	GC_09	Q1	16/02/2023	0.018	0.010	0.010	2.510	8.0	464	8.21	96.4	10.98	199	10	2.00	0.030	0.010	2.500	6.210	310.79	Good
Grand Canal	GCE8	GC_09	Q1	16/02/2023	0.016	0.010	0.010	2.200	7.4	445	8.20	98.4	11.43	135	10	3.00	0.040	0.010	2.190	5.790	289.67	Moderate
Grand Canal	GCE10	GC_09	Q1	16/02/2023	0.017	0.010	0.010	2.120	7.5	422	8.37	102.0	12.20	10	10	2.00	0.030	0.010	2.110	5.350	267.86	Good
Grand Canal	GCE12	GC_09	Q1	16/02/2023	0.013	0.010	0.010	1.930	7.6	416	8.40	95.3	11.26	20	10	2.00	0.030	0.010	1.920	5.400	270.41	Good
Grand Canal	GCE14	GC_09	Q1	16/02/2023	0.018	0.010	0.010	1.770	7.5	208	8.30	86.5	10.25	10	10	2.00	0.040	0.010	1.760	5.210	260.82	Good
Grand Canal	GCW1	GC_14E	Q1	16/02/2023	0.013	0.010	0.010	2.240	7.5	443	8.09	92.1	11.02	30	10	2.00	0.020	0.010	2.240	6.350	317.57	Good
Grand Canal	GCW4	GC_07	Q1	23/02/2023	0.013	0.010	0.010	1.810	7.8	407	8.25	102.0	12.05	10	10	2.00	0.040	0.010	1.800	5.340	267.17	Good
Grand Canal	GCW6	GC_07	Q1	23/02/2023	0.013	0.010	0.010	1.170	7.8	394	8.24	91.4	10.80	10	10	2.00	0.060	0.010	1.150	5.220	261.18	Good
Grand Canal	GCW8	GC_14W	Q1	23/02/2023	0.026	0.020	0.010	1.370	8.2	392	8.50	98.5	11.57	10	10	9.00	0.120	0.010	1.370	5.210	260.52	Moderate
Grand Canal	GCW12	GC_14W	Q1	23/02/2023	0.035	0.020	0.010	2.170	8.1	492	8.20	102.0	12.10	10	10	2.00	0.090	0.020	2.150	6.810	340.63	Good
Grand Canal	GCW16	GC_25A	Q1	23/02/2023	0.022	0.010	0.010	1.740	8.0	446	8.39	90.4	10.00	10	10	2.00	0.030	0.020	1.720	5.870	293.88	Good
Grand Canal	GCW18	GC_25A	Q1	23/02/2023	0.020	0.010	0.010	1.790	8.3	433	8.43	93.7	10.90	20	10	4.00	0.060	0.010	1.790	5.760	288.52	Moderate
Grand Canal	GCW20	GC_25A	Q1	23/02/2023	0.015	0.010	0.010	2.470	8.7	375	8.29	94.1	10.90	10	10	6.00	0.060	0.010	2.470	4.760	238.47	Moderate
Grand Canal	GCW22	GC_25A	Q1	23/02/2023	0.015	0.010	0.010	2.150	8.6	400	8.34	94.5	9.81	10	10	2.00	0.060	0.010	2.150	5.190	259.86	Good
Grand Canal	GCW24	GC_25A	Q1	23/02/2023	0.013	0.010	0.010	1.930	8.2	360	8.15	71.4	8.34	10	10	2.00	0.060	0.020	1.910	4.620	231.43	Good
Grand Canal	GCW27	GC_25A	Q1	23/02/2023	0.013	0.010	0.010	0.500	8.2	314	8.16	95.6	11.60	10	10	2.00	0.100	0.010	0.500	3.990	199.74	Good
Grand Canal	NL1	GCNL_09	Q1	16/02/2023	0.013	0.010	0.010	4.610	8.7	470	8.10	87.0	10.11	292	60	1.00	0.020	0.010	4.600	6.310	316.01	Moderate
Grand Canal	MF1	GCMF_14	Q1	16/02/2023	0.013	0.010	0.010	2.750	8.3	484	8.04	90.7	10.35	31	10	1.00	0.030	0.010	2.740	6.940	347.45	Good
Grand Canal	BL2	GCBL_14	Q1	16/02/2023	0.019	0.010	0.010	1.390	7.9	416	8.15	96.8	11.36	10	10	2.00	0.050	0.010	1.380	6.290	314.88	Good
Grand Canal	BL6	GCBL_14	Q1	16/02/2023	0.017	0.010	0.010	2.450	7.9	431	8.21	90.6	10.52	10	10	3.00	0.030	0.010	2.440	5.790	289.65	Moderate
Grand Canal	BL10	GCBL_14	Q1	16/02/2023	0.020	0.010	0.010	4.880	8.1	491	7.91	80.1	9.06	10	10	2.00	0.040	0.010	4.870	6.140	307.15	Moderate
Grand Canal	BL15	GCBL_14	Q1	16/02/2023	0.020	0.010	0.010	3.290	8.3	432	8.20	84.7	9.86	908	145	2.00	0.060	0.030	3.260	4.940	247.07	Good
Grand Canal	GCB4	GCB*	Q1	16/02/2023	0.026	0.010	0.010	2.310	7.0	425	8.50	104.0	12.50	10	10	1.00	0.050	0.010	2.300	5.070	253.65	Good
Grand Canal	GCB7	GCB*	Q1	16/02/2023	0.021	0.010	0.010	2.310	8.0	418	8.30	94.0	11.15	691	495	2.00	0.120	0.020	2.290	5.170	258.81	Moderate
Royal Canal	RCE4	RC_07	Q1	23/02/2023	0.013	0.010	0.010	0.500	7.3	427	8.19	81.4	9.83	10	10	2.00	0.140	0.010	0.500	5.960	298.49	Moderate
Royal Canal	RCE6	RC_07	Q1	23/02/2023	0.013	0.010	0.010	1.280	7.3	413	8.07	88.9	10.37	10	10	1.00	0.080	0.010	1.270	5.550	277.97	Good
Royal Canal	RCE8	RC_07	Q1	23/02/2023	0.018	0.010	0.010	0.500	7.6	371	8.15	94.9	11.40	145	10	2.00	0.100	0.010	0.500	4.810	240.76	Good
Royal Canal	RCE9	RC_07	Q1	16/02/2023	0.017	0.010	0.010	0.500	7.7	384	8.15	84.3	9.73	1,050	10	2.00	0.060	0.010	0.500	5.110	255.86	Good
Royal Canal	RCE12	RC_07	Q1	16/02/2023	0.015	0.010	0.010	2.340	7.6	480	8.07	86.0	10.24	98	63	2.00	0.050	0.010	2.330	6.920	346.25	Good
Royal Canal	RCE14	RC_09	Q1	16/02/2023	0.017	0.010	0.010	1.700	8.1	306	7.85	85.0	9.94	10	10	2.00	0.040	0.010	1.690	6.510	325.89	Good
Royal Canal	RCE16	RC_09	Q1	16/02/2023	0.021	0.010	0.010	2.330	7.5	490	8.25	96.7	11.49	1,076	10	2.00	0.030	0.010	2.320	6.430	321.96	Good
Royal Canal	RCE19	RC_09	Q1	16/02/2023	0.013	0.010	0.010	2.160	7.6	476	8.34	102.1	12.23	10	10	1.00	0.050	0.010	2.150	6.120	306.33	Good
Royal Canal	RCE22	RC_09	Q1	16/02/2023	0.017	0.010	0.010	1.100	7.4	471	7.90	129.0	15.00	175	31	2.00	0.050	0.010	1.100	6.200	310.45	Good
Royal Canal	RCE25	RC_09	Q1	16/02/2023	0.054	0.010	0.010	1.390	7.4	442	8.24	130.0	15.00	108	10	3.00	0.030	0.010	1.390	7.300	365.32	Moderate
Royal Canal	RCW1	RC_25A	Q1	23/02/2023	0.013	0.010	0.010	0.500	6.3	214	8.06	83.4	10.10	10	10	1.00	0.040	0.010	0.500	2.950	147.43	Good
Royal Canal	RCW3	RC_25A	Q1	23/02/2023	0.013	0.010	0.010	0.500	7.1	215	8.05	82.5	9.86	10	10	2.00	0.060	0.010	0.500	3.280	164.41	Good
Royal Canal	RCW5	RC_26F	Q1	23/02/2023	0.014	0.010	0.010	0.890	7.7	370	7.97	83.0	8.06	10	10	2.00	0.070	0.010	0.890	5.330	266.88	Good
Royal Canal	RCW7	RC_26F	Q1	23/02/2023	0.013	0.010	0.010	1.190	7.5	419	8.27	81.9	8.27	10	10	1.00	0.060	0.010	1.180	5.850	293.04	Good
Royal Canal	RCW9	RC_26F	Q1	23/02/2023	0.013	0.010	0.010	1.340	7.7	401	8.21	84.0	9.81	10	10	1.00	0.070	0.010	1.340	5.560	278.28	Good
Royal Canal	RCW12	RC_26E	Q1	23/02/2023	0.015	0.020	0.010	0.500	7.9	309	7.99	74.1	8.63	10	10	1.00	0.120	0.010	0.500	3.910	195.82	Moderate
Royal Canal	RCW14	RC_26C	Q1	23/02/2023	0.013	0.010	0.010	0.500	6.7	228	8.16	79.1	9.56	10	10	1.00	0.060	0.010	0.500	2.980	149.20	Good
Shannon Erne	SE40	SE_26A	Q1	23/02/2023	0.024	0.020	0.010	0.500	7.7	182	8.07	76.7	9.10	10	10	2.00	0.080	0.010	0.500	2.040	102.26	Good
Shannon Erne	SE42	SE_26A	Q1	23/02/2023	0.034	0.030	0.020	0.500	7.4	367	8.40	81.4	9.72	30	10	2.00	0.050	0.010	0.500	3.400	170.42	Good

Appendix II. Physico-chemical results and indicative ecological potential for canal feeder/drain sites sampled in Q1 2023.

Canal	Site	Location	AWB_Code	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature (degree C)	Conductivity (µS)	pH	DO %	DO (mg/L O$_2$)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO$_3$)	Indicative Physico-chemical Potential
Grand Canal	GCE5.1	Monread Feeder	GC_09	Q1	16/02/2023	0.024	0.010	0.020	3.150	8.40	475	8.05	89.5	10.60	3,255	175	1.00	0.020	0.020	3.140	5.890	294.59	Good
Grand Canal	GCW12.1	Ballymullen Feeder	GC_14	Q1	23/02/2023	0.040	0.030	0.030	3.050	6.90	495	8.10	96.6	11.71	52	10	2.00	0.070	0.040	3.020	7.370	369.05	Moderate
Grand Canal	GCW13.1	Ballylennon Feeder	GC_14	Q1	23/02/2023	0.057	0.050	0.040	1.880	6.60	442	7.73	82.5	9.95	31	10	7.00	0.160	0.030	1.850	6.090	304.87	Moderate
Grand Canal Barrow Line	BL15.1	Athy Drain	GCBL_14	Q1	16/02/2023	0.018	0.010	0.010	6.120	9.20	426	8.60	85.8	9.50	1,616	63	2.00	0.060	0.020	6.090	5.280	264.51	Moderate
Royal Canal	RCE16.1	Kilcock Harbour Drain	RC_09	Q1	16/02/2023	0.032	0.020	0.010	2.020	7.40	479	8.25	84.0	9.90	5,172	146	2.00	0.080	0.010	2.010	3.690	184.79	Good

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Appendix V

Water Framework Directive Compliance Report

Physico-chemistry

Second Quarter 2023

Water Framework Directive Compliance Report

Physico-chemistry

Second Quarter 2023

June 2023

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Front Cover: Turbid water post-weed cutting at Ballycowan (GCW20) on 25th May 2023.

1. Introduction

Water Framework Directive (WFD) surveillance monitoring of the Royal and Grand Canals and the canalised section of the Shannon-Erne Waterway for Q2 2023 was carried out on 17th and 25th May 2023.

A canal is identified as an Artificial Water Body (AWB) in the WFD and is defined as 'a body of water created by human activity'. In recognition of their navigational role, AWBs must achieve good ecological potential as opposed to good ecological status, the latter which applies to natural water bodies, such as rivers and lakes. Ecological potential is assessed using a combination of biological (native and invasive macroinvertebrate and macrophyte), physico-chemical and hydromorphological quality elements. For classification purposes, the ecological potential of a site or AWB can be Maximum, Good, Moderate, Poor or Bad. Where physico-chemistry alone is being assessed, as in this report, sites and AWBs can achieve either Good or Moderate potential only. In assigning ecological potential, the one-out-all-out rule applies, whereby the lowest value quality element determines the overall classification of the AWB. A system for classifying British and Irish canals based on macroinvertebrate, macrophyte, invasive species, physico-chemical and hydromorphological quality elements is used to assess the ecological potential of AWBs. In the current reporting period (Q2 2023), the canals are classified based on the physico-chemistry of the water during this period.

Figure 1. Artificial Water Bodies (AWBs), sites and monitored feeder streams on the Royal and Grand Canals, and the Shannon-Erne Waterway. The AWBs are grouped based on associated river catchments.
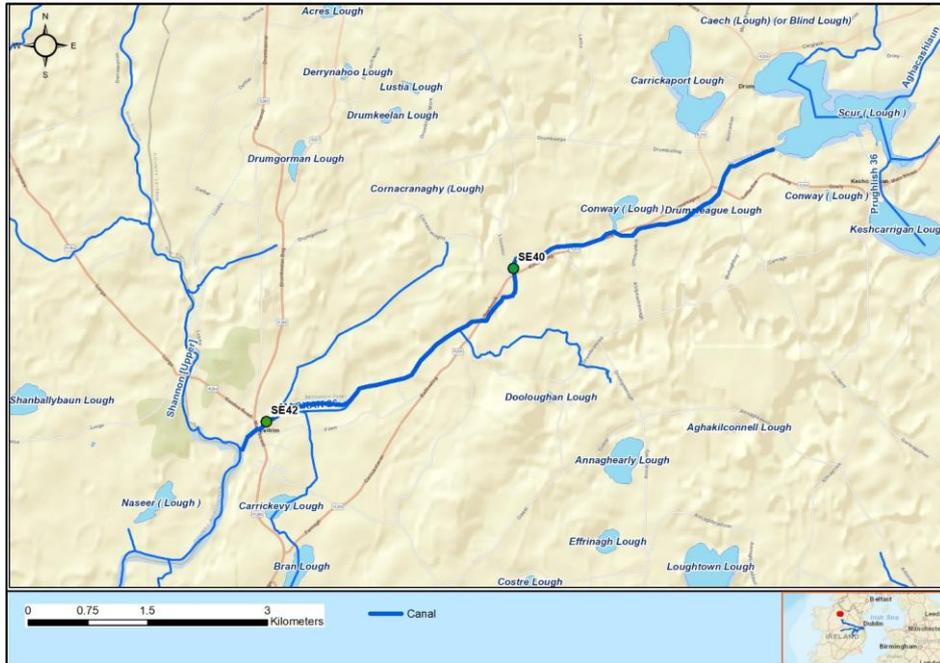
The canals are currently divided into 15 AWBs based on their locations within river catchments (Table 1). The Grand Canal supports eight AWBs (this does not include the Grand Canal Basin), the Royal Canal has six AWBs and there is just a single AWB on the Shannon-Erne Waterway. Four of the AWBs have only a single canal sampling site (Table 1), which can be potentially problematic when ecological potential for individual AWBs is being assigned. This reflects the fact that a breach in any biological or abiotic parameter can result in the AWB being changed from Good to Moderate.

For reporting purposes, a simple code has been assigned, whereby AWBs are labelled according to the river catchment in which they occur (Table 1).

Table 1. Artificial Water Bodies (AWBs) included in the WFD Monitoring Programme.

Artificial Water Body (AWB)	Catchment No	New ID Code	New Report Code	Length (km)	No of Sites
GRAND CANAL					
Grand Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_GCMLE	GC_09	41.4	6
Grand Canal Main Line East - Barrow	14	IE_14_AWB_GCMLE	GC_14E	15.7	2
Grand Canal Main Line West - Barrow	14	IE_14_AWB_GCMLW	GC_14W	12.9	2
Grand Canal Main Line - Boyne	7	IE_07_AWB_GCMLW	GC_07	14.5	2
Grand Canal Main Line - Lower Shannon	25A	IE_25A_AWB_GCMLW	GC_25A	47.0	6
Grand Canal Naas Line - Liffey and Dublin Bay	9	IE_09_AWB_GCNL	GCNL_09	11.9	1
Grand Canal Milltown Feeder - Barrow	14	IE_14_AWB_GCMF	GCMF_14	10.5	1
Grand Canal Barrow Line - Barrow	14	IE_14_AWB_GCBL	GCBL_14	50.8	4
Grand Canal Basin - Liffey and Dublin Bay	9	IE_09_AWB_GCB	GCB		2
ROYAL CANAL					
Royal Canal Main Line - Boyne Catchment	7	IE_07_AWB_RCMLE	RC_07	42.6	5
Royal Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_RCMLE	RC_09	39.4	5
Royal Canal Main Line - Lower Shannon	25A	IE_25A_AWB_RCMLW	RC_25A	13.3	2
Royal Canal Main Line - Upper Shannon	26F	IE_26F_AWB_RCMLW	RC_26F	33.8	3
Royal Canal Main Line - Upper Shannon	26E	IE_26E_AWB_RCMLW	RC_26E	3.7	1
Royal Canal Main Line - Upper Shannon	26C	IE_26C_AWB_RCMLW	RC_26C	14.2	1
SHANNON ERNE WATERWAY					
Shannon Erne Waterway - Upper Shannon	26A	IE_26A_AWB_SEW	SE_26A	25.5	2

During 2020 a second site (SE42) was included on the Shannon-Erne Waterway to better represent the water quality status of this Waterway and AWB (Table 1.1). This site is located adjacent to the marina in Leitrim village, close to where the Shannon-Erne Waterway discharges to the River Shannon (Figure 2).

Figure 2. Location of the two WFD monitoring sites (SE40 and 42) on the Shannon-Erne Waterway.
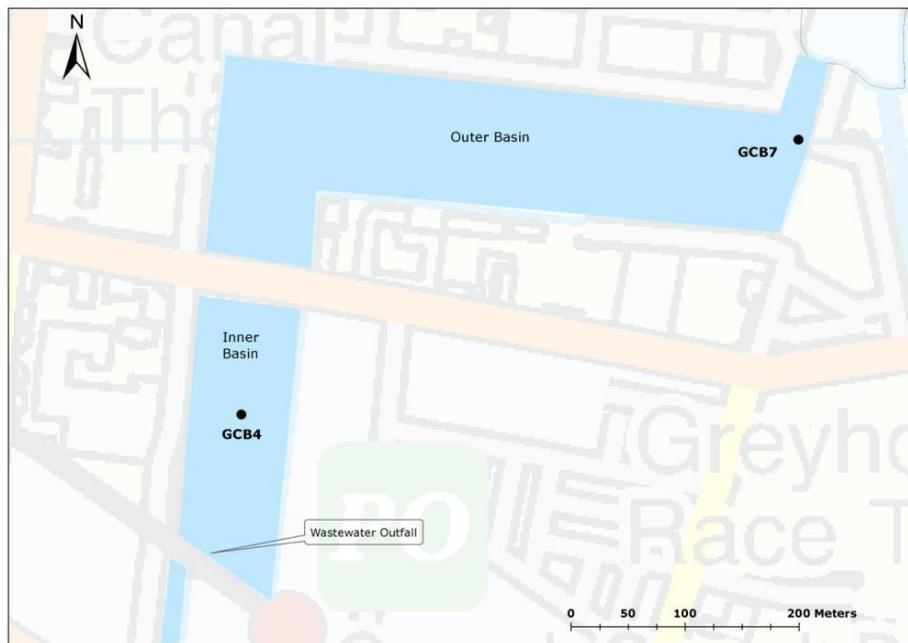

Plate 1. Discharge from the Athy drain (BL15.1) into the Barrow Canal at Athy (BL15) on 17ᵗʰ May 2023.

2. Materials and Methods

2.1. *Sampling locations*

Physico-chemical sampling is conducted on a quarterly basis at 50 monitoring sites – 41 on the Royal, Grand and Barrow Canals, two on the Grand Canal Basin, two on the Shannon-Erne Waterway, and five on selected canal feeder streams/drains (see Figures 1, 2 and 3). The canal feeders/drains have been a source of elevated nutrient and coliform inputs in the past. They include the Monread drain (GCE5.1) and Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeder streams on the Grand Canal, the Athy drain (BL15.1) on the Barrow Line, and the Kilcock Harbour drain (RCE16.1) on the Royal Canal. In addition to the quarterly water samples taken by INVAS at two sites in the Grand Canal Basin as part of the WFD Canals Surveillance Programme, Waterways Ireland (WI) and Dublin City Council (DCC) conduct regular water sampling for bacteriological (*E. coli* and *Enterococci*) analysis at up to 11 sites in the Basin (three in the Inner, eight in the Outer) and two in the adjacent Grand Canal (Figure 4). In 2022 and 2023, just five samples for bacteriology have been collected and analysed on a fortnightly basis. The sampling sites were 1st level of the Grand Canal (1), the inner basin (2 – sites 4 and 5 in Figure 4) and the outer basin (2 – sites 6 and 7 in Figure 4).

Figure 3. Grand Canal Basin (Dublin) showing the two monitoring sites (GCB4 and GCB7).

2.2. *Physico-Chemical Monitoring*

Water sampling involves the deployment of a YSI water logger at each site to measure temperature, conductivity, pH and dissolved oxygen (DO). Water samples are collected from canal sites and returned to the Independent Analytical Supplies (IAS) laboratory in Bagenalstown for analysis of a range of

determinands (Table 2). A subset of these is used to assess indicative ecological potential - Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON), Ammonia, Biological Oxygen Demand (BOD) and Faecal Coliforms.

Figure 4. Grand Canal Basin (Dublin) showing the 13 sites that have been sampled in the past by Waterways Ireland and Dublin City Council for bacteriology.

Table 2. Physico-chemical determinands measured as part of WFD monitoring. (Chlorophyll monitoring has been discontinued since 2021.)

Determinand	Limit	Determinand	Limit
Total Phosphorus (TP) (mg/l P)*	0.063 mg/l P	Dissolved Oxygen (DO) (mg/l and % saturation)	>5.0 mg/l O_2
Molybdate Reactive Phosphorus (MRP) (mg/l P)	0.025 mg/l P	pH	
Soluble Reactive Phosphorus (SRP) (mg/l P)*	0.025 mg/l P	Conductivity (µS)	
Total Oxidised Nitrogen (TON) (meq/l N)*	4.1 mg/l N	Alkalinity (meq/l)	
Nitrite (mg/l)		Chlorophyll (µg/l)	
Nitrate (mg/l)		Biological Oxygen Demand (BOD) (mg/l O_2)*	<2.5 mg/l O_2
Ammonia (mg/l N)*	0.12 mg/l N	Total Coliforms (TC) (counts/100ml)	5000/100 ml
Temperature (°C)		Faecal Coliforms (counts/100ml)*	1000/100 ml

* Determinands used to assign ecological potential to the Artificial Water Bodies (AWBs)

3. Results

The full set of results from physico-chemical analysis of the water samples taken from the 50 canal, feeder/drain and Grand Canal Basin sites surveyed in Q2 2023 is presented in Appendices I and II.

3.1. *Physico-chemistry at Canal Sites*

Water sampling in Q2 2023 was conducted over two days – 17th and 25th May 2023. The weather throughout May was dry, with only a few rain showers in the weeks prior to water sampling. The water levels were more or less normal and the water was generally clear, except in areas where weed cutting was in progress. In many canal sections, the water surface was lightly covered with a layer of pollen. Reflecting the lack of rain in recent weeks, most feeders/drains supported little or no flow, although an appreciable flow was recorded from the Athy drain (BL15.1). Water temperature over the sampling period varied from 12.9 to 20.9°C and ranged from 12.9 to 17.3°C on 17th and from 14.0 to 20.9°C on 25th May 2023 (see Appendix I). The highest temperature in Q2 of 20.9°C was recorded at GCW4 (Lock 20).

Plate 2. Surface mats of blanketweed and filamentous cyanobacteria close to the discharge pipe from the Monread drain on 17th May 2023.

The water at the seven Grand Canal East (GCE) sites was crystal clear on the day of sampling in Q2 2023 and water quality conditions were generally good at all sites, bar GCE4 (Sallins). This site supports a large volume of permanently moored cruisers, although there has been no overt evidence of pollution from any of these craft on any of the more recent water sampling occasions. Because of the congestion with moored craft along the towpath, it was necessary to take the water sample from between two craft.

It is recommended that the location of this site should be moved *circa* 300m to the west of its current location. In May 2023, moderate to high levels of MRP, SRP and Ammonia were recorded from the water at this site. In addition, very high bacteriological counts were recorded, for both Total Coliforms and *E. coli* (see Appendix I). As on previous sampling occasions, relatively high Ammonia levels were recorded at a number of sites along this section of canal, with four sites reporting levels $\geq$ 0.1mg/l N (see Appendix I).

At all 11 sites on Grand Canal West (GCW), levels recorded for TP, MRP, SRP, TON, Ammonia, Nitrite and Nitrate were low and well within acceptable limits (see Appendix I) when sampled in Q2 2023. Total coliform counts were somewhat elevated at GCW12 (west of Daingean), probably reflecting the high Total coliform count recorded from the adjacent Ballymullen feeder stream (GCW12.1) (see Appendix II) on this sampling occasion. *E. coli* counts were generally low, although an elevated count of 687 per 100ml was recorded at GCW20 (Cornalaur). It is noteworthy that high *E. coli* counts were recorded at this site in Q3 and Q4 2022, and it will be necessary to continue to closely monitor the site for any signs of disturbance during sampling events in 2023. Ammonia levels were very low along this section of canal in May 2023, with no site reporting a value > 0.06mg/l N. Results from recent sampling events have shown relatively high BOD levels at sites throughout this section of canal, with the threshold limit (2.5mg/l O_2) being breached on numerous occasions. In Q2 2023, while no threshold breaches were reported, ten of the 11 sites displayed levels of 2mg/l O_2. As suggested previously, it is possible that the decay of aquatic vegetation in the channel following weed cutting may have contributed to the elevated BOD levels recorded.

A layer of pollen covered the water surface on the Naas Line at NL1 in Q2 2023, although the water was crystal clear and lacking the opaqueness that was a feature here on recent sampling occasions. Phosphorus levels were low, as were counts for Total coliforms and *E. coli* (see Appendix I). The Ammonia level was slightly elevated, at 0.09mg/l N, as was the BOD reading, at 2mg/l O_2. As has become expected at this site, the levels recorded for TON and Nitrate were high, although the former was not in breach of the threshold limit (set at 4.1mg/l N).

On 17th May 2023 there was a steady flow of clear water in the Milltown Feeder (MF1). Results from water analysis on this occasion were good, with values well within acceptable limits reported for most of the physico-chemical parameters measured (see Appendix I).

On the Barrow Line, the levels recorded for TP, MRP, SRP and Total coliforms were low in Q2 2023 and well within acceptable limits (see Appendix I). The TON levels were significantly reduced from those recorded at BL10 (Vicarstown) and BL15 (Athy) in Q1 2023, although slightly elevated readings for TON (1.8mg/l N) and Nitrate (1.73mg/l N) were recorded at BL6 (Umeras). The levels of Ammonia recorded on this sampling occasion were generally high, with three of the four sites displaying readings

$\geq$ 0.13mg/l N. The reason for these high readings is not clear as there was no evidence of disturbance at any of the sites.

Water quality conditions were good at most sites on Royal Canal East (RCE) in Q2 2023 (see Appendix I). Levels for TP, MRP and SRP were low at all sites, as were levels for TON and Nitrate. The highest *E. coli* count of 355 per 100ml was recorded at RCE22 (Castleknock), where the water was somewhat turbid on the morning of sampling. Ammonia levels were generally high, with six sites reporting levels $\geq$ 0.1mg/l N (see Appendix I). It is possible that weed decay in the channel post-cutting could have contributed to these elevated figures. The high levels for TP and BOD recorded at RCE25 (Croke Park) in Q1 2023 were not repeated in Q2, although an algal scum of benthic origin (probably blanketweed and/or filamentous cyanobacteria) was present on the water surface.

Phosphorus levels recorded at the seven sites in Royal Canal West (RCW) were very low and well within acceptable limits (see Appendix I) in Q2 2023. Levels for TON and Nitrate were likewise very low, as were counts for *E. coli*. High Ammonia levels ($\geq$ 0.13mg/l N) were recorded at two sites – RCW9 (Allard's Bridge) and RCW14 (west of Ballydrum).

At the time of sampling, the water in the Shannon-Erne Waterway was highly peat-stained, although there was no evidence of algal scums, either in the water or on the water surface. Nor was there any evidence of extraneous inputs to the channel. Physico-chemical results for water samples at SE40 and SE42 (Leitrim village) in Q2 2023 were low and indicated good water quality conditions at the time of sampling (see Appendix I).

3.2. *Indicative Ecological Potential of Canal Sites and Artificial Water Bodies*

Breaches of determinand threshold limits were recorded at five of the 43 canal and Shannon-Erne Waterway sites examined when readings for Q1 and Q2 2023 were assessed, resulting in each being assigned Moderate rather than Good indicative eco-potential (Table 3 and Figure 5). All five sites recorded breaches for just a single determinand, with BOD being responsible at four sites (GCW8 - east of Rhode, GCW18 – Ballycowan, GCW20 – Cornalaur and RCE25 – Croke Park) and TON at the Naas Line. It is noteworthy that all of the determinand breaches responsible for these elevated readings were recorded in Q1 2023.

Twelve of the 15 AWBs were assigned Good indicative eco-potential when results from physico-chemical analyses in Q1 and Q2 2023 were combined (Table 4). Of the three AWBs that breached threshold limits, two breached for BOD and one for TON (Table 4). Again, all of the breach events responsible for these elevated readings were recorded in Q1.

Table 3. Classification of the 43 canal sites in the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands for Q1 and Q2 combined in 2023.

AWB	Site Code	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	GCE4	2023	0.024	0.015	2.305	629.500	1.500	0.100	**Good**
	GCE6	2023	0.014	0.010	2.005	10.000	1.500	0.050	**Good**
	GCE8	2023	0.013	0.010	1.700	42.000	2.000	0.045	**Good**
	GCE10	2023	0.014	0.010	1.510	10.000	1.500	0.050	**Good**
	GCE12	2023	0.012	0.010	1.265	92.500	2.000	0.075	**Good**
	GCE14	2023	0.019	0.010	1.135	15.000	2.000	0.080	**Good**
GCNL_09	NL1	2023	0.017	0.010	**4.105**	40.000	1.500	0.055	**Moderate**
GCMF_14	MF1	2023	0.012	0.010	2.475	10.000	1.500	0.055	**Good**
GCBL_14	BL2	2023	0.015	0.010	0.945	10.000	1.500	0.090	**Good**
	BL6	2023	0.014	0.010	2.125	10.000	2.000	0.060	**Good**
	BL10	2023	0.020	0.010	2.690	10.000	1.500	0.115	**Good**
	BL15	2023	0.020	0.010	1.895	77.500	2.000	0.100	**Good**
GC_14E	GCE1	2023	0.012	0.010	1.950	20.500	1.500	0.065	**Good**
	GCW1	2023	0.012	0.010	1.720	10.000	2.000	0.040	**Good**
GC_14W	GCW8	2023	0.018	0.010	1.185	6.500	**5.000**	0.085	**Moderate**
	GCW12	2023	0.028	0.010	1.585	10.500	2.000	0.065	**Good**
GC_07	GCW4	2023	0.012	0.010	1.405	6.500	2.000	0.040	**Good**
	GCW6	2023	0.012	0.010	1.085	5.500	2.000	0.050	**Good**
GC_25A	GCW16	2023	0.016	0.010	1.370	12.500	2.000	0.030	**Good**
	GCW18	2023	0.015	0.010	1.395	30.500	**3.000**	0.060	**Moderate**
	GCW20	2023	0.013	0.010	1.735	348.500	**4.000**	0.045	**Moderate**
	GCW22	2023	0.013	0.010	1.575	5.000	2.000	0.055	**Good**
	GCW24	2023	0.012	0.010	1.465	5.000	2.000	0.060	**Good**
	GCW27	2023	0.012	0.010	0.750	6.000	2.000	0.065	**Good**
GCB*	GCB4	2023	0.018	0.010	1.705	25.500	1.000	0.075	**Good**
	GCB7	2023	0.026	0.020	1.555	252.500	2.000	**0.145**	**Moderate**
RC_07	RCE4	2023	0.012	0.010	0.750	7.000	2.000	0.110	**Good**
	RCE6	2023	0.012	0.010	1.890	37.500	1.000	0.085	**Good**
	RCE8	2023	0.014	0.010	1.350	11.000	2.000	0.080	**Good**
	RCE9	2023	0.014	0.010	0.500	10.000	2.000	0.085	**Good**
	RCE12	2023	0.013	0.010	1.520	41.500	2.000	0.080	**Good**
RC_09	RCE14	2023	0.014	0.010	1.150	15.000	1.500	0.070	**Good**
	RCE16	2023	0.021	0.010	1.515	10.000	1.500	0.055	**Good**
	RCE19	2023	0.012	0.010	1.330	10.000	1.000	0.080	**Good**
	RCE22	2023	0.014	0.010	0.850	193.000	1.500	0.080	**Good**
	RCE25	2023	0.037	0.015	0.945	54.000	**2.500**	0.075	**Moderate**
RC_25A	RCW1	2023	0.012	0.010	0.750	22.000	1.500	0.045	**Good**
	RCW3	2023	0.012	0.010	0.750	5.000	2.000	0.045	**Good**
RC_26F	RCW5	2023	0.012	0.010	0.945	6.000	2.000	0.065	**Good**
	RCW7	2023	0.012	0.010	1.095	7.500	1.000	0.060	**Good**
	RCW9	2023	0.012	0.010	1.170	7.500	1.500	0.100	**Good**
RC_26E	RCW12	2023	0.013	0.010	0.750	13.000	1.000	0.085	**Good**
RC_26C	RCW14	2023	0.012	0.010	0.750	6.500	1.500	0.100	**Good**
SE_26A	SE40	2023	0.027	0.010	0.750	9.500	2.000	0.080	**Good**
	SE42	2023	0.027	0.015	0.750	9.500	1.500	0.035	**Good**

* The Grand Canal Basin is not a designated AWB.

Table 4. Indicative ecological potential for the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands in Q1 and Q2 combined in 2023.

AWB	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	2023	0.016	0.011	1.653	133.167	1.750	0.067	Good
GCNL_09	2023	0.017	0.010	**4.105**	40.000	1.500	0.055	**Moderate**
GCMF_14	2023	0.012	0.010	2.475	10.000	1.500	0.055	Good
GCBL_14	2023	0.017	0.010	1.914	26.875	1.750	0.091	Good
GC_14E	2023	0.012	0.010	1.835	15.250	1.750	0.053	Good
GC_14W	2023	0.023	0.010	1.385	8.500	**3.500**	0.075	**Moderate**
GC_07	2023	0.012	0.010	1.245	6.000	2.000	0.045	Good
GC_25A	2023	0.013	0.010	1.382	67.917	**2.500**	0.053	**Moderate**
GCB*	2023	0.022	0.015	1.630	139.000	1.500	0.110	Good
RC_07	2023	0.013	0.010	1.202	21.400	1.800	0.088	Good
RC_09	2023	0.019	0.011	1.158	56.400	1.600	0.072	Good
RC_25A	2023	0.012	0.010	0.750	13.500	1.750	0.045	Good
RC_26F	2023	0.012	0.010	1.070	7.000	1.500	0.075	Good
RC_26E	2023	0.013	0.010	0.750	13.000	1.000	0.085	Good
RC_26C	2023	0.012	0.010	0.750	6.500	1.500	0.100	Good
SE_26A	2023	0.027	0.013	0.750	9.500	1.750	0.058	Good

* The Grand Canal Basin is not a designated AWB.

3.3. *Physico-chemistry and Indicative Ecological Potential of Canal Feeders/Drains*

Three of the five feeders/drains were assigned Good indicative eco-potential based on physico-chemical sampling in Q2 2023 (see Appendix II and Figure 5). This compared with two feeders/drains at Good in Q1 2023.

When sampled on 17th May 2023, there was a moderate flow of clear water discharging from the Monread drain (GCE5.1). Many small mats of an algal scum floated on the water surface (see Plate 2), probably comprised of benthic blanketweed and filamentous cyanobacteria. Phosphorus levels in the water on this occasion were low, while nitrogen levels were more elevated but not in breach of any determinand threshold limit (see TON and Nitrate values in Appendix II). The *E. coli* count, however, was high and in breach of the threshold limit for that parameter, at 1,725 counts per 100ml. Because of this breach, the drain was assigned Moderate indicative eco-potential on this occasion (see Appendix II).

On 25th May 2023 there was no apparent flow from either the Ballymullen (GCW12.1) or Ballylennon (GCW13.1) feeder, although the canal water did not appear to be backing into either stream. Levels for most of the physico-chemical parameters analysed were low and well within acceptable limits (see

Appendix II). A relatively high Total coliform count was recorded from the Ballymullen feeder, although the count for *E. coli* at this site did not breach the threshold limit. By comparison, the bacteriological counts for the Ballylennon feeder were very low and showed no sign of any bacteriological contamination. As there were no breaches for any of the determinand parameters, both feeders were assigned Good indicative eco-potential (see Appendix II). These results for Q2 2023 compared very favourably with previous results from these feeders but probably reflect the very dry weather in recent weeks and the lack of flow in both streams.

When the Athy drain (BL15.1) was sampled on 17th May 2023, it supported a strong flow of clear water (see Plate 1), even though there had been no rain in the area for a prolonged period. Levels recorded for TP and MRP were slightly elevated, while that for SRP was low (see Appendix II). Nitrogen levels were also somewhat elevated but were significantly lower than the values recorded in Q1 2023. The threshold limit for Ammonia (0.12mg/l N) was breached on this occasion, resulting in the drain being assigned Moderate indicative eco-potential (see Appendix II). The *E. coli* count was elevated but well below the threshold limit.

When sampled in May 2023 there was no flow emerging from the Kilcock drain (RCE16.1) and it is probable that water from the main line of the Royal Canal was entering the drain. This is reflected by the results recorded where there is not a significant difference between the results recorded from the drain water and those from the canal itself (see RCE16 in Appendix I). A notable difference, however, was recorded for Total coliforms, where the sample from the drain reported a count > 24,000 per 100ml, compared with 1,860 per 100ml for the main canal water. A relatively high Ammonia level of 0.11mg/l N was also recorded from the drain sample, compared with 0.08mg/l N for the canal water. As no breaches of determinand parameter limits were recorded, the drain was assigned Good indicative eco-potential (see Appendix II).

Table 5. Indicative ecological potential for the five canal feeders/drains based on results for the six physico-chemical determinands in Q1 and Q2 combined in 2023.

			Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Monread	GCE5.1	2023	0.022	0.015	3.125	950.000	1.000	0.050	**Good**
Ballymullen	GCW12.1	2023	0.035	**0.025**	2.875	348.500	1.500	0.055	**Moderate**
Ballylennon	GCW13.1	2023	0.044	**0.030**	1.740	28.000	**4.500**	0.095	**Moderate**
Athy	BL15.1	2023	0.029	0.010	**4.560**	309.500	2.000	0.100	**Moderate**
Kilcock Harbour	RCE16.1	2023	0.031	0.010	1.460	122.000	2.000	0.095	**Good**

When physico-chemical results from Q1 and Q2 2023 were combined for the feeder/drain systems, only two were assigned Good indicative eco-potential (Table 5). These were the Monread and Kilcock

Harbour drains. The Ballymullen feeder and the Athy drain each breached a single determinand parameter, both in Q1, while the Ballylennon feeder breached for SRP and BOD, again both in Q1.

3.4. *Grand Canal Basin*

A Dublin City Council urban wastewater outfall is located in the inner Grand Canal Basin (see Figure 3). This outfall is used to carry storm water overflow but, on occasions, sewage contamination is discharged to the Basin *via* this outfall.

When sampled in May 2023, the water level in the basin was normal for the time of year and the water was crystal clear. As on the previous sampling occasion in February 2023, results from physico-chemical analysis of water from the inner basin (GCB4) were good, with levels for all parameters being well within acceptable limits (see Appendix I and Table 3). The Ammonia level was elevated, at 0.1mg/l N, but was not in breach of the threshold limit. The site was assigned Good indicative eco-potential on this occasion. Levels for MRP and SRP in the outer basin (GCB7) were high in May, with that for SRP breaching the determinand threshold limit (see Appendix I and Table 3). The level recorded for Ammonia was also high, at 0.17mg/l N, and also in breach of the threshold value. As a consequence, the site was assigned Moderate indicative eco-potential. Total coliform and *E. coli* counts were low at both sites, indicating no bacterial contamination in the basin at the time of sampling.

When the data for the two sites in Grand Canal Basin were assessed, this artificial waterbody was assigned Good indicative eco-potential (Table 4).

Twenty sets of samples for bacteriological analysis (*E. coli* and *Enterococci*) were taken by WI/DCC in and immediately upstream of the Grand Canal Basin between the January and May 2023 (Table 6). Up to 27th March, sampling was conducted at five sites – one in the Grand Canal immediately upstream of the basin and two in each of the inner and outer basins. From 27th March, of the 14 sets of samples taken, four were taken from the original five site locations, while ten included a sixth site, located in the middle of the outer basin. Hence, on these latter sampling occasions, water was taken from one site on the Grand Canal, two in the inner basin and three in the outer basin.

A total of 16 breach events involving *E. coli* and *Enterococci* were reported from the water samples taken between January and May 2023 and analysed by DCC (Table 6). Three were recorded in the Grand Canal before it entered the basin, all reporting high *Enterococci* counts. One of the counts was particularly high, at 2,100 per 100ml (the threshold limit is 250 per 100ml), and, interestingly, did not correspond to a high rainfall event in the Dublin area.

In the inner basin, six breaches were reported, with two for *E. coli* and four for *Enterococci*. The counts for *Enterococci* reported on 26th April 2023 were very high, at 570 and 770 per 100ml. It is notable that, while there was little or no rain recorded at the Phoenix Park on 26th or 25th, a significant rainfall event

was recorded on 24th April. In the outer basin, of the seven breaches reported, just one was for *E. coli*. This was recorded on 21st March, the same date that a high *Enterococci* count was recorded at the same site. On 10th May 2023, breaches of the *Enterococci* threshold limit were recorded at the three sites sampled in the outer basin. Breaches for this parameter were also recorded on this date in the inner basin, at one site, and in the Grand Canal upstream of the basin (Table 6). Light rainfall was recorded in the Dublin area on the 10th but also in the days preceding this.

E. coli counts reported by WI/DCC on 16th May and by INVAS on 17th May for sites in the inner and outer basins were very similar and all below 50 counts per 100ml.

Table 6. Number of sites that breached acceptable limits for *E. coli* (>900 counts per 100ml) and *Enterococci* (>250 counts per 100ml) in water samples taken by Waterways Ireland and analysed by Dublin City Council in Level 1 of the Grand Canal (1 site) and in the inner (2 sites) and outer (2 or 3 sites) Grand Canal Basins between January and May 2023.

DATE	CANAL *E coli*	CANAL *Enterococci*	INNER *E coli*	INNER *Enterococci*	OUTER *E coli*	OUTER *Enterococci*
10.1.23	0	0	0	0	0	1
24.1.23	0	0	0	0	0	0
7.2.23	0	0	0	0	0	0
21.2.23	0	0	0	0	0	0
7.3.23	0	0	0	0	0	0
21.3.23	0	0	0	0	1	1
27.3.23	0	0	1	1	0	0
29.3.23	0	0	1	0	0	0
3.4.23	0	0	0	0	0	0
4.4.23	0	0	0	0	0	0
12.4.23	0	0	0	0	0	0
17.4.23	0	0	0	0	0	0
18.4.23	0	1	0	0	0	0
24.4.23	0	1	0	0	0	0
26.4.23	0	0	0	2	0	1
2.5.23	0	0	0	0	0	0
8.5.23	0	0	0	0	0	0
10.5.23	0	1	0	1	0	3
15.5.23	0	0	0	0	0	0
16.5.23	0	0	0	0	0	0

## 4. Issues for Waterways Ireland Resulting from Sampling in Q2 2023

While an elevated reading for TON was again recorded in the water from the Naas Line in Q2 2023, this was below the threshold limit. Interestingly, the opaqueness that occupied the water at this site in recent months was not evident on the date of sampling (17th May).

Good water quality conditions were reported from the sites on the Shannon-Erne Waterway on this sampling occasion, with no evidence of any deleterious matter or disturbance at either site.

The Monread and Athy drains were again assigned Moderate indicative eco-potential reflecting, respectively, a high *E. coli* count and Ammonia reading. Both the Ballymullen and Ballylennon feeders were assigned Good indicative eco-potential on this sampling occasion, probably reflecting the fact that there was no flow of water in either stream following the prolonged dry weather.

Because of the congestion with moored craft along the towpath, it was again necessary to take the water samples from between two craft. It is recommended that the location of this site should be moved *circa* 300m to the west of its current location in order to obtain a more accurate determination of the indicative eco-potential of the Grand Canal in this area.

Ammonia levels remain high at many sites throughout the canal system, for reasons that are not apparent. This is causing problems in terms of ecological compliance as many sites, and AWBs, are being assigned less than Good indicative eco-potential where the Ammonia threshold limit of 0.12mg/l N is breached. It is possible that this threshold limit is too low for Irish canals and it is recommended that it be reviewed.
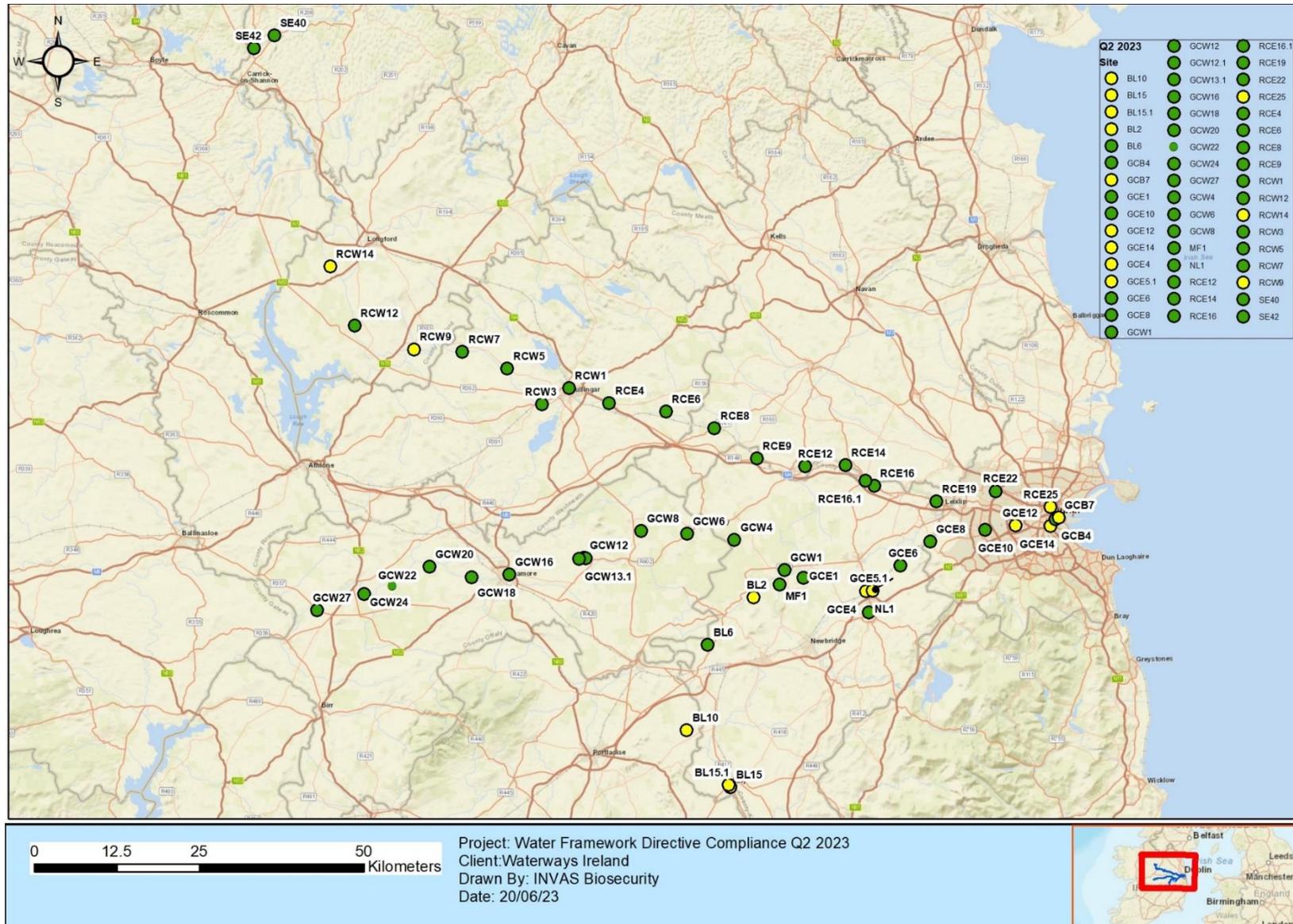
Figure 5. Indicative ecological potential based on physico-chemical data for the 50 canal, Shannon-Erne Waterway and feeder/drain sites monitored in Q2 2023 (Green = Good, Yellow = Moderate).

Appendix I. Physico-chemical results and indicative ecological potential for canal (41), Shannon-Erne Waterway (2) and Grand Canal Basin (2) sites sampled in Q2 2023.

	Canal	Site Code	AWB	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature	Conductivity (µS)	pH	DO %	DO (mg/L O2)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO3)	Indicative Physico-chemical Potential
GCE1_Q2	Grand Canal	GCE1	GC_14E	Q2	17/05/2023	0.010	0.010	0.010	1.500	16.2	496	7.90	124.0	12.10	323	31	2.00	0.100	0.060	1.410	5.780	289.41	Good
GCE4_Q2	Grand Canal	GCE4	GC_09	Q2	17/05/2023	0.030	0.030	0.020	2.000	13.2	488	7.80	90.2	9.30	24,200	1,162	1.00	0.170	0.030	1.930	5.910	296.04	Moderate
GCE6_Q2	Grand Canal	GCE6	GC_09	Q2	17/05/2023	0.010	0.010	0.010	1.500	15.2	490	8.00	110.0	11.10	83	10	1.00	0.070	0.010	1.480	5.640	282.21	Good
GCE8_Q2	Grand Canal	GCE8	GC_09	Q2	17/05/2023	0.010	0.010	0.010	1.200	15.6	463	8.00	91.7	9.00	231	74	1.00	0.050	0.050	1.160	5.090	254.53	Good
GCE10_Q2	Grand Canal	GCE10	GC_09	Q2	17/05/2023	0.010	0.010	0.010	0.900	15.6	423	8.00	78.8	7.70	63	10	1.00	0.070	0.060	0.850	4.470	223.70	Good
GCE12_Q2	Grand Canal	GCE12	GC_09	Q2	17/05/2023	0.010	0.010	0.010	0.600	15.9	405	8.10	80.0	7.80	504	175	2.00	0.120	0.050	0.560	4.220	211.19	Moderate
GCE14_Q2	Grand Canal	GCE14	GC_09	Q2	17/05/2023	0.020	0.010	0.010	0.500	15.2	373	8.00	82.0	8.10	166	20	2.00	0.120	0.050	0.500	3.820	190.97	Moderate
GCW1_Q2	Grand Canal	GCW1	GC_14E	Q2	17/05/2023	0.010	0.010	0.010	1.200	17.0	462	8.10	143.0	13.10	52	10	2.00	0.060	0.040	1.110	5.080	254.17	Good
GCW4_Q2	Grand Canal	GCW4	GC_07	Q2	25/05/2023	0.010	0.010	0.010	1.000	20.9	402	8.30	119.1	10.70	196	3	2.00	0.040	0.030	1.000	4.090	204.70	Good
GCW6_Q2	Grand Canal	GCW6	GC_07	Q2	25/05/2023	0.010	0.010	0.010	1.000	20.1	298	8.10	112.1	10.30	138	1	2.00	0.040	0.030	1.000	3.780	189.20	Good
GCW8_Q2	Grand Canal	GCW8	GC_14W	Q2	25/05/2023	0.010	0.010	0.010	1.000	20.7	403	7.90	76.6	9.80	276	3	1.00	0.050	0.030	1.000	4.090	204.80	Good
GCW12_Q2	Grand Canal	GCW12	GC_14W	Q2	25/05/2023	0.020	0.010	0.010	1.000	19.9	438	8.00	104.6	9.70	1,986	11	2.00	0.040	0.030	1.000	4.800	240.40	Good
GCW16_Q2	Grand Canal	GCW16	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	18.3	541	8.10	92.9	8.60	326	15	2.00	0.030	0.030	1.000	6.320	316.20	Good
GCW18_Q2	Grand Canal	GCW18	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	19.0	531	8.10	103.7	9.50	345	51	2.00	0.060	0.030	1.000	5.650	283.00	Good
GCW20_Q2	Grand Canal	GCW20	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	19.0	445	8.10	111.8	10.20	866	687	2.00	0.030	0.030	1.000	4.660	233.00	Good
GCW22_Q2	Grand Canal	GCW22	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	19.7	456	8.00	91.0	8.40	214	0	2.00	0.050	0.030	1.000	4.730	236.60	Good
GCW24_Q2	Grand Canal	GCW24	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	19.0	461	7.90	100.0	9.20	122	0	2.00	0.060	0.030	1.000	4.950	247.50	Good
GCW27_Q2	Grand Canal	GCW27	GC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	18.8	384	8.00	98.1	9.00	248	2	2.00	0.030	0.030	1.000	4.040	202.00	Good
NL1_Q2	Grand Canal	NL1	GCNL_09	Q2	17/05/2023	0.020	0.010	0.010	3.600	12.9	504	7.80	96.6	10.80	203	20	2.00	0.090	0.010	3.540	6.160	308.47	Good
MF1_Q2	Grand Canal	MF1	GCMF_14	Q2	17/05/2023	0.010	0.010	0.010	2.200	16.0	552	7.90	111.2	11.20	75	10	2.00	0.080	0.040	2.140	6.670	333.68	Good
BL2_Q2	Grand Canal	BL2	GCBL_14	Q2	17/05/2023	0.010	0.010	0.010	0.500	16.7	402	8.10	114.1	10.90	108	10	1.00	0.130	0.030	0.500	4.440	222.37	Moderate
BL6_Q2	Grand Canal	BL6	GCBL_14	Q2	17/05/2023	0.010	0.010	0.010	1.800	16.2	546	7.90	107.0	10.60	30	10	1.00	0.090	0.060	1.730	6.430	321.93	Good
BL10_Q2	Grand Canal	BL10	GCBL_14	Q2	17/05/2023	0.020	0.010	0.010	0.500	17.3	451	8.30	124.0	11.90	305	10	1.00	0.190	0.030	0.500	5.120	256.32	Moderate
BL15_Q2	Grand Canal	BL15	GCBL_14	Q2	17/05/2023	0.020	0.010	0.010	0.500	17.1	466	8.20	120.0	11.40	20	10	2.00	0.140	0.040	0.500	4.650	232.66	Moderate
GCB4_Q2	Grand Canal	GCB4	GCB*	Q2	17/05/2023	0.010	0.010	0.010	1.100	15.6	400	8.30	112.0	11.20	41	41	1.00	0.100	0.030	1.100	3.710	185.79	Good
GCB7_Q2	Grand Canal	GCB7	GCB*	Q2	17/05/2023	0.030	0.030	0.030	0.800	15.3	389	8.20	96.3	9.50	708	10	2.00	0.170	0.030	0.730	3.820	191.28	Moderate
RCE4_Q2	Royal Canal	RCE4	RC_07	Q2	25/05/2023	0.010	0.010	0.010	1.000	16.5	377	7.70	81.1	7.80	205	4	2.00	0.080	0.030	1.000	4.280	214.00	Good
RCE6_Q2	Royal Canal	RCE6	RC_07	Q2	25/05/2023	0.010	0.010	0.010	2.500	14.0	473	7.60	82.0	8.40	461	65	1.00	0.090	0.030	2.490	5.580	279.40	Good
RCE8_Q2	Royal Canal	RCE8	RC_07	Q2	25/05/2023	0.010	0.010	0.010	2.200	17.3	464	7.90	97.3	9.60	276	12	2.00	0.060	0.030	2.190	5.170	258.80	Good
RCE9_Q2	Royal Canal	RCE9	RC_07	Q2	17/05/2023	0.010	0.010	0.010	0.500	15.9	426	7.90	90.3	6.90	63	10	2.00	0.110	0.030	0.500	4.820	241.47	Good
RCE12_Q2	Royal Canal	RCE12	RC_07	Q2	17/05/2023	0.010	0.010	0.010	0.700	14.3	453	7.70	83.1	8.40	85	20	2.00	0.110	0.050	0.640	5.210	260.72	Good
RCE14_Q2	Royal Canal	RCE14	RC_09	Q2	17/05/2023	0.010	0.010	0.010	0.600	15.8	478	7.70	76.1	7.50	41	20	1.00	0.100	0.030	0.520	5.240	262.45	Good
RCE16_Q2	Royal Canal	RCE16	RC_09	Q2	17/05/2023	0.020	0.020	0.010	0.700	16.8	505	7.90	83.1	8.20	1,860	10	1.00	0.080	0.030	0.680	5.510	275.81	Good
RCE19_Q2	Royal Canal	RCE19	RC_09	Q2	17/05/2023	0.010	0.010	0.010	0.500	16.7	446	7.80	83.4	8.20	41	10	1.00	0.110	0.040	0.500	4.710	235.51	Good
RCE22_Q2	Royal Canal	RCE22	RC_09	Q2	17/05/2023	0.010	0.010	0.010	0.600	14.5	500	7.80	96.5	9.80	1,211	355	1.00	0.110	0.060	0.570	5.100	255.39	Good
RCE25_Q2	Royal Canal	RCE25	RC_09	Q2	17/05/2023	0.020	0.020	0.020	0.500	15.2	419	8.10	93.1	9.20	317	98	2.00	0.120	0.040	0.500	3.850	192.67	Moderate
RCW1_Q2	Royal Canal	RCW1	RC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	15.2	222	7.80	86.0	8.30	980	34	2.00	0.050	0.030	1.000	2.370	118.60	Good
RCW3_Q2	Royal Canal	RCW3	RC_25A	Q2	25/05/2023	0.010	0.010	0.010	1.000	16.5	227	8.00	88.0	8.60	326	0	2.00	0.030	0.030	1.000	2.690	134.80	Good
RCW5_Q2	Royal Canal	RCW5	RC_26F	Q2	25/05/2023	0.010	0.010	0.010	1.000	16.4	295	7.70	83.4	8.10	276	2	2.00	0.060	0.030	1.000	3.140	157.10	Good
RCW7_Q2	Royal Canal	RCW7	RC_26F	Q2	25/05/2023	0.010	0.010	0.010	1.000	16.7	337	8.00	93.7	9.10	548	5	1.00	0.060	0.030	1.000	3.610	180.60	Good
RCW9_Q2	Royal Canal	RCW9	RC_26F	Q2	25/05/2023	0.010	0.010	0.010	1.000	17.1	335	7.70	79.8	7.50	236	5	2.00	0.130	0.030	1.000	3.580	179.20	Moderate
RCW12_Q2	Royal Canal	RCW12	RC_26E	Q2	25/05/2023	0.010	0.010	0.010	1.000	17.1	336	8.00	83.3	8.00	16	16	1.00	0.050	0.030	1.000	3.700	185.10	Good
RCW14_Q2	Royal Canal	RCW14	RC_26C	Q2	25/05/2023	0.010	0.010	0.010	1.000	17.0	297	7.90	103.8	7.90	3	3	2.00	0.140	0.030	1.000	3.390	169.70	Moderate
SE40_Q2	Shannon Erne	SE40	SE_26A	Q2	25/05/2023	0.030	0.010	0.010	1.000	16.2	207	7.70	76.6	7.40	10	9	2.00	0.080	0.030	1.000	1.930	96.50	Good
SE42_Q2	Shannon Erne	SE42	SE_26A	Q2	25/05/2023	0.020	0.010	0.010	1.000	16.9	266	7.80	97.2	7.90	34	9	1.00	0.020	0.030	1.000	3.160	158.10	Good

Appendix II. Physico-chemical results and indicative ecological potential for canal feeder/drain sites sampled in Q2 2023.

Canal	Site	Location	AWB_Code	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature (degree C)	Conductivity (µS)	pH	DO %	DO (mg/L O₂)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO₃)	Indicative Physico-chemical Potential
Grand Canal	GCE5.1	Monread Feeder	GC_09	Q2	17/05/2023	0.020	0.020	0.010	3.100	11.40	525	8.00	100.2	11.00	2,603	1,725	1.00	0.080	0.010	3.060	6.400	320.41	Moderate
Grand Canal	GCW12.1	Ballymullen Feeder	GC_14	Q2	25/05/2023	0.030	0.020	0.020	2.700	13.70	557	7.80	91.1	9.60	2,420	687	1.00	0.040	0.030	2.670	6.980	349.40	Good
Grand Canal	GCW13.1	Ballylennon Feeder	GC_14	Q2	25/05/2023	0.030	0.020	0.020	1.600	14.00	558	7.60	70.3	7.00	291	46	2.00	0.030	0.040	1.570	7.310	365.90	Good
Grand Canal Barrow Line	BL15.1	Athy Drain	GCBL_14	Q2	17/05/2023	0.040	0.020	0.010	3.000	14.40	313	8.00	101.0	10.50	2,723	556	2.00	0.140	0.040	2.950	5.080	254.32	Moderate
Royal Canal	RCE16.1	Kilcock Harbour Drain	RC_09	Q2	17/05/2023	0.030	0.010	0.010	0.900	13.00	490	7.90	92.1	8.80	24,196	98	2.00	0.110	0.010	0.890	5.770	288.61	Good

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Appendix VI

Water Framework Directive Compliance Report

Physico-chemistry

Third Quarter 2023

Water Framework Directive Compliance Report

Physico-chemistry

Third Quarter 2023

September 2023

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Front Cover: Early morning water sampling at Blackhorse (GCE12) in mid-August 2023.

1. Introduction

Water Framework Directive (WFD) surveillance monitoring of the Royal and Grand Canals, and the Shannon-Erne Waterway, for Q3 2023 was carried out on 17th and 23rd August 2023.

A canal is identified as an Artificial Water Body (AWB) in the WFD and is defined as 'a body of water created by human activity'. In recognition of their navigational role, AWBs must achieve good ecological potential as opposed to good ecological status, the latter which applies to natural water bodies, such as rivers and lakes. Ecological potential is assessed using a combination of biological (native and invasive macroinvertebrate and macrophyte), physico-chemical and hydromorphological quality elements. For classification purposes, the ecological potential of a site or AWB can be Maximum, Good, Moderate, Poor or Bad. Where physico-chemistry alone is being assessed, as in this report, sites and AWBs can achieve either Good or Moderate potential only. In assigning ecological potential, the one-out-all-out rule applies, whereby the lowest value quality element determines the overall classification of the AWB. A system for classifying British and Irish canals based on macroinvertebrate, macrophyte, invasive species, physico-chemical and hydromorphological quality elements is used to assess the ecological potential of AWBs. In the current reporting period (Q3 2023), the canals are classified based on the physico-chemistry of the water during this period.

Figure 1. Artificial Water Bodies (AWBs), sites and monitored feeder streams on the Royal and Grand Canals, and the Shannon-Erne Waterway. The AWBs are grouped based on associated river catchments.
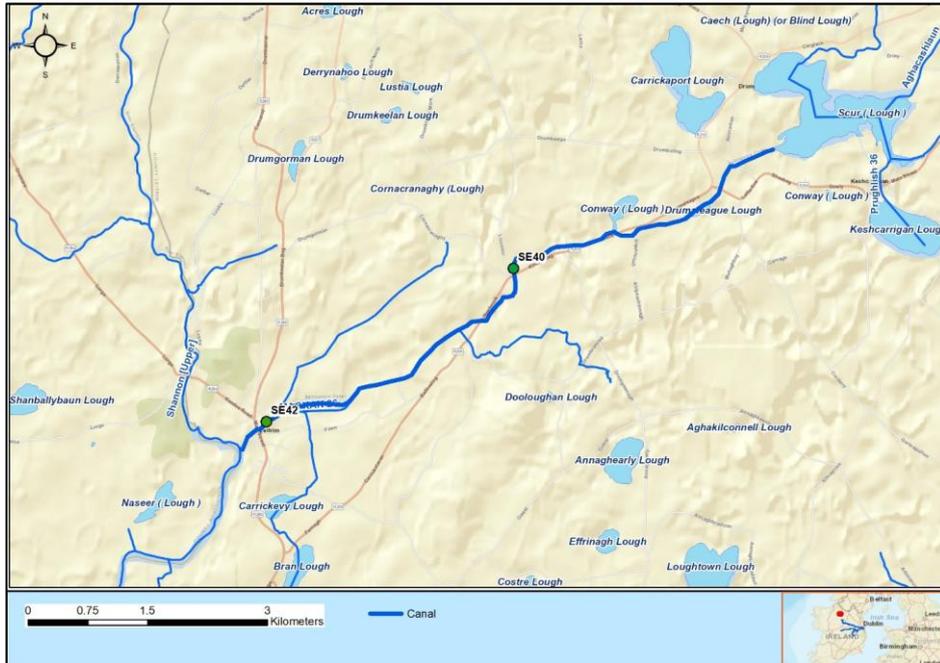
The canals are currently divided into 15 AWBs based on their locations within river catchments (Table 1). The Grand Canal supports eight AWBs (this does not include the Grand Canal Basin), the Royal Canal has six AWBs and there is just a single AWB on the Shannon-Erne Waterway. Four of the AWBs have only a single canal sampling site (Table 1), which can be potentially problematic when ecological potential for individual AWBs is being assigned. This reflects the fact that a breach in any biological or abiotic parameter can result in the AWB being changed from Good to Moderate.

For reporting purposes, a simple code has been assigned, whereby AWBs are labelled according to the river catchment in which they occur (Table 1).

Table 1. Artificial Water Bodies (AWBs) included in the WFD Monitoring Programme.

Artificial Water Body (AWB)	Catchment No	New ID Code	New Report Code	Length (km)	No of Sites
GRAND CANAL					
Grand Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_GCMLE	GC_09	41.4	6
Grand Canal Main Line East - Barrow	14	IE_14_AWB_GCMLE	GC_14E	15.7	2
Grand Canal Main Line West - Barrow	14	IE_14_AWB_GCMLW	GC_14W	12.9	2
Grand Canal Main Line - Boyne	7	IE_07_AWB_GCMLW	GC_07	14.5	2
Grand Canal Main Line - Lower Shannon	25A	IE_25A_AWB_GCMLW	GC_25A	47.0	6
Grand Canal Naas Line - Liffey and Dublin Bay	9	IE_09_AWB_GCNL	GCNL_09	11.9	1
Grand Canal Milltown Feeder - Barrow	14	IE_14_AWB_GCMF	GCMF_14	10.5	1
Grand Canal Barrow Line - Barrow	14	IE_14_AWB_GCBL	GCBL_14	50.8	4
Grand Canal Basin - Liffey and Dublin Bay	9	IE_09_AWB_GCB	GCB		2
ROYAL CANAL					
Royal Canal Main Line - Boyne Catchment	7	IE_07_AWB_RCMLE	RC_07	42.6	5
Royal Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_RCMLE	RC_09	39.4	5
Royal Canal Main Line - Lower Shannon	25A	IE_25A_AWB_RCMLW	RC_25A	13.3	2
Royal Canal Main Line - Upper Shannon	26F	IE_26F_AWB_RCMLW	RC_26F	33.8	3
Royal Canal Main Line - Upper Shannon	26E	IE_26E_AWB_RCMLW	RC_26E	3.7	1
Royal Canal Main Line - Upper Shannon	26C	IE_26C_AWB_RCMLW	RC_26C	14.2	1
SHANNON ERNE WATERWAY					
Shannon Erne Waterway - Upper Shannon	26A	IE_26A_AWB_SEW	SE_26A	25.5	2

During 2020 a second site (SE42) was included on the Shannon-Erne Waterway to better represent the water quality status of this Waterway and AWB (Table 1.1). This site is located adjacent to the marina in Leitrim village, close to where the Shannon-Erne Waterway discharges to the River Shannon (Figure 2).

Figure 2. Location of the two WFD monitoring sites (SE40 and 42) on the Shannon-Erne Waterway.

Plate 1. YSI probe sampling the clear water emerging from the Monread drain (GCE5.1) in August 2023.

2. Materials and Methods

2.1. *Sampling locations*

Physico-chemical sampling is conducted on a quarterly basis at 50 monitoring sites – 41 on the Royal, Grand and Barrow Canals, two on the Grand Canal Basin, two on the Shannon-Erne Waterway, and five on selected canal feeder streams/drains (see Figures 1, 2 and 3). The canal feeders/drains have been a source of elevated nutrient and coliform inputs in the past. They include the Monread drain (GCE5.1) and Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeder streams on the Grand Canal, the Athy drain (BL15.1) on the Barrow Line, and the Kilcock Harbour drain (RCE16.1) on the Royal Canal.

Between the end of May and the middle of July, WI took water samples for bacteriological analysis (*E. coli* and *Enterococci*) at a number of 'recreational and hotspot' sites on the canals and Shannon-Erne Waterway, at Leitrim. A small number of these sites correspond with sites used for the quarterly WFD Canals Surveillance Monitoring Programme, including Leitrim village/marina, GCE8 (Hazelhatch), GCE14 (Baggot Street), GCE5 (Sallins), RCE12 (Castleknock) and RCE16 (Kilcock). A site in Naas Harbour, upstream of NL1, was also sampled by WI during this period.
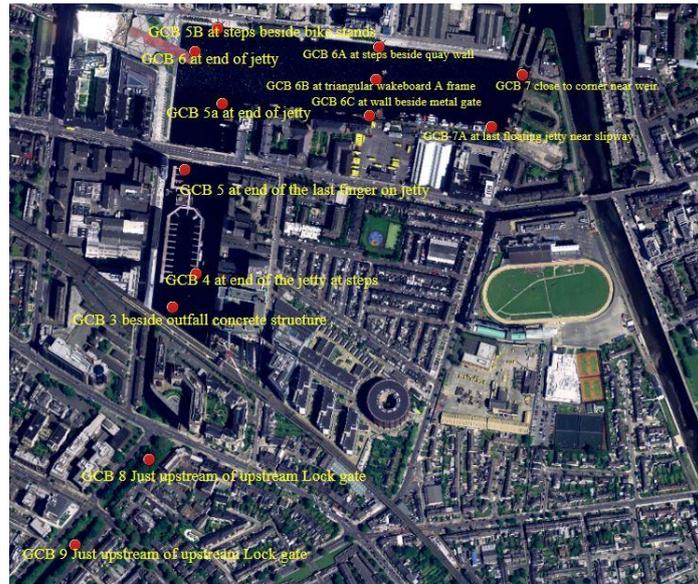
In addition to the quarterly water samples taken by INVAS at two sites in the Grand Canal Basin as part of the WFD Canals Surveillance Programme, Waterways Ireland (WI) and Dublin City Council (DCC) conduct regular water sampling for bacteriological (*E. coli* and *Enterococci*) analysis at up to 11 sites in the Basin (three in the inner, eight in the outer) and two in the adjacent Grand Canal (Figure 4). From early 2022 to late March 2023, just five samples for bacteriology were collected and analysed on a fortnightly basis, these taken from the 1st level of the Grand Canal (1), the inner basin (2 – sites 4 and 5 in Figure 4) and the outer basin (2 – sites 6 and 7 in Figure 4). Between late March and mid-May 2023, when the last set of results were received by INVAS, a sixth sampling site, located in the middle of the outer basis, was included in the sampling programme.

Figure 3. Grand Canal Basin (Dublin) showing the two monitoring sites (GCB4 and GCB7) used by INVAS.

2.2. *Physico-Chemical Monitoring*

Water sampling involves the deployment of a YSI water logger at each site to measure temperature, conductivity, pH and dissolved oxygen (DO). Water samples are collected from canal sites and returned to the Independent Analytical Supplies (IAS) laboratory in Bagenalstown for analysis of a range of determinands (Table 2). A subset of these is used to assess indicative ecological potential - Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON), Ammonia, Biological Oxygen Demand (BOD) and Faecal Coliforms.

Figure 4. Grand Canal Basin (Dublin) showing the 13 sites that have been sampled in the past by Waterways Ireland and Dublin City Council for bacteriology.

Table 2. Physico-chemical determinands measured as part of WFD monitoring. (Chlorophyll monitoring has been discontinued since 2021.)

| Determinand	Limit	Determinand	Limit
Total Phosphorus (TP) (mg/l P)*	0.063 mg/l P	Dissolved Oxygen (DO) (mg/l and % saturation)	>5.0 mg/l O_2
Molybdate Reactive Phosphorus (MRP) (mg/l P)	0.025 mg/l P	pH	
Soluble Reactive Phosphorus (SRP) (mg/l P)*	0.025 mg/l P	Conductivity (µS)	
Total Oxidised Nitrogen (TON) (mg/l N)*	4.1 mg/l N	Alkalinity (meq/l)	
Nitrite (mg/l)		Chlorophyll (µg/l)	
Nitrate (mg/l)		Biological Oxygen Demand (BOD) (mg/l O_2)*	<2.5 mg/l O_2
Ammonia (mg/l N)*	0.12 mg/l N	Total Coliforms (TC) (counts/100ml)	5000/100 ml
Temperature (°C)		Faecal Coliforms (counts/100ml)*	1000/100 ml

* Determinands used to assign ecological potential to the Artificial Water Bodies (AWBs)

3. Results

The full set of results from physico-chemical analysis of the water samples taken from the 50 canal, feeder/drain and Grand Canal Basin sites surveyed in Q3 2023 is presented in Appendices I and II.

3.1. *Physico-chemistry at Canal Sites*

Water sampling in Q3 2023 was conducted over two days – 17th and 23rd August 2023. July 2023 was the wettest month on record across Ireland and high levels of rainfall were also recorded during August, prior to and post the Q3 water sampling events. As a consequence, water levels throughout the canals during sampling were somewhat higher than normal for the time of year. This was the case for most of the sampling sites used in the current WFD Canals Surveillance Monitoring Programme, except that at Croke Park (RCE25) where the water level was artificially lowered to facilitate Blueway construction activities (Plate 2). Most of the drains and feeders that were sampled supported at least a moderate flow of water during sampling in August. Water temperature over the sampling period varied from 14.5 to 19.4°C on 17th and from 16.6 to 19.9°C on 23rd August 2023 (see Appendix I). The highest temperature in Q3 of 19.9°C was recorded at GCW6 (George's Bridge).
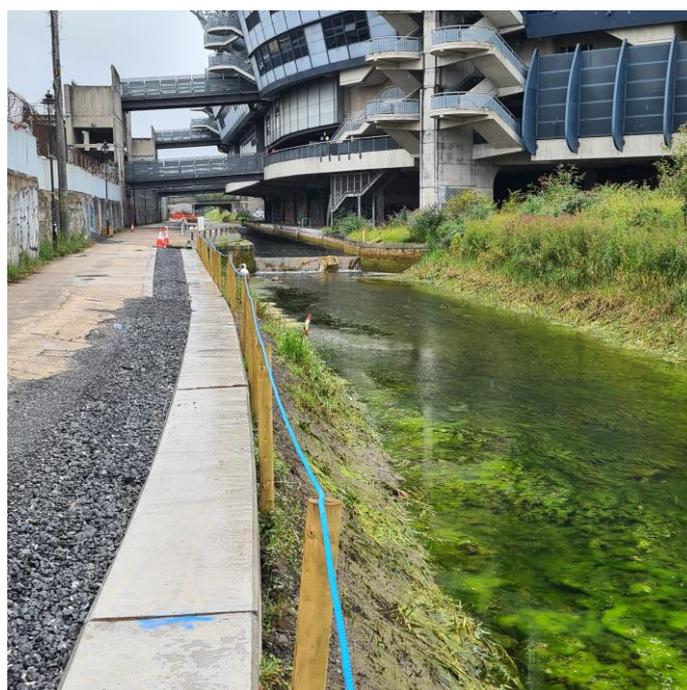
Plate 2. Artificially low water levels (and an abundance of filamentous green algae) in the Royal Canal at Croke Park (RCE25) to facilitate Blueway construction in August 2023.

The water at the seven Grand Canal East (GCE) WFD monitoring sites was clear when sampled on 17th August and there was relatively little turbidity resulting from the high levels of rainfall in the canal catchment. Because of the increase in the numbers of moored craft at GCE4 (Sallins), it was necessary to move the traditional sampling site a few hundred metres westward in order to be able to collect water

and biological samples without coming into direct contact with these boats. Levels recorded for TP, SRP, MRP, TON and Nitrate were very low at all sampling sites, as were levels for Total coliforms, *E. coli* and BOD (see Appendix I). The only elevated readings recorded on this sampling occasion were for Ammonia, at three of the seven sites – GCE1 (Robertstown), GCE4 (Sallins) and GCE8 (Hazelhatch), with the determinand threshold of 0.12mg/l N being exceeded at the latter two sites (see Appendix I). It is noteworthy that permanently moored barges are present at these three sites, although there was no evidence of any contamination in the vicinity of any of the craft at the time of sampling. In Q2 a very high *E. coli* count of 1,162 per 100ml was recorded at GCE4, in addition to a high Ammonia reading of 0.17mg/l N. The coliform count was significantly lower in Q3 and there was no indication of bacterial contamination. Breaches in the threshold limit for *E. coli* was recorded when WI sampled a site at Hazelhatch, close to GCE8, in late May and a breach in the limit for *Enterococci* was recorded at Baggot Street when sampled on 4th July 2023.

Phosphorus levels at sites on Grand Canal West (GCW) have generally been very low during recent sampling events, as was the case at ten of the 11 sites sampled in Q3 2023. However, a very high TP value of 0.13mg/l P, well in excess of the threshold limit for this determinand, was recorded at GCW22 (west of Pollagh), suggesting some form of external contamination. An examination of the other parameters analysed for this site on this occasion revealed that levels were low and well within acceptable limits (see Appendix I). The lack of any indication of any artificial nutrient input to the canal or any obvious disturbance, along with the very low readings for all other parameters measured for this site, would suggest the possibility of some form of sample contamination or reading error. Water quality conditions were excellent at most sites, bar GCW12 (west of Daingean) where a BOD reading of 3mg/l O_2 was recorded. This site is located between the Ballymullen and Ballylennon feeder streams, which commonly discharge enriched and even polluted water to the canal although, on this sampling occasion, levels for most parameters in both feeders were low and indicated relatively clean water conditions (see Appendix II and Section 3.3). There was no indication of the elevated *E. coli* levels that have been recently recorded at GCW20 (Cornalaur), with a count of 10 per 100ml reported here in Q3.

The water in the Naas Line of the Grand Canal was crystal clear during sampling in Q3 2023 and the opaqueness that had previously been present in the water was gone. Levels recorded for TP, SRP, MRP and BOD were very low, as were the counts for Total coliforms and *E. coli* (see Appendix I). Bacteriological sampling at Naas Harbour, upstream of this site, by WI on 20th June and 11th July reported counts above threshold limits for both *E. coli* and *Enterococci*. The levels for TON and Nitrate were slightly elevated, at 2.9 and 2.29mg/l N, respectively. These levels are significantly lower than have been recorded for this site in recent months and years, and are well within acceptable limits. The threshold limit for TON (4.1mg/l N) was breached in Q1 2023 and a reading of 3.6mg/l N was reported here in Q2 2023.

During sampling in Q3, there was a moderate to good flow in the Monread feeder (MF1), although the water was very clear. Results recorded for all parameters were good and well within acceptable limits (see Appendix I), as has been the case on recent sampling occasions.

The water quality conditions at all four sites on the Barrow Line were excellent in Q3 2023 and low readings for most parameters were recorded (see Appendix I). The only slightly elevated reading reported was for BOD at BL15 (Athy), but this was still below the threshold limit for this parameter. Of interest is the fact that TON, Nitrate and Ammonia levels were particularly low, where these have previously been elevated or even unacceptably high at some of the Barrow Canal sites. It may be the case that the high and persistent rainfall levels in the catchment in recent weeks had flushed the system of contaminants and resulted in cleaner water being discharged through the feeders.

Water quality conditions on Royal Canal East (RCE) in Q3 2023 were generally good at most sites. Readings for TP, MRP, SRP, TON and Nitrate were all low and well within acceptable limits (see Appendix I). In Q2, Ammonia levels were generally high, with six of the ten sites reporting levels $\geq$ 0.1mg/l N, while in Q3 only a single site reported a reading over 0.1mg/l N. This was RCE25 (Croke Park) at 0.13mg/l N, although on this occasion the water sample was taken *circa* 500m upstream, within the same canal level, because access to the regular site was impeded due to Blueway construction activities. The next highest Ammonia level was 0.09mg/l N, recorded at RCE22 (Castleknock). WI sampling on 13th at Kilcock and 20th June at Castleknock reported breaches in the threshold limits for *Enterococci* (680 per 100ml) and *E. coli* (1700 per 100ml), respectively.

As on recent sampling occasions, levels for phosphorus and nitrogen were low at all sites on Royal Canal West (RCW) (see Appendix I). Interestingly, Ammonia levels were very low at all seven sites in Q3, where it was common for levels to exceed 0.1mg/l N at at least some of these sites on previous sampling occasions. High Total coliform and *E. coli* counts were recorded at RCW7 (Kelly's Bridge) and RCW12 (Island Bridge) in Q3, with the latter also reporting a high BOD reading of 3mg/l O_2. At the time of sampling, the water level at these sites was slightly elevated and the water was strongly peat stained, but there was no evidence of any extraneous matter in the water that could result in the observed readings. Results for the other parameters measured in Q3 were good, as they were in Q2 and Q1 for most parameters, including Total coliform, *E. coli* and BOD. The sites will be examined closely when next sampling in October 2023. A high BOD reading of 3mg/l O_2 was also recorded at RCW9 (Allard's Bridge) in Q3, with no apparent reason for it. Again, the site will be closely monitored during Q4 sampling.

Physico-chemical results in Q1 and Q2 for both WFD monitoring sites on the Shannon-Erne Waterway were good, with all parameters examined being well within acceptable limits. In Q3, the readings for TP were elevated at both sites, but were very high (0.14mg/l P) at SE40. Also elevated at SE40, but

also at SE42 (Leitrim marina), were the readings for BOD, at 2 and 4mg/l O_2, respectively. On the day of sampling the river was high and the water was turbid, but there was no obvious sign of any disturbance or artificial input to the water at either site. Bacteriological counts for the samples taken at SE42 on 23rd August were low (see Appendix I) but counts for samples taken at a nearby site by Waterways Ireland on 22nd August were very high and above threshold limits (*E. coli* – 930 and *Enterococci* – 320 per 100ml), indicating that deleterious matter is continuing to be discharged to the river in the vicinity of Leitrim village.

3.2. *Indicative Ecological Potential of Canal Sites and Artificial Water Bodies*

Results from sampling in Q3 2023 revealed that determinand parameters were breached at nine of the 43 canal and Shannon-Erne Waterway sites monitored, with eight sites breaching for one of the six determinands and one site (RCW12 – Island Bridge) breaching for two determinands – *E. coli* and BOD (see Appendix I). In Q2 2023, again nine sites breach for a single determinand and just one site (GCE4 – Sallins) for two – *E. coli* and Ammonia. In Q1, ten sites breached for one determinand, with the site at GCW8 (east of Rhode) breaching for BOD and Ammonia.

Five sites breached determinand parameters on more than one occasion during the three sampling events in 2023. These were GCE4 (Sallins) in Q2 and Q3 (twice for Ammonia and once for *E. coli*), GCE8 (Hazelhatch) in Q1 for BOD and Q3 for Ammonia, BL10 (upstream of Vicarstown) in Q1 for TON and Q2 for Ammonia, RCW12 (Island Bridge) in Q1 and Q3 for *E. coli*, BOD and Ammonia, and RCE25 (Croke Park), which recorded determinand breaches on all three sampling occasions – Q1 for BOD, Q2 for Ammonia and Q3 for Ammonia.

No breaches in any of the six determinand threshold limits were recorded at 39 of the 43 sites examined when readings for Q1 to Q3 2023 were combined, resulting in just four sites being assigned Moderate rather than Good indicative eco-potential at the end of this period (Table 3). The four sites recorded breaches for just a single determinand, with BOD being responsible at three sites (GCW8 - east of Rhode, GCW18 – Ballycowan, GCW20 – Cornalaur) and TP at SE40. The three BOD readings responsible for breaching the threshold level of 2.5mg/l O_2 were recorded in Q1, while the very high TP reading of 0.14mg/l P was recorded in Q3.

Fourteen of the 15 AWBs were assigned Good indicative eco-potential when results from physico-chemical analyses in Q1, Q2 and Q3 2023 were combined (Table 4). The only AWB to breach any threshold limit was GC_14W, which contains GCW8 (east of Rhode) and GCW12 (west of Daingean). The determinand that breached was BOD, resulting from the unexplained and exceptionally high BOD reading of 9 mg/l O_2 that was recorded in Q1.

Table 3. Classification of the 43 canal sites in the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands for Q1, Q2 and Q3 combined in 2023.

AWB	Site Code	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	GCE4	2023	0.022	0.013	2.137	430.000	1.333	0.117	Good
	GCE6	2023	0.013	0.010	1.803	10.000	1.333	0.053	Good
	GCE8	2023	0.015	0.010	1.600	34.667	1.667	0.073	Good
	GCE10	2023	0.012	0.010	1.340	10.000	1.333	0.053	Good
	GCE12	2023	0.011	0.010	1.177	159.000	1.667	0.077	Good
	GCE14	2023	0.019	0.010	1.090	16.667	1.667	0.067	Good
GCNL_09	NL1	2023	0.014	0.010	3.703	44.000	1.333	0.060	Good
GCMF_14	MF1	2023	0.011	0.010	2.417	10.000	1.333	0.053	Good
GCBL_14	BL2	2023	0.013	0.010	0.963	40.000	1.333	0.077	Good
	BL6	2023	0.012	0.010	1.850	17.000	1.667	0.053	Good
	BL10	2023	0.017	0.010	2.127	10.000	1.333	0.097	Good
	BL15	2023	0.017	0.010	1.597	55.000	2.000	0.083	Good
GC_14E	GCE1	2023	0.011	0.010	1.633	17.000	1.333	0.077	Good
	GCW1	2023	0.011	0.010	1.513	10.000	1.667	0.043	Good
GC_14W	GCW8	2023	0.019	0.010	1.123	7.667	**3.667**	0.063	Moderate
	GCW12	2023	0.032	0.010	1.390	10.333	2.333	0.050	Good
GC_07	GCW4	2023	0.011	0.010	1.270	7.667	1.667	0.033	Good
	GCW6	2023	0.011	0.010	1.057	7.000	1.667	0.040	Good
GC_25A	GCW16	2023	0.014	0.010	1.247	11.667	1.667	0.030	Good
	GCW18	2023	0.017	0.010	1.263	101.333	**2.667**	0.047	Moderate
	GCW20	2023	0.015	0.010	1.490	235.667	**3.000**	0.040	Moderate
	GCW22	2023	0.052	0.010	1.383	6.667	1.667	0.043	Good
	GCW24	2023	0.011	0.010	1.310	6.667	1.667	0.047	Good
	GCW27	2023	0.011	0.010	0.833	7.333	1.667	0.050	Good
GCB*	GCB4	2023	0.019	0.010	1.470	50.333	1.000	0.080	Good
	GCB7	2023	0.024	0.017	1.370	197.000	1.667	**0.120**	Moderate
RC_07	RCE4	2023	0.011	0.010	0.833	8.000	1.667	0.083	Good
	RCE6	2023	0.014	0.010	1.593	28.333	1.000	0.070	Good
	RCE8	2023	0.013	0.010	1.233	97.000	1.667	0.067	Good
	RCE9	2023	0.012	0.010	0.667	10.000	1.667	0.077	Good
	RCE12	2023	0.012	0.010	1.447	31.000	1.667	0.067	Good
RC_09	RCE14	2023	0.012	0.010	1.100	13.333	1.333	0.063	Good
	RCE16	2023	0.017	0.010	1.343	40.000	1.333	0.057	Good
	RCE19	2023	0.011	0.010	1.220	10.000	1.000	0.070	Good
	RCE22	2023	0.016	0.010	0.967	288.333	1.333	0.083	Good
	RCE25	2023	0.035	0.013	0.963	64.333	2.000	0.093	Good
RC_25A	RCW1	2023	0.011	0.010	0.833	18.000	1.333	0.043	Good
	RCW3	2023	0.011	0.010	0.833	6.667	1.667	0.037	Good
RC_26F	RCW5	2023	0.011	0.010	0.963	7.333	1.667	0.050	Good
	RCW7	2023	0.011	0.010	1.063	299.000	1.000	0.050	Good
	RCW9	2023	0.014	0.010	1.113	57.667	2.000	0.073	Good
RC_26E	RCW12	2023	0.012	0.010	0.833	467.333	1.667	0.070	Good
RC_26C	RCW14	2023	0.011	0.010	0.833	7.667	1.667	0.073	Good
SE_26A	SE40	2023	**0.065**	0.010	0.833	27.333	2.000	0.063	Moderate
	SE42	2023	0.038	0.013	0.833	60.000	2.333	0.030	Good

* The Grand Canal Basin is not a designated AWB.

Table 4. Indicative ecological potential for the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands in Q1, Q2 and Q3 combined in 2023.

AWB	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	2023	0.016	0.011	1.524	110.056	1.500	0.073	Good
GCNL_09	2023	0.014	0.010	3.703	44.000	1.333	0.060	Good
GCMF_14	2023	0.011	0.010	2.417	10.000	1.333	0.053	Good
GCBL_14	2023	0.015	0.010	1.634	30.500	1.583	0.078	Good
GC_14E	2023	0.011	0.010	1.573	13.500	1.500	0.060	Good
GC_14W	2023	0.025	0.010	1.257	9.000	**3.000**	0.057	**Moderate**
GC_07	2023	0.011	0.010	1.163	7.333	1.667	0.037	Good
GC_25A	2023	0.020	0.010	1.254	61.556	2.056	0.043	Good
GCB*	2023	0.021	0.013	1.420	123.667	1.333	0.100	Good
RC_07	2023	0.012	0.010	1.155	34.867	1.533	0.073	Good
RC_09	2023	0.018	0.011	1.119	83.200	1.400	0.073	Good
RC_25A	2023	0.011	0.010	0.833	12.333	1.500	0.040	Good
RC_26F	2023	0.012	0.010	1.047	121.333	1.556	0.058	Good
RC_26E	2023	0.012	0.010	0.833	467.333	1.667	0.070	Good
RC_26C	2023	0.011	0.010	0.833	7.667	1.667	0.073	Good
SE_26A	2023	0.051	0.012	0.833	43.667	2.167	0.047	Good

* The Grand Canal Basin is not a designated AWB.

3.3. *Physico-chemistry and Indicative Ecological Potential of Canal Feeders/Drains*

Three of the five feeders/drains were assigned Good indicative eco-potential based on physico-chemical sampling in Q3 2023 (see Appendix II and Figure 5), as was the case for the same feeders/drains in Q2 2023. This compared with just two feeders/drains at Good in Q1 2023.

Resulting from the heavy and persistent rainfall over the country in July and August, there was a relatively strong flow of water from the Monread drain when sampled on 17th August 2023, although the water was clear and there were no filamentous algal carpets in its vicinity. Phosphorus levels were low on this occasion and, while nitrogen levels were slightly elevated (see TON and Nitrate in Appendix II), they were within acceptable limits. The Ammonia and BOD levels were also low. As in Q2, the *E. coli* count was very high, at 1,580 per 100ml, and in breach of the threshold limit. This suggests that deleterious matter is continuing to enter the drain and is representing a water quality issue for the receiving canal system. Because of this breach, the drain was assigned Moderate indicative eco-potential on this occasion (see Appendix II).

A steady flow of slightly turbid water was discharging to the Grand Canal from both the Ballymullen (GCW12.1) or Ballylennon (GCW13.1) feeders when sampled in Q3 2023. Nutrient levels in the water

from both feeders were low, except for TP, which was somewhat elevated (see Appendix II). Counts for Total coliforms and *E. coli* were low and well within acceptable limits. As a result, both feeders were assigned Good indicative eco-potential, as they were in Q2 2023. In Q1, however, both feeders were at Moderate ecological status – the Ballymullen feeder for a breach of the SRP threshold and the Ballylennon feeder for breaches of the threshold limits for SRP, BOD and Ammonia.

A strong flow of clear water was discharging from the Athy drain (BL15.1) when sampled in Q3 2023. The results from physico-chemical analysis of the sample taken at this time revealed high levels for a number of parameters, and significant breaches of the threshold limits for TON, *E. coli*, BOD and Ammonia (see Appendix II). The *E. coli* and Ammonia levels recorded were extremely high, at 14,830 per 100ml and 0.58mg/l N, respectively, and were among the highest levels that have been recorded at any of the monitoring sites in recent years. It is clear that deleterious matter is being discharged or gaining access to this drain and the adverse consequences for water quality in both the receiving Barrow Canal and the Barrow River downstream are serious. It will be important to inform Offaly County Council of these results and to insist that some form of restorative action is urgently taken. This drain was also assigned Moderate rather than Good indicative eco-potential in Q1 and Q2 this year for threshold breaches of TON and Ammonia, respectively.

A slow flow of relatively clear water was discharging from the Kilcock drain (RCE16.1) when sampled in Q3 2023. Levels for most parameters were low and well within acceptable limits (see Appendix II). The only slight elevation was for Ammonia, at 0.09mg/l N. A relatively high Ammonia level of 0.11mg/l N, still below the threshold limit for this determinand, was recorded here in Q2, but this would not be regarded as representing a significant water quality issue for the receiving Royal Canal at Kilcock. As in Q1 and Q2, the drain was assigned Good indicative eco-potential in Q3.

Table 5. Indicative ecological potential for the five canal feeders/drains based on results for the six physico-chemical determinands in Q1, Q2 and Q3 combined in 2023.

			Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Monread	GCE5.1	2023	0.025	0.013	3.117	**1,160**	1.000	0.043	**Moderate**
Ballymullen	GCW12.1	2023	0.040	0.020	2.417	307	1.333	0.043	**Good**
Ballylennon	GCW13.1	2023	0.046	0.023	1.493	36	**3.667**	0.070	**Moderate**
Athy	BL15.1	2023	0.039	0.010	**4.840**	**5,150**	2.333	**0.260**	**Moderate**
Kilcock Harbour	RCE16.1	2023	0.027	0.010	1.307	92	1.667	0.093	**Good**

When physico-chemical results from Q1, Q2 and Q3 2023 were combined for the feeder/drain systems, three were assigned Moderate rather than Good indicative eco-potential (Table 5). These were the Monread and Athy drains and the Ballylennon feeder. Two *E. coli* readings in breach of the threshold limit for this determinand, in Q2 and Q3, resulted in this status being assigned for the Monread feeder,

while a BOD reading of 7mg/l O_2 in Q1 was the cause at the Ballylennon feeder. The Athy drain breached for three of the six parameters – TON, *E, coli* and Ammonia (Table 5).

3.4. *Grand Canal Basin*

A Dublin City Council urban wastewater outfall is located in the inner Grand Canal Basin (see Figure 3). This outfall is used to carry storm water overflow but, on occasions, sewage contamination is discharged to the Basin *via* this outfall.

Following the heavy rain in July and August, the water level in the Grand Canal Basin was slightly higher than normal but the water was clear. Water quality conditions from samples taken in Q3 were good, with readings for all parameters examined being well within acceptable limits (see Appendix I). As a result, both sites were assigned Good indicative eco-potential (see Table 3). In Q1 and Q2, GCB4 (inner basin) was also at Good potential, while GCB7 (outer basin) was at Moderate in Q1 because of a high Ammonia reading and in Q2 because of an elevated reading in SRP.

When the data for the two sites in Grand Canal Basin for Q1, Q2 and Q3 were combined, this artificial waterbody was assigned Good indicative eco-potential (Table 4).

4. Issues for Waterways Ireland Resulting from Sampling in Q3 2023

Results from physico-chemical analysis of water discharging from the Athy drain (BL15.1) showed serious contamination, with significant breaches of the threshold limits for TON, *E. coli*, BOD and Ammonia. In fact, the *E. coli* and Ammonia levels in Q3 were among the highest that have been recorded at any of the monitoring sites in recent years. It is clear that deleterious matter continues to be discharged to this drain and the adverse consequences for water quality in the receiving Barrow Canal and Barrow River downstream are serious. This information must be relayed to Offaly County Council and an assurance gained that immediate restorative action will be taken.

As in Q2 2023, the *E. coli* count for the Monread drain in Q3 was very high, at 1,580 per 100ml. This suggests that sewage contamination is continuing to enter the drain and represents a continuing water quality issue for the receiving Grand Canal system.

While results for most parameters measured at GCE1 (Robertstown), GCE4 (Sallins) and GCE8 (Hazelhatch) were well within acceptable limits, those for Ammonia were elevated, with the determinand threshold limit of 0.12mg/l N being exceeded at the latter two sites. It is noteworthy that permanently moored barges are present at these three sites, although there was no evidence of any contamination from any of the craft at the time of sampling.

Results from INVAS sampling at SE42 (Leitrim marina) on 23rd August showed low bacterial counts, while samples taken by Waterways Ireland on 22nd August revealed levels for *E. coli* and *Enterococci* that were in breach of threshold limits for these parameters. This suggests that contaminated waste continues to be discharged to the river in the vicinity of Leitrim village.

Figure 5. Indicative ecological potential based on physico-chemical data for the 50 canal, Shannon-Erne Waterway and feeder/drain sites monitored in Q3 2023 (Green = Good, Yellow = Moderate).

Appendix I. Physico-chemical results and indicative ecological potential for canal (41), Shannon-Erne Waterway (2) and Grand Canal Basin (2) sites sampled in Q3 2023.

	Canal	Site Code	AWB	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature	Conductivity (µS)	pH	DO %	DO (mg/L O2)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO3)	Indicative Physico-chemical Potential
GCE1_Q3	Grand Canal	GCE1	GC_14E	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.0	489	7.66	110.4	11.50	520	10	1.00	0.100	0.030	1.000	3.000	150.40	Good
GCE4_Q3	Grand Canal	GCE4	GC_14E	Q3	17/08/2023	0.020	0.010	0.010	1.800	16.2	514	7.30	88.2	8.80	410	31	1.00	0.150	0.030	1.780	3.780	189.10	Moderate
GCE6_Q3	Grand Canal	GCE6	GC_14E	Q3	17/08/2023	0.010	0.010	0.010	1.400	17.1	515	8.05	114.2	10.72	980	10	1.00	0.060	0.030	1.390	3.530	176.50	Good
GCE8_Q3	Grand Canal	GCE8	GC_14E	Q3	17/08/2023	0.020	0.010	0.010	1.400	17.9	578	7.92	103.2	9.55	364	20	1.00	0.130	0.030	1.390	3.230	161.90	Moderate
GCE10_Q3	Grand Canal	GCE10	GC_14E	Q3	17/08/2023	0.010	0.010	0.010	1.000	17.8	562	8.05	97.2	9.19	85	10	1.00	0.060	0.030	1.000	3.250	162.60	Good
GCE12_Q3	Grand Canal	GCE12	GC_14E	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.0	512	8.15	79.2	7.45	836	292	1.00	0.080	0.030	1.000	2.820	141.00	Good
GCE14_Q3	Grand Canal	GCE14	GC_14E	Q3	17/08/2023	0.020	0.010	0.010	1.000	18.3	390	8.00	83.1	7.73	465	20	1.00	0.040	0.030	1.000	3.210	160.50	Good
GCW1_Q3	Grand Canal	GCW1	GC_14E	Q3	17/08/2023	0.010	0.010	0.010	1.100	18.5	501	7.84	101.3	9.38	328	10	1.00	0.050	0.030	1.090	3.050	152.80	Good
GCW4_Q3	Grand Canal	GCW4	GC_07	Q3	23/08/2023	0.010	0.010	0.010	1.000	19.5	443	8.10	130.0	11.23	120	10	1.00	0.020	0.030	1.000	4.900	245.40	Good
GCW6_Q3	Grand Canal	GCW6	GC_07	Q3	23/08/2023	0.010	0.010	0.010	1.000	19.9	378	7.91	94.2	8.52	373	10	1.00	0.020	0.030	1.000	4.160	208.10	Good
GCW8_Q3	Grand Canal	GCW8	GC_14W	Q3	23/08/2023	0.020	0.010	0.010	1.000	19.4	358	8.04	87.5	8.40	228	10	1.00	0.020	0.030	1.000	3.740	187.00	Good
GCW12_Q3	Grand Canal	GCW12	GC_14W	Q3	23/08/2023	0.040	0.010	0.010	1.000	17.8	617	7.78	97.5	9.11	211	10	3.00	0.020	0.070	1.000	7.350	368.10	Moderate
GCW16_Q3	Grand Canal	GCW16	GC_25A	Q3	23/08/2023	0.030	0.010	0.010	1.000	19.6	622	8.04	100.2	9.54	131	10	1.00	0.030	0.030	1.000	6.600	330.10	Good
GCW18_Q3	Grand Canal	GCW18	GC_25A	Q3	23/08/2023	0.020	0.020	0.010	1.000	19.0	505	7.94	79.8	7.94	10	243	2.00	0.020	0.030	1.000	5.390	269.60	Good
GCW20_Q3	Grand Canal	GCW20	GC_25A	Q3	23/08/2023	0.020	0.010	0.010	1.000	19.5	459	8.10	120.0	10.90	288	10	1.00	0.030	0.030	1.000	5.200	260.40	Good
GCW22_Q3	Grand Canal	GCW22	GC_25A	Q3	23/08/2023	0.130	0.010	0.010	1.000	19.6	437	7.90	111.1	10.30	134	10	1.00	0.020	0.030	1.000	4.760	238.00	Moderate
GCW24_Q3	Grand Canal	GCW24	GC_25A	Q3	23/08/2023	0.010	0.010	0.010	1.000	19.3	425	7.74	78.4	7.60	259	10	1.00	0.020	0.030	1.000	4.250	212.80	Good
GCW27_Q3	Grand Canal	GCW27	GC_25A	Q3	23/08/2023	0.010	0.010	0.010	1.000	19.2	328	7.98	94.0	8.62	85	10	1.00	0.020	0.030	1.000	3.380	169.40	Good
NL1_Q3	Grand Canal	NL1	GCNL_09	Q3	17/08/2023	0.010	0.010	0.010	2.900	14.5	527	7.84	116.4	11.88	520	52	1.00	0.070	0.040	2.860	3.590	179.90	Good
MF1_Q3	Grand Canal	MF1	GCMF_14	Q3	17/08/2023	0.010	0.010	0.010	2.300	16.7	585	7.82	100.1	10.30	119	10	1.00	0.050	0.030	2.290	4.530	226.70	Good
BL2_Q3	Grand Canal	BL2	GCBL_14	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.4	485	8.02	112.0	10.40	410	100	1.00	0.050	0.030	1.000	3.360	168.00	Good
BL6_Q3	Grand Canal	BL6	GCBL_14	Q3	17/08/2023	0.010	0.010	0.010	1.300	18.3	394	7.33	101.0	9.41	122	31	1.00	0.040	0.030	1.300	3.240	162.30	Good
BL10_Q3	Grand Canal	BL10	GCBL_14	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.3	564	7.90	117.1	10.95	100	10	1.00	0.060	0.030	1.000	3.210	160.50	Good
BL15_Q3	Grand Canal	BL15	GCBL_14	Q3	17/08/2023	0.010	0.010	0.010	1.000	19.4	378	8.12	133.0	12.02	310	10	2.00	0.050	0.030	1.000	2.340	117.00	Good
GCB4_Q3	Grand Canal	GCB4	GCB*	Q3	17/08/2023	0.020	0.010	0.010	1.000	18.3	369	8.20	105.0	9.78	200	100	1.00	0.090	0.030	1.000	2.250	112.80	Good
GCB7_Q3	Grand Canal	GCB7	GCB*	Q3	17/08/2023	0.020	0.010	0.010	1.000	18.6	401	8.50	119.0	11.20	2,660	86	1.00	0.070	0.030	1.000	2.520	125.90	Good
RCE4_Q3	Royal Canal	RCE4	RC_07	Q3	23/08/2023	0.010	0.010	0.010	1.000	17.9	410	7.68	88.9	8.32	97	10	1.00	0.030	0.030	1.000	4.640	232.30	Good
RCE6_Q3	Royal Canal	RCE6	RC_07	Q3	23/08/2023	0.020	0.010	0.010	1.000	18.4	408	7.90	86.2	8.03	134	10	1.00	0.040	0.030	1.000	4.460	223.40	Good
RCE8_Q3	Royal Canal	RCE8	RC_07	Q3	23/08/2023	0.010	0.010	0.010	1.000	18.9	419	7.83	82.9	7.70	4,352	269	1.00	0.040	0.030	1.000	5.350	268.00	Good
RCE9_Q3	Royal Canal	RCE9	RC_07	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.8	433	7.93	85.2	8.30	310	10	1.00	0.060	0.030	1.000	3.170	158.50	Good
RCE12_Q3	Royal Canal	RCE12	RC_07	Q3	17/08/2023	0.010	0.010	0.010	1.300	16.6	436	7.50	78.1	7.20	41	10	1.00	0.040	0.030	1.300	3.360	168.40	Good
RCE14_Q3	Royal Canal	RCE14	RC_09	Q3	17/08/2023	0.010	0.010	0.010	1.000	17.7	516	7.50	78.2	7.20	98	10	1.00	0.050	0.030	1.000	3.370	168.70	Good
RCE16_Q3	Royal Canal	RCE16	RC_09	Q3	17/08/2023	0.010	0.010	0.010	1.000	18.2	552	7.90	73.1	6.83	620	100	1.00	0.060	0.030	1.000	3.140	157.40	Good
RCE19_Q3	Royal Canal	RCE19	RC_09	Q3	17/08/2023	0.010	0.010	0.010	1.000	17.9	461	7.67	87.1	8.17	259	10	1.00	0.050	0.030	1.000	3.120	156.00	Good
RCE22_Q3	Royal Canal	RCE22	RC_09	Q3	17/08/2023	0.020	0.010	0.010	1.200	17.4	542	7.65	75.2	7.60	706	479	1.00	0.090	0.030	1.200	3.260	163.30	Good
RCE25_Q3	Royal Canal	RCE25	RC_09	Q3	17/08/2023	0.030	0.010	0.010	1.000	18.4	439	7.81	72.3	7.60	520	85	1.00	0.130	0.030	1.000	2.810	140.40	Moderate
RCW1_Q3	Royal Canal	RCW1	RC_25A	Q3	23/08/2023	0.010	0.010	0.010	1.000	17.7	253	7.74	104.2	9.79	697	10	1.00	0.040	0.030	1.000	2.520	126.00	Good
RCW3_Q3	Royal Canal	RCW3	RC_25A	Q3	23/08/2023	0.010	0.010	0.010	1.000	18.6	206	7.85	109.0	10.09	288	10	1.00	0.020	0.030	1.000	2.650	132.40	Good
RCW5_Q3	Royal Canal	RCW5	RC_26F	Q3	23/08/2023	0.010	0.010	0.010	1.000	18.5	501	7.87	99.0	9.25	336	10	1.00	0.020	0.030	1.000	5.460	273.30	Good
RCW7_Q3	Royal Canal	RCW7	RC_26F	Q3	23/08/2023	0.010	0.010	0.010	1.000	19.6	478	8.05	107.5	9.96	12,997	882	1.00	0.030	0.030	1.000	5.550	277.70	Good
RCW9_Q3	Royal Canal	RCW9	RC_26F	Q3	23/08/2023	0.020	0.010	0.010	1.000	19.1	409	7.80	98.1	9.02	1,850	158	3.00	0.020	0.030	1.000	4.850	242.80	Moderate
RCW12_Q3	Royal Canal	RCW12	RC_26E	Q3	23/08/2023	0.010	0.010	0.010	1.000	18.7	402	7.78	96.2	9.60	9,804	1,376	3.00	0.040	0.030	1.000	4.540	227.10	Moderate
RCW14_Q3	Royal Canal	RCW14	RC_26C	Q3	23/08/2023	0.010	0.010	0.010	1.000	18.7	336	7.60	81.2	7.60	435	10	2.00	0.020	0.030	1.000	3.870	193.50	Good
SE40_Q3	Shannon Erne	SE40	SE_26A	Q3	23/08/2023	0.140	0.010	0.010	1.000	17.6	199	7.60	96.3	8.90	309	63	2.00	0.030	0.030	1.000	2.390	119.70	Moderate
SE42_Q3	Shannon Erne	SE42	SE_26A	Q3	23/08/2023	0.060	0.010	0.010	1.000	17.7	274	7.82	99.1	9.32	991	161	4.00	0.020	0.030	1.000	3.410	170.80	Moderate

Appendix II. Physico-chemical results and indicative ecological potential for canal feeder/drain sites sampled in Q3 2023.

Canal	Site	Location	AWB_Code	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature (degree C)	Conductivity (µS)	pH	DO %	DO (mg/L O₂)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO₃)	Indicative Physico-chemical Potential
Grand Canal	GCE5.1	Monread Feeder	GC_09	Q3	17/08/2023	0.030	0.010	0.010	3.100	13.80	560	7.98	114.1	11.80	6,867	1,580	1.00	0.030	0.030	3.100	4.010	200.70	Moderate
Grand Canal	GCW12.1	Ballymullen Feeder	GC_14	Q3	23/08/2023	0.050	0.010	0.010	1.500	13.70	603	7.79	80.6	7.79	2,909	223	1.00	0.020	0.090	1.410	7.790	389.80	Good
Grand Canal	GCW13.1	Ballylennon Feeder	GC_14	Q3	23/08/2023	0.050	0.010	0.010	1.000	16.40	660	7.27	62.4	6.42	933	52	2.00	0.020	0.070	1.000	7.040	352.20	Good
Grand Canal Barrow Line	BL15.1	Athy Drain	GCBL_14	Q3	17/08/2023	0.060	0.010	0.010	5.400	15.80	533	7.83	90.9	8.85	24,960	14,830	3.00	0.580	0.300	5.100	3.700	185.20	Moderate
Royal Canal	RCE16.1	Kilcock Harbour Drain	RC_09	Q3	17/08/2023	0.020	0.010	0.010	1.000	18.20	587	8.02	108.2	10.30	740	31	1.00	0.090	0.030	1.000	3.970	198.90	Good

Appendix VII

Water Framework Directive Compliance Report

Physico-chemistry

Fourth Quarter 2023

Water Framework Directive Compliance Report

Physico-chemistry

Fourth Quarter 2023

November 2023

Table of Contents

Front Cover: New WFD surveillance monitoring site location west of Sallins (GCE4) in October 2023.

1. Introduction

Water Framework Directive (WFD) surveillance monitoring of the Royal and Grand Canals, and the Shannon-Erne Waterway, for Q4 2023 was carried out on 19th and 26th October 2023.

A canal is identified as an Artificial Water Body (AWB) in the WFD and is defined as 'a body of water created by human activity'. In recognition of their navigational role, AWBs must achieve good ecological <u>potential</u> as opposed to good ecological <u>status</u>, the latter which applies to natural water bodies, such as rivers and lakes. Ecological potential is assessed using a combination of biological (native and invasive macroinvertebrate and macrophyte), physico-chemical and hydromorphological quality elements. For classification purposes, the ecological potential of a site or AWB can be Maximum, Good, Moderate, Poor or Bad. Where physico-chemistry alone is being assessed, as in this report, sites and AWBs can achieve either Good or Moderate potential only. In assigning ecological potential, the one-out-all-out rule applies, whereby the lowest value quality element determines the overall classification of the AWB. A system for classifying British and Irish canals based on macroinvertebrate, macrophyte, invasive species, physico-chemical and hydromorphological quality elements is used to assess the ecological potential of AWBs. In the current reporting period (Q4 2023), the canals are classified based on the physico-chemistry of the water during this period.

Figure 1. Artificial Water Bodies (AWBs), sites and monitored feeder streams on the Royal and Grand Canals, and the Shannon-Erne Waterway. The AWBs are grouped based on associated river catchments.
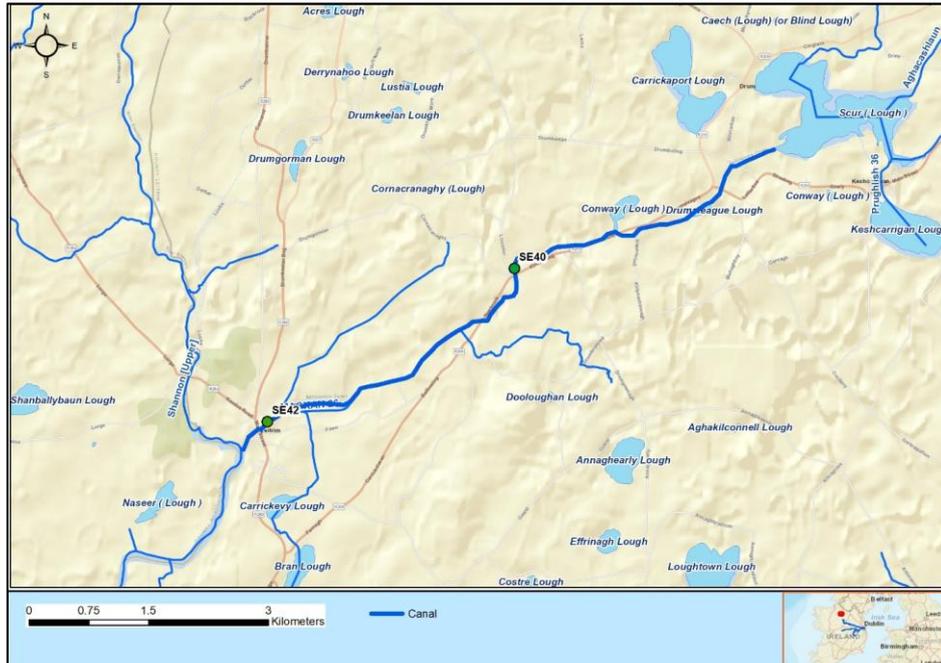
The canals are currently divided into 15 AWBs based on their locations within river catchments (Table 1). The Grand Canal supports eight AWBs (this does not include the Grand Canal Basin), the Royal Canal has six AWBs and there is just a single AWB on the Shannon-Erne Waterway. Four of the AWBs have only a single canal sampling site (Table 1), which can be potentially problematic when ecological potential for individual AWBs is being assigned. This reflects the fact that a breach in any biological or abiotic parameter can result in the AWB being changed from Good to Moderate.

For reporting purposes, a simple code has been assigned, whereby AWBs are labelled according to the river catchment in which they occur (Table 1).

Table 1. Artificial Water Bodies (AWBs) included in the WFD Monitoring Programme.

Artificial Water Body (AWB)	Catchment No	New ID Code	New Report Code	Length (km)	No of Sites
GRAND CANAL					
Grand Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_GCMLE	GC_09	41.4	6
Grand Canal Main Line East - Barrow	14	IE_14_AWB_GCMLE	GC_14E	15.7	2
Grand Canal Main Line West - Barrow	14	IE_14_AWB_GCMLW	GC_14W	12.9	2
Grand Canal Main Line - Boyne	7	IE_07_AWB_GCMLW	GC_07	14.5	2
Grand Canal Main Line - Lower Shannon	25A	IE_25A_AWB_GCMLW	GC_25A	47.0	6
Grand Canal Naas Line - Liffey and Dublin Bay	9	IE_09_AWB_GCNL	GCNL_09	11.9	1
Grand Canal Milltown Feeder - Barrow	14	IE_14_AWB_GCMF	GCMF_14	10.5	1
Grand Canal Barrow Line - Barrow	14	IE_14_AWB_GCBL	GCBL_14	50.8	4
Grand Canal Basin - Liffey and Dublin Bay	9	IE_09_AWB_GCB	GCB		2
ROYAL CANAL					
Royal Canal Main Line - Boyne Catchment	7	IE_07_AWB_RCMLE	RC_07	42.6	5
Royal Canal Main Line - Liffey and Dublin Bay	9	IE_09_AWB_RCMLE	RC_09	39.4	5
Royal Canal Main Line - Lower Shannon	25A	IE_25A_AWB_RCMLW	RC_25A	13.3	2
Royal Canal Main Line - Upper Shannon	26F	IE_26F_AWB_RCMLW	RC_26F	33.8	3
Royal Canal Main Line - Upper Shannon	26E	IE_26E_AWB_RCMLW	RC_26E	3.7	1
Royal Canal Main Line - Upper Shannon	26C	IE_26C_AWB_RCMLW	RC_26C	14.2	1
SHANNON ERNE WATERWAY					
Shannon Erne Waterway - Upper Shannon	26A	IE_26A_AWB_SEW	SE_26A	25.5	2

During 2020 a second site (SE42) was included on the Shannon-Erne Waterway to better represent the water quality status of this Waterway and AWB (Table 1.1). This site is located adjacent to the marina in Leitrim village, close to where the Shannon-Erne Waterway discharges to the River Shannon (Figure 2).

Figure 2. Location of the two WFD monitoring sites (SE40 and 42) on the Shannon-Erne Waterway.

Plate 1. Brisk flow of relatively clear water entering the Grand Canal from the Monread drain on 19th October 2023.
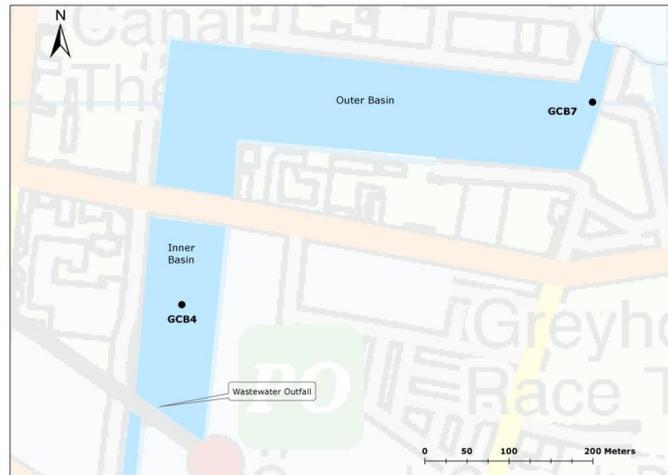
2. Materials and Methods

2.1. *Sampling locations*

Physico-chemical sampling is conducted on a quarterly basis at 50 monitoring sites – 41 on the Royal, Grand and Barrow Canals, two on the Grand Canal Basin, two on the Shannon-Erne Waterway, and five on selected canal feeder streams/drains (see Figures 1, 2 and 3). The canal feeders/drains have been a source of elevated nutrient and coliform inputs in the past. They include the Monread drain (GCE5.1) and Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeder streams on the Grand Canal, the Athy drain (BL15.1) on the Barrow Line, and the Kilcock Harbour drain (RCE16.1) on the Royal Canal.

Over the last number of months, the water level at the Croke Park (RCE25) monitoring site was significantly lowered and access to the canal was blocked to facilitate Greenway construction activities. It was, therefore, necessary to take this set of water samples at the nearest accessible upstream site, on this occasion at Cross Guns Bridge. It was also necessary to permanently relocate the Sallins (RCE4) monitoring site some 600 metres west (see Front Cover) so that water and biological samples could be collected without interference from the permanently moored craft in this area.

During 2023, WI have occasionally taken water samples for bacteriological analysis (*E. coli* and *Enterococci*) at a number of 'recreational and hotspot' sites on the canals and Shannon-Erne Waterway, at Leitrim. A small number of these sites roughly correspond with sites used for the quarterly WFD Canals Surveillance Monitoring Programme, including Leitrim village/marina, GCE8 (Hazelhatch), GCE14 (Baggot Street), GCE5 (Sallins), RCE12 (Castleknock) and RCE16 (Kilcock). A site in Naas Harbour, upstream of NL1, has also been sampled by WI during this period. The last sets of results received from WI from this sampling programme were for the following dates – 22nd August, 20th and 26th September 2023.

In addition to the quarterly water samples taken by INVAS at two sites in the Grand Canal Basin as part of the WFD Canals Surveillance Programme, WI and Dublin City Council (DCC) conduct regular water sampling for bacteriological (*E. coli* and *Enterococci*) analysis at up to 11 sites in the Basin (three in the inner, eight in the outer) and two in the adjacent Grand Canal (Figure 4). From early 2022 to late March 2023, just five samples for bacteriology were collected and analysed on a fortnightly basis, these taken from the 1st level of the Grand Canal (1), the inner basin (2 – sites 4 and 5 in Figure 4) and the outer basin (2 – sites 6 and 7 in Figure 4). Between late March and mid-May 2023, when the last set of results were received by INVAS, a sixth sampling site, located in the middle of the outer basis, was included in the sampling programme.

Figure 3. Grand Canal Basin (Dublin) showing the two monitoring sites (GCB4 and GCB7) used by INVAS.

2.2. *Physico-Chemical Monitoring*

Water sampling involves the deployment of a YSI water logger at each monitoring site to measure temperature, conductivity, pH and dissolved oxygen (% and mg/l O_2). Water samples are collected from canal sites and returned to the Independent Analytical Supplies (IAS) laboratory in Bagenalstown for analysis of a range of physico-chemical parameters (Table 2). A subset of these is used to assess indicative ecological potential - Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Oxidised Nitrogen (TON), Ammonia, Biological Oxygen Demand (BOD) and Faecal Coliforms.

Figure 4. Grand Canal Basin (Dublin) showing the 13 sites that have been sampled in the past by Waterways Ireland and Dublin City Council for bacteriology.

Table 2. Physico-chemical determinands measured as part of WFD monitoring. (Chlorophyll monitoring has been discontinued since 2021.)

Determinand	Limit	Determinand	Limit
Total Phosphorus (TP) (mg/l P)*	0.063 mg/l P	Dissolved Oxygen (DO) (mg/l and % saturation)	>5.0 mg/l O_2
Molybdate Reactive Phosphorus (MRP) (mg/l P)	0.025 mg/l P	pH	
Soluble Reactive Phosphorus (SRP) (mg/l P)*	0.025 mg/l P	Conductivity (μS)	
Total Oxidised Nitrogen (TON) (mg/l N)*	4.1 mg/l N	Alkalinity (meq/l)	
Nitrite (mg/l)		Chlorophyll (μg/l)	
Nitrate (mg/l)		Biological Oxygen Demand (BOD) (mg/l O_2)*	<2.5 mg/l O_2
Ammonia (mg/l N)*	0.12 mg/l N	Total Coliforms (TC) (counts/100ml)	5000/100 ml
Temperature (°C)		Faecal Coliforms (counts/100ml)*	1000/100 ml

* Determinands used to assign ecological potential to the Artificial Water Bodies (AWBs)

3. Results

The full set of results from physico-chemical analysis of the water samples taken from the 50 canal, feeder/drain and Grand Canal Basin sites surveyed in Q4 2023 is presented in Appendices I and II.

3.1. *Physico-chemistry at Canal Sites*

Water sampling in Q4 2023 was conducted over two days – 19th and 26th October 2023. The weather across Ireland since early July to date had been extremely wet, with July being the wettest month on record. The persistent rainfall continued during October and sampling on 19th October was preceded by Storm Babet, which brought extremely heavy rainfall. As a consequence, the water levels were high throughout the canals during sampling and, in places, the water was highly coloured or peat stained (see colour in sample bottles in Plate 3). The only site where low water levels were recorded was at Croke Park (RCE25) where the water had been artificially lowered to facilitate Greenway construction. Most of the feeders and drains supported a brisk flow of water during sampling. Water temperature over the sampling period varied from 10.1 to 13.1°C and ranged from 10.1 to 13.1°C on 19th and from 10.1 to 12.7°C on 26th October 2023 (see Appendix I). The highest temperature in Q4 of 13.1°C was recorded at GCB7 (outer basin).

Plate 2. Collecting water samples at Cloncurry (RCE12) on 19th October 2023.

Water levels at the seven Grand Canal East (GCE) WFD monitoring sites were higher than normal for the time of year when sampled on 19th October but the water was very clear at most sites. Results for TP, SRP, MRP, TON, Nitrate and BOD were low at all sampling sites and well within acceptable limits (see Appendix I). Two values for Ammonia ≥0.1mg/l N were recorded, at GCE1 (Robertstown) and GCE14 (Baggot Street), but these were within the threshold limit for this determinand. The counts for

Total coliform and *E. coli* at the newly located GCE4 (Sallins), some 600m west of the original site, were somewhat elevated but well within the threshold limits for these parameters. In Q2 a very high *E. coli* count of 1,162 per 100ml was recorded at this site, in addition to a high Ammonia reading of 0.17mg/l N. An Ammonia reading of 0.15mg/l N was also recorded here in Q3 2023. This site hosts a large number of permanently moored craft and particular attention needs to be paid to local water quality conditions. However, in Q4, conditions were good, bar the elevated coliform levels. Bacteriological sampling by WI on 19th September at GCE8 (Hazelhatch), also a site with a large number of moored craft, revealed high *E. coli* counts (2,300 and 1,600 per 100ml). Counts for *E. coli* were very low when this site was sampled by INVAS in October 2023 (see Appendix I).

Water quality conditions were generally good at most sites on GCW in Q4 (see Appendix I). The site at GCW8 (east of Rhode), however, displayed elevated TP and BOD levels, while that at GCW12 (west of Daingean) displayed elevated TP, MRP, SRP, BOD and Ammonia levels, the latter being just on the threshold limit for this parameter. These readings for the latter site probably reflect the quality of the water being discharged to the canal close to this monitoring site *via* the Ballymullen (GCW12.1) and Ballylennon (GCW13.1) feeders (see Section 3.3). An elevated *E. coli* count of 687 per 100ml was recorded at GCW20 (Cornalaur) in Q2, but subsequent counts in 2023 were low and well within acceptable limits. The unacceptably high TP reading of 0.13mg/l P that was recorded at GCW22 (west of Pollagh) in Q3 was a cause for some concern but TP readings for this site in Q4 were low and gave no suggestion that the site had been contaminated or artificially enriched.

The water level in the Naas Line of the Grand Canal was high and the water was slightly turbid when sampled in October 2023. Phosphorus and Ammonia levels were low but those for TON and nitrate were relatively high, although within the threshold limit for the determinand TON (see Appendix I). Reasonably high levels for TON have been recorded in each of the four quarters of 2023, with that in Q1 breaching the threshold limit. The coliform counts were very high on this occasion, at 4,106 and 1,515 per 100ml for Total coliform and *E. coli*, respectively, and a slightly elevated BOD reading of 2mg/l O_2 was also recorded. Bacteriological sampling by WI close to Naas Harbour in mid-September 2023 recorded very high counts for *E. coli* (4,700 per 100ml) and *Enterococci* (>1,000 per 100ml). It is apparent, based on results collected by both INVAS and WI in Q4, that contaminated water continues to be discharged to the Naas Canal *via* the drain at the harbour and Kildare County Council should be urged to act to mitigate this.

The water level in the Milltown Feeder was very high and a fast flow of clear water passed through the channel on 19th October 2023. The water quality at this time was excellent and levels for all parameters that were measured were low, as has been the case in Q1, Q2 and Q3 2023.

The water quality conditions at all four sites on the Barrow Line were excellent in Q4, as they had been in Q3 2023, and low readings for all parameters were recorded (see Appendix I). High TON and nitrate levels have been a feature of some of the BL sites in the past and regular breaches of the TON determinand have been recorded. In 2023, this parameter was only breached once, at BL10 (Vicarstown) in Q1. In Q2, Q3 and Q4, levels recorded for this parameter have been particularly low for this canal.

Plate 3. Water samples collected on 26th October 2023 and delivered to the IAS Laboratory in Bagenalstown.

As in Q3 2023, water quality conditions on Royal Canal East (RCE) in Q4 were very good at most sites and readings for TP, MRP, SRP, TON, Nitrate, Total coliforms and *E. coli* were well within acceptable limits (see Appendix I). Ammonia levels were low at all sites except RCE22 (Clondalkin), where a relatively high Ammonia reading of 0.11mg/l N was reported. High Ammonia levels that were in breach of the threshold for this determinand were reported in Q2 and Q3 at RCE25 (Croke Park) but a very low reading of 0.02mg/l N was recorded here in Q4. Ammonia levels have been reasonably low at RCE sites through 2023, although in Q2 six of the ten sites reported Ammonia levels ≥ 0.1mg/l N (compared with two, none and one ≥ 0.1mg/l N in Q1, Q3 and Q4 2023, respectively). Results from bacteriological sampling by WI at three sites close to Kilcock Harbour in mid-September produced very high counts for both *E. coli* and *Enterococci*, counts that were not mirrored when the canal at RCE16 (east of Kilcock Harbour) was sampled on 19th October.

Water quality conditions at all seven sites on Royal Canal West (RCW) were excellent in Q4, with readings for all parameters being well within acceptable limits (see Appendix I). In Q3, high Total coliform and *E. coli* counts were reported at RCW7 (Kelly's Bridge) and RCW12 (Island Bridge), with the latter also reporting a high BOD reading of 3mg/l O_2. A physical examination of these sites during

sampling in Q4 revealed no obvious cause for the results recorded, and low levels for these parameters were reported on this sampling occasion.

The results recorded in Q4 for SE40 on the Shannon-Erne Waterway were good for all of the parameters examined and no levels that might cause concern were reported (see Appendix I). In Q3, an exceptionally high TP reading of 0.14mg/l P was recorded, although levels for SRP and MRP were very low on this occasion. A far more acceptable TP value of 0.04mg/l P emerged from the Q4 results. For SE42 (Leitrim marina), elevated readings for TP, SRP, MRP and BOD were reported in Q4, although these were within threshold limits for the determinand parameters (TP, SRP and BOD). A slightly elevated *E. coli* count of 631 per 100ml was reported here in October 2023, which was far lower than the counts of 44,000 and 26,000 per 100ml for *E. coli* and >1,000 per 100ml for *Enterococci* reported by WI from bacteriological sampling at this location in mid-September 2023. These latter results clearly demonstrate that highly deleterious matter, containing sewage, continues to be discharged to the Shannon-Erne Waterway in the vicinity of the marina and Leitrim village, to the detriment of the aquatic ecology (and possibly human health) in and associated with the river.

3.2. *Indicative Ecological Potential of Canal Sites and Artificial Water Bodies*

In Q4 2023, just two of the 43 canal and Shannon-Erne Waterway sites breached determinand parameters, with each breaching for just a single parameter – GCW12 (west of Daingean) for Ammonia and NL1 (Naas Line) for *E. coli* (see Appendix I). This compared very favourably with results for the other three quarters in 2023 where nine, nine and ten sites breached determinand threshold limits in Q3, Q2 and Q1, respectively. The former site had breached determinand threshold limits in Q3, while the latter site had previously breached in Q1.

Forty-one of the 43 canal and Shannon-Erne Waterway sites were at Good indicative eco-potential when physico-chemical data for Q1 to Q4 were assessed, with just GCW8 (east of Rhode) and GCW20 (Cornalaur) at Moderate status (Table 3). Both sites breached for BOD, with the former resulting from a very high reading of 9mg/l O_2 that was recorded in Q1, while a high reading of 6mg/l O_2 was recorded, also in Q1, for the latter.

As in Q3, 14 of the 15 AWBs were assigned Good indicative eco-potential when results from physico-chemical analyses in Q1, Q2, Q3 and Q4 2023 were averaged (Table 4). The only AWB to breach any threshold limit was GC_14W, which contains GCW8 (east of Rhode) and GCW12 (west of Daingean). The determinand that breached was BOD, resulting mainly from the unexplained and exceptionally high BOD reading of 9 mg/l O_2 that was recorded in Q1, even though a number of elevated BOD readings were recorded during the year at both sites.

Table 3. Classification of the 43 canal sites in the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands for Q1, Q2, Q3 and Q4 combined in 2023.

AWB	Site Code	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	GCE4	2023	0.024	0.013	1.978	504.250	1.250	0.095	Good
	GCE6	2023	0.017	0.010	1.778	60.750	1.250	0.053	Good
	GCE8	2023	0.017	0.010	1.650	39.000	1.500	0.060	Good
	GCE10	2023	0.012	0.010	1.355	29.000	1.250	0.048	Good
	GCE12	2023	0.013	0.010	1.133	132.250	1.500	0.065	Good
	GCE14	2023	0.022	0.010	1.068	15.000	1.500	0.078	Good
GCNL_09	NL1	2023	0.021	0.010	3.703	411.750	1.500	0.060	Good
GCMF_14	MF1	2023	0.011	0.010	2.388	10.000	1.250	0.045	Good
GCBL_14	BL2	2023	0.012	0.010	0.973	32.500	1.250	0.070	Good
	BL6	2023	0.012	0.010	1.838	15.250	1.500	0.045	Good
	BL10	2023	0.018	0.010	1.870	10.000	1.250	0.080	Good
	BL15	2023	0.020	0.010	1.473	148.250	1.750	0.073	Good
GC_14E	GCE1	2023	0.011	0.010	1.475	15.250	1.250	0.083	Good
	GCW1	2023	0.011	0.010	1.510	28.500	1.500	0.038	Good
GC_14W	GCW8	2023	0.027	0.010	1.268	13.500	3.250	0.063	Moderate
	GCW12	2023	0.039	0.013	1.568	37.750	2.250	0.068	Good
GC_07	GCW4	2023	0.011	0.010	1.303	16.000	1.500	0.038	Good
	GCW6	2023	0.011	0.010	1.118	7.750	1.500	0.040	Good
GC_25A	GCW16	2023	0.021	0.010	1.360	11.250	1.750	0.038	Good
	GCW18	2023	0.018	0.010	1.323	86.250	2.250	0.040	Good
	GCW20	2023	0.016	0.010	1.418	189.750	2.500	0.045	Moderate
	GCW22	2023	0.041	0.010	1.363	7.500	1.500	0.048	Good
	GCW24	2023	0.011	0.010	1.233	7.500	1.500	0.043	Good
	GCW27	2023	0.011	0.010	0.875	15.750	1.500	0.045	Good
GCB*	GCB4	2023	0.027	0.010	1.353	56.500	1.000	0.070	Good
	GCB7	2023	0.045	0.020	1.278	6,196.750	1.750	0.120	Moderate
RC_07	RCE4	2023	0.016	0.010	0.875	8.500	1.500	0.075	Good
	RCE6	2023	0.013	0.010	1.445	26.250	1.000	0.063	Good
	RCE8	2023	0.012	0.010	1.200	100.000	1.500	0.060	Good
	RCE9	2023	0.014	0.010	0.750	29.000	1.500	0.063	Good
	RCE12	2023	0.016	0.010	1.335	31.000	1.500	0.060	Good
RC_09	RCE14	2023	0.014	0.010	1.075	12.500	1.250	0.058	Good
	RCE16	2023	0.018	0.010	1.258	32.500	1.500	0.050	Good
	RCE19	2023	0.013	0.010	1.165	37.750	1.250	0.058	Good
	RCE22	2023	0.019	0.010	0.975	223.750	1.250	0.090	Good
	RCE25	2023	0.031	0.013	0.973	53.250	1.750	0.075	Good
RC_25A	RCW1	2023	0.011	0.010	0.875	16.000	1.250	0.043	Good
	RCW3	2023	0.013	0.010	0.875	7.500	1.500	0.040	Good
RC_26F	RCW5	2023	0.011	0.010	0.973	8.000	1.500	0.043	Good
	RCW7	2023	0.011	0.010	1.148	226.750	1.000	0.045	Good
	RCW9	2023	0.013	0.010	1.085	45.750	1.750	0.065	Good
RC_26E	RCW12	2023	0.011	0.010	0.875	355.500	1.500	0.065	Good
RC_26C	RCW14	2023	0.011	0.010	0.875	8.250	1.500	0.075	Good
SE_26A	SE40	2023	0.059	0.010	0.875	25.500	1.750	0.065	Good
	SE42	2023	0.044	0.015	0.875	202.750	2.250	0.038	Good

* The Grand Canal Basin is not a designated AWB.

Table 4. Indicative ecological potential for the 15 Artificial Water Bodies (AWBs), and the Grand Canal Basin, based on results for the six physico-chemical determinands in Q1, Q2, Q3 and Q4 combined in 2023.

AWB	Year	Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
GCE_09	2023	0.017	0.010	1.493	130.042	1.375	0.066	Good
GCNL_09	2023	0.021	0.010	3.703	411.750	1.500	0.060	Good
GCMF_14	2023	0.011	0.010	2.388	10.000	1.250	0.045	Good
GCBL_14	2023	0.015	0.010	1.538	51.500	1.438	0.067	Good
GC_14E	2023	0.011	0.010	1.493	21.875	1.375	0.060	Good
GC_14W	2023	0.033	0.011	1.418	25.625	**2.750**	0.065	Moderate
GC_07	2023	0.011	0.010	1.210	11.875	1.500	0.039	Good
GC_25A	2023	0.020	0.010	1.262	53.000	1.833	0.043	Good
GCB*	2023	0.036	0.015	1.315	**3,126.625**	1.375	0.095	Moderate
RC_07	2023	0.014	0.010	1.121	38.950	1.400	0.064	Good
RC_09	2023	0.019	0.011	1.089	71.950	1.400	0.066	Good
RC_25A	2023	0.012	0.010	0.875	11.750	1.375	0.041	Good
RC_26F	2023	0.012	0.010	1.068	93.500	1.417	0.051	Good
RC_26E	2023	0.011	0.010	0.875	355.500	1.500	0.065	Good
RC_26C	2023	0.011	0.010	0.875	8.250	1.500	0.075	Good
SE_26A	2023	0.051	0.013	0.875	114.125	2.000	0.051	Good

* The Grand Canal Basin is not a designated AWB.

3.3. *Physico-chemistry and Indicative Ecological Potential of Canal Feeders/Drains*

Just one of the five feeders/drains was assigned Good indicative eco-potential based on physico-chemical sampling in Q4 2023 (see Appendix II and Figure 5). This compared with three feeders/drains at Good in Q2 and Q3, and two at Good in Q1 2023.

During sampling in October 2023, a fast flow of relatively clear water was being discharged to the Grand Canal *via* the Monread drain (GCE5.1) (see Plate 1). A very high TP reading of 0.09mg/l P was recorded here on this occasion, although readings for MRP and SRP were within threshold limits (see Appendix II). Very high counts for Total coliform (14,136 per 100ml) and *E. coli* (3,448 per 100ml) were also recorded, as was the case in Q2 and Q3 of this year. An elevated BOD reading of 2mg/l O2 was also reported. The physico-chemical results, and particularly the bacteriological counts, for the last three quarters of 2023 indicate that deleterious matter is continuing to be discharged to the Grand Canal through the Monread drain and this represents a serious water quality issue for the receiving canal system. It is imperative that Kildare County Council takes immediate action to identify and eliminate the source(s) of this pollution to the canal. Because of the recorded breaches to TP and *E. coli* threshold limits in Q4, the drain was again assigned Moderate indicative eco-potential (see Appendix II), as in

Q2 and Q3 of this year. In addition, because of significant breaches in the threshold limit for *E. coli* recorded in Q2, Q3 and Q4, this site was at Moderate indicative eco-potential when figures for 2023 were averaged (Table 5).

A fast flow of very brown but not turbid water discharged to the Grand Canal from the Ballymullen (GCW12.1) feeder when sampled in Q4 2023. A similar flow of relatively clear water emerged from the Ballylennon feeder (GCW13.1) on this sampling occasion. Results from physico-chemical analysis for the former feeder were generally good for most parameters, although somewhat elevated readings for TP (0.05mg/l P) were recorded. Based on these results, the feeder was assigned Good indicative eco-potential (see Appendix II), as it had in Q2 and Q3 this year. A breach in the threshold limit for SRP in Q1 resulted in the site being assigned Moderate indicative eco-potential on this occasion.

Phosphate levels in Q4 for the Ballylennon feeder were elevated but within threshold limits, and bacteriological counts and BOD levels were low (see Appendix II). The only high reading recorded was for Ammonia, at 0.15mg/l N, which breached the threshold limit (of 0.12mg/l N), meaning the site was assigned Moderate indicative eco-potential on this occasion. This feeder had been at Good indicative eco-potential in Q2 and Q3 2023 but was again at Moderate status in Q1, resulting from significant breaches of SRP, BOD and Ammonia thresholds. When results for the four sampling occasions in 2023 were assessed, the Ballymullen feeder remained at Good, while the Ballylennon feeder was at Moderate, the latter based on the very high BOD reading of 7mg/l O_2 recorded here in Q1 (Table 5).

 A strong flow of relatively clear water discharged from the Athy drain (BL15.1) when sampled in Q4 2023. Elevated TP and Ammonia levels were recorded during water sample analysis, although MRP, SRP, TON, Nitrate and BOD levels were satisfactory (see Appendix II). Bacteriological counts were very high, however, with that for *E. coli* well in breach of the threshold limit for this determinand. An exceptionally high *E. coli* count was also recorded here in Q3 2023, indicating that highly deleterious matter is regularly, if not constantly, being discharged to the canal, and to the nearby River Barrow, *via* this drain. Offaly County Council must address this issue as a matter of urgency as it is already having adverse consequences for the ecology of the receiving canal. The Athy drain was assigned Moderate rather than Good indicative eco-potential in Q4, as it was in Q1, Q2 and Q3 2023. The drain was also at Moderate indicative eco-potential when results for Q1 to Q4 were averaged (Table 5), reflecting very significant breaches of threshold limits for three determinands – TON, *E. coli* and Ammonia.

A slow flow of coloured but not turbid water discharged from the Kilcock drain (RCE16.1) when sampled in Q4 2023. A very high *E. coli* count of 2,143 per 100ml was recorded on this occasion, in addition to a high TP reading of 0.07mg/l P, both of which breach the threshold limits for these determinands. Bacteriological counts for this drain were very low in Q1 to Q3 2023. The high *E. coli* count recorded in Q4 follows on from very high *E. coli* and *Enterococci* results recorded from WI

sampling in the Royal Canal close to the discharge point of the drain on 19th September 2023. These results suggest that deleterious matter that probably includes sewage and possibly animal waste contamination is being discharged to the Royal Canal *via* the Kilcock Harbour drain, a fact that must be brought to the attention of Kildare County Council. Results for most other parameters were within acceptable limits (see Appendix II). While this drain was assigned Moderate rather than Good indicative eco-potential in Q4, it had remained at Good status from Q1 through Q3. This is reflected in the fact that the drain was assigned Good status when physico-chemical results for Q1 through Q4 2023 were assessed (Table 5).

Table 5. Indicative ecological potential for the five canal feeders/drains based on results for the six physico-chemical determinands in Q1, Q2, Q3 and Q4 combined in 2023.

			Total P (mg/L P)	SRP (mg/L P)	TON (mg/L N)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Indicative Physico-chemical Potential
Monread	GCE5.1	2023	0.041	0.013	2.738	**1,732**	1.250	0.043	**Moderate**
Ballymullen	GCW12.1	2023	0.043	0.018	2.363	303	1.250	0.053	**Good**
Ballylennon	GCW13.1	2023	0.049	0.023	1.545	40	**3.000**	0.090	**Moderate**
Athy	BL15.1	2023	0.045	0.010	**4.280**	**4,293**	2.000	**0.220**	**Moderate**
Kilcock Harbour	RCE16.1	2023	0.038	0.010	1.455	605	1.500	0.075	**Good**

3.4. *Grand Canal Basin*

A Dublin City Council urban wastewater outfall is located in the inner Grand Canal Basin (see Figure 3). This outfall is used to carry storm water overflow but, on occasions, sewage contamination is discharged to the Basin *via* this outfall.

The water level in the Grand Canal Basin was high when sampled on 19th October and the water was clear. The physico-chemical results from water samples taken at GCB4 (inner basin) were good, although the value recorded for TP (0.05mg/l P) was somewhat elevated. The values for MRP and SRP, however, were low and well within acceptable limits (see Appendix I). As in each of the three preceding quarters in 2023, this site was at Good indicative eco-potential in Q4 (Appendix I). When the results for Q1 through Q4 were assessed, the site was also assigned Good status (Table 3).

Results for GCB7 (outer basin) in Q4 revealed highly elevated readings for TP, MRP, SRP, Total coliform, *E. coli* and Ammonia (see Appendix I). In fact, exceptionally high counts for Total coliform and *E. coli*, both in excess of 24,000 per 100ml were reported. A BOD reading of 2mg/l O_2 was also recorded. When sampling took place, there was no indication of any disturbance to the water or of any obvious contaminant in it. However, these results indicate that water quality conditions in this area of the outer basin were less than satisfactory on this sampling occasion, even though conditions in the inner basin on the same day were good. As a consequence of these results, GCB7 was at Moderate indicative eco-potential in Q4 2023. Physico-chemical results at this site in Q3 were good, but

determinand thresholds for Ammonia were breached here in Q1 and Q2, and for SRP in Q2 2023. When physico-chemical results for Q1 to Q4 2023 were assessed, breaches for *E. coli* and Ammonia were recorded and it was assigned Moderate status (Table 3).

When the data for the two sites in Grand Canal Basin for Q1, Q2, Q3 and Q4 were assessed, this artificial waterbody was assigned Moderate indicative eco-potential (Table 4), reflecting the extremely high *E. coli* count recorded at GCB7 in Q4 2023.

No results from bacteriological sampling by WI/DCC have been received by INVAS since late May 2023.

4. Issues for Waterways Ireland Resulting from Sampling in Q4 2023

It is apparent from bacteriological results obtained by both INVAS and WI in Q4 that contaminated water, probably containing sewage and/or animal waste, is continuing to be discharged to the Naas Canal *via* the drain at the harbour. Kildare County Council must be urged to act to mitigate this pollution to the canal.

A slightly elevated *E. coli* count of 631 per 100ml was reported at Leitrim marina (SE42) following sampling by INVAS in October 2023. This result was far lower than the counts of 26,000 and 44,000 per 100ml for *E. coli* and >1,000 per 100ml for *Enterococci* reported by WI from bacteriological sampling in the vicinity of the marina in mid-September 2023. These latter results clearly demonstrate that highly deleterious matter continues to be discharged to the Shannon-Erne Waterway in the vicinity of this marina and of Leitrim village, to the detriment of the aquatic ecology (and possibly human health) in and associated with the river.

Unacceptably high bacteriological results were recorded at the three drain sites to the canals (Monread, Athy and Kilcock Harbour) in Q4 2023, with *E. coli* counts at each significantly in breach of the threshold limit. This limit had also been breached at the Monread drain in Q2 and Q3 this year, while an exceptionally high *E. coli* count of 14,830 per 100ml was recorded at the Athy drain in Q3 2023. These results indicate that deleterious matter containing sewage is continuing to be discharged to the receiving canal systems, to the detriment of the resident flora and fauna, and the broad ecology of these unique canal systems. This ongoing pollution of the canals cannot be permitted to continue, and the local County Councils must be urged to take immediate action to identify and eliminate the source(s) of this pollution to the canals.

Figure 5. Indicative ecological potential based on physico-chemical data for the 50 canal, Shannon-Erne Waterway and feeder/drain sites monitored in Q4 2023 (Green = Good, Yellow = Moderate).

Appendix I. Physico-chemical results and indicative ecological potential for canal (41), Shannon-Erne Waterway (2) and Grand Canal Basin (2) sites sampled in Q4 2023.

	Canal	Site Code	AWB	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature	Conductivity (µS)	pH	DO %	DO (mg/L O₂)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO₃)	Indicative Physico-chemical Potential
GCE1_Q4	Grand Canal	GCE1	GC_14E	Q4	19/10/2023	0.010	0.010	0.010	1.000	11.2	440	7.74	80.2	8.49	98	10	1.00	0.100	0.030	1.000	3.380	169.40	Good
GCE4_Q4	Grand Canal	GCE4	GC_14E	Q4	19/10/2023	0.030	0.010	0.010	1.500	11.5	436	7.97	107.1	11.49	4,352	727	1.00	0.030	0.030	1.490	2.520	126.20	Good
GCE6_Q4	Grand Canal	GCE6	GC_14E	Q4	19/10/2023	0.030	0.010	0.010	1.700	11.2	441	7.33	93.9	10.03	1,918	213	1.00	0.050	0.030	1.690	2.830	141.80	Good
GCE8_Q4	Grand Canal	GCE8	GC_14E	Q4	19/10/2023	0.020	0.010	0.010	1.800	11.1	435	7.98	104.0	11.11	1,198	52	1.00	0.020	0.030	1.800	3.320	166.20	Good
GCE10_Q4	Grand Canal	GCE10	GC_14E	Q4	19/10/2023	0.010	0.010	0.010	1.400	11.1	448	8.05	116.5	12.49	546	86	1.00	0.030	0.030	1.390	3.360	168.30	Good
GCE12_Q4	Grand Canal	GCE12	GC_14E	Q4	19/10/2023	0.020	0.010	0.010	1.000	11.3	430	8.15	114.0	12.10	420	52	1.00	0.030	0.030	1.000	2.540	127.30	Good
GCE14_Q4	Grand Canal	GCE14	GC_14E	Q4	19/10/2023	0.030	0.010	0.010	1.000	11.7	409	7.80	101.0	11.20	41	10	1.00	0.110	0.030	1.000	3.450	172.50	Good
GCW1_Q4	Grand Canal	GCW1	GC_14E	Q4	19/10/2023	0.010	0.010	0.010	1.500	11.3	486	7.93	110.2	11.70	504	84	1.00	0.020	0.030	1.500	2.690	134.40	Good
GCW4_Q4	Grand Canal	GCW4	GC_07	Q4	26/10/2023	0.010	0.010	0.010	1.400	10.8	459	7.96	10.3	11.40	728	41	1.00	0.050	0.030	1.400	3.260	163.10	Good
GCW6_Q4	Grand Canal	GCW6	GC_07	Q4	26/10/2023	0.010	0.010	0.010	1.300	10.8	436	7.96	115.2	12.80	31	10	1.00	0.040	0.030	1.300	3.280	164.10	Good
GCW8_Q4	Grand Canal	GCW8	GC_14W	Q4	26/10/2023	0.050	0.010	0.010	1.700	10.6	408	7.50	73.3	79.50	228	31	2.00	0.060	0.030	1.680	4.120	206.40	Good
GCW12_Q4	Grand Canal	GCW12	GC_14W	Q4	26/10/2023	0.060	0.020	0.020	2.100	11.0	450	7.30	86.2	8.50	650	120	2.00	**0.120**	0.030	2.080	5.360	268.10	**Moderate**
GCW16_Q4	Grand Canal	GCW16	GC_25A	Q4	26/10/2023	0.040	0.010	0.010	1.700	11.0	516	7.81	113.0	12.80	259	10	2.00	0.060	0.030	1.690	5.300	265.40	Good
GCW18_Q4	Grand Canal	GCW18	GC_25A	Q4	26/10/2023	0.020	0.010	0.010	1.500	10.5	504	8.17	126.0	13.80	148	41	1.00	0.020	0.030	1.500	4.470	223.50	Good
GCW20_Q4	Grand Canal	GCW20	GC_25A	Q4	26/10/2023	0.020	0.010	0.010	1.200	10.7	424	7.89	114.4	12.80	388	52	1.00	0.060	0.030	1.200	3.730	186.80	Good
GCW22_Q4	Grand Canal	GCW22	GC_25A	Q4	26/10/2023	0.010	0.010	0.010	1.300	10.7	430	7.91	91.6	10.77	10	10	1.00	0.060	0.030	1.300	1.870	93.50	Good
GCW24_Q4	Grand Canal	GCW24	GC_25A	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.9	396	7.69	94.3	10.77	75	10	1.00	0.030	0.030	1.000	3.870	193.80	Good
GCW27_Q4	Grand Canal	GCW27	GC_25A	Q4	26/10/2023	0.010	0.010	0.010	1.000	12.7	339	7.66	84.2	9.31	63	41	1.00	0.030	0.030	1.000	2.830	141.60	Good
NL1_Q4	Grand Canal	NL1	GCNL_09	Q4	19/10/2023	0.040	0.010	0.010	3.700	12.1	428	7.76	103.1	10.91	4,106	**1,515**	2.00	0.060	0.030	3.680	4.100	205.20	**Moderate**
MF1_Q4	Grand Canal	MF1	GCMF_14	Q4	19/10/2023	0.010	0.010	0.010	2.300	10.7	497	7.75	96.0	11.40	135	10	1.00	0.020	0.030	2.300	2.830	141.80	Good
BL2_Q4	Grand Canal	BL2	GCBL_14	Q4	19/10/2023	0.010	0.010	0.010	1.000	11.3	469	7.70	95.2	10.64	75	10	1.00	0.050	0.030	1.000	3.020	151.10	Good
BL6_Q4	Grand Canal	BL6	GCBL_14	Q4	19/10/2023	0.010	0.010	0.010	1.800	11.6	516	7.80	86.7	9.37	193	10	1.00	0.020	0.030	1.790	3.490	174.50	Good
BL10_Q4	Grand Canal	BL10	GCBL_14	Q4	19/10/2023	0.020	0.010	0.010	1.100	11.6	434	7.59	73.5	7.72	73	10	1.00	0.030	0.030	1.090	3.790	189.80	Good
BL15_Q4	Grand Canal	BL15	GCBL_14	Q4	19/10/2023	0.030	0.010	0.010	1.100	12.2	379	7.79	94.2	10.02	5,172	428	1.00	0.040	0.030	1.090	2.990	149.70	Good
GCB4_Q4	Grand Canal	GCB4	GCB*	Q4	19/10/2023	0.050	0.010	0.010	1.000	13.0	392	8.03	97.7	92.20	384	75	1.00	0.040	0.030	1.000	2.560	128.20	Good
GCB7_Q4	Grand Canal	GCB7	GCB*	Q4	19/10/2023	**0.110**	0.030	**0.030**	1.000	13.1	270	7.88	102.1	10.60	24,196	**24,196**	2.00	**0.120**	0.030	1.000	1.600	80.10	**Moderate**
RCE4_Q4	Royal Canal	RCE4	RC_07	Q4	26/10/2023	0.030	0.010	0.010	1.000	10.1	463	7.53	91.1	10.02	31	10	1.00	0.050	0.030	1.000	4.010	200.90	Good
RCE6_Q4	Royal Canal	RCE6	RC_07	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.1	397	7.87	97.2	10.81	41	20	1.00	0.040	0.030	1.000	4.460	223.40	Good
RCE8_Q4	Royal Canal	RCE8	RC_07	Q4	26/10/2023	0.010	0.010	0.010	1.100	10.1	442	7.71	99.7	11.06	1,274	109	1.00	0.040	0.030	1.100	4.610	230.50	Good
RCE9_Q4	Royal Canal	RCE9	RC_07	Q4	19/10/2023	0.020	0.010	0.010	1.000	10.9	368	7.79	82.0	8.00	657	86	1.00	0.020	0.030	1.000	2.470	123.60	Good
RCE12_Q4	Royal Canal	RCE12	RC_07	Q4	19/10/2023	0.030	0.010	0.010	1.000	11.1	438	7.55	63.5	6.80	135	31	1.00	0.040	0.030	1.000	2.750	137.60	Good
RCE14_Q4	Royal Canal	RCE14	RC_09	Q4	19/10/2023	0.020	0.010	0.010	1.000	10.1	449	7.67	70.5	7.78	132	10	1.00	0.040	0.030	1.000	3.240	162.30	Good
RCE16_Q4	Royal Canal	RCE16	RC_09	Q4	19/10/2023	0.020	0.010	0.010	1.000	11.1	488	8.07	104.9	11.28	97	10	2.00	0.030	0.030	1.000	3.620	181.10	Good
RCE19_Q4	Royal Canal	RCE19	RC_09	Q4	19/10/2023	0.020	0.010	0.010	1.000	11.3	444	7.87	85.5	9.13	631	121	2.00	0.020	0.030	1.000	3.520	176.40	Good
RCE22_Q4	Royal Canal	RCE22	RC_09	Q4	19/10/2023	0.030	0.010	0.010	1.000	11.1	453	7.48	60.2	6.50	295	30	1.00	0.110	0.030	1.000	2.560	128.20	Good
RCE25_Q4	Royal Canal	RCE25	RC_09	Q4	19/10/2023	0.020	0.010	0.010	1.000	11.1	423	8.11	119.0	13.07	85	20	1.00	0.020	0.030	1.000	1.880	94.10	Good
RCW1_Q4	Royal Canal	RCW1	RC_25A	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.7	277	7.65	97.0	10.57	63	10	1.00	0.040	0.030	1.000	1.580	79.20	Good
RCW3_Q4	Royal Canal	RCW3	RC_25A	Q4	26/10/2023	0.020	0.010	0.010	1.000	10.2	333	7.75	100.5	11.50	131	10	1.00	0.050	0.030	1.000	1.930	96.50	Good
RCW5_Q4	Royal Canal	RCW5	RC_26F	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.3	373	7.62	119.0	13.12	63	10	1.00	0.020	0.030	1.000	4.340	217.30	Good
RCW7_Q4	Royal Canal	RCW7	RC_26F	Q4	26/10/2023	0.010	0.010	0.010	1.400	10.4	465	8.05	118.0	13.12	98	10	1.00	0.030	0.030	1.400	4.190	209.80	Good
RCW9_Q4	Royal Canal	RCW9	RC_26F	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.5	419	7.97	110.0	12.17	31	10	1.00	0.040	0.030	1.000	3.800	190.30	Good
RCW12_Q4	Royal Canal	RCW12	RC_26E	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.5	348	7.61	90.3	9.78	21	20	1.00	0.050	0.030	1.000	4.090	204.50	Good
RCW14_Q4	Royal Canal	RCW14	RC_26C	Q4	26/10/2023	0.010	0.010	0.010	1.000	10.4	321	7.95	104.4	11.30	10	10	1.00	0.080	0.030	1.000	3.070	153.80	Good
SE40_Q4	Shannon Erne	SE40	SE_26A	Q4	26/10/2023	0.040	0.010	0.010	1.000	10.4	196	7.70	117.1	12.99	132	20	1.00	0.070	0.030	1.000	1.570	78.70	Good
SE42_Q4	Shannon Erne	SE42	SE_26A	Q4	26/10/2023	0.060	0.020	0.020	1.000	10.7	213	7.57	110.7	12.29	1,296	631	2.00	0.060	0.030	1.000	2.890	144.40	Good

Appendix II. Physico-chemical results and indicative ecological potential for canal feeder/drain sites sampled in Q4 2023.

Canal	Site	Location	AWB_Code	Quarter	Date	Total P (mg/L P)	MRP (mg/L P)	SRP (mg/L P)	TON (mg/L N)	Temperature (degree C)	Conductivity (µS)	pH	DO %	DO (mg/L O₂)	Total Coliform (Count/100ml)	E-Coli (Count/100ml)	B.O.D. (mg/L O2)	Ammonia (mg/L N)	Nitrite (mg/L N)	Nitrate (mg/L N)	Alkalinity (meq/L)	Alkalinity (mg/L CaCO₃)	Indicative Physico-chemical Potential
Grand Canal	GCE5.1	Monread Feeder	GC_09	Q4	19/10/2023	0.090	0.020	0.010	1.600	12.40	422	7.62	98.7	10.48	14,136	3,448	2.00	0.040	0.030	1.590	3.060	153.10	Moderate
Grand Canal	GCW12.1	Ballymullen Feeder	GC_14	Q4	26/10/2023	0.050	0.010	0.010	2.200	11.20	578	7.74	93.8	10.20	1,842	292	1.00	0.080	0.040	2.160	5.660	283.10	Good
Grand Canal	GCW13.1	Ballylennon Feeder	GC_14	Q4	26/10/2023	0.060	0.020	0.020	1.700	10.80	503	7.34	97.4	10.67	213	52	1.00	0.150	0.030	1.680	5.930	296.90	Moderate
Grand Canal Barrow Line	BL15.1	Athy Drain	GCBL_14	Q4	19/10/2023	0.060	0.010	0.010	2.600	12.90	432	7.69	83.6	8.60	24,196	1,723	1.00	0.100	0.030	2.580	2.400	120.30	Moderate
Royal Canal	RCE16.1	Kilcock Harbour Drain	RC_09	Q4	19/10/2023	0.070	0.010	0.010	1.900	13.10	420	7.50	110.0	11.50	7,701	2,143	1.00	0.020	0.030	1.900	1.820	91.20	Moderate

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