ATTACHMENT D.2:

ASSESSMENT OF IMPACT ON RECEIVING WATERS

ATTACHMENT D.2.1:

IMPACT ASSESSMENT REPORT NOVEMBER 2024

ATTACHMENT D.2.1: IMPACT ASSESSMENT REPORT, NOVEMBER 2024

1. Introduction

This Report provides a summary of the Impact Assessments prepared to determine the impact of the operational discharges from the Virginia agglomeration on the receiving waterbodies, Lough Ramor and Blackwater (Kells)_070 River and also addresses the criteria as outlined in **Section D.2** of the EPA guidance document.

2. Water Environment

The Virginia Waste Water Treatment Plant (WwTP) existing primary discharge and proposed operational discharges are to Lough Ramor and the Blackwater (Kells)_070 and Blackwater (Kells)_080 rivers. All 3 no. waterbodies are part of the Boyne Catchment (Hydrometric Area: 07). This catchment includes the area drained by the River Boyne and by all streams entering tidal water between The Haven and Mornington Point, Co. Meath, draining a total area of 2,694km².

According to Catchments.ie (at the time of preparing this Application (November 2024)), the main significant pressures for '*At Risk*' surface waterbodies are agriculture, followed by hydromorphological pressures, peat, domestic waste water, urban waste water, unknown, invasive species, industry, abstractions and mines & quarries. The Virginia agglomeration is listed as a significant pressure in '*At Risk*' Waterbodies in the 3rd cycle catchment assessment (2024).

The Water Framework Directive (WFD) Status of Lough Ramor is *'Poor'* and *'At Risk'* of not of achieving *'Good'* water quality status by 2027. Significant pressures for the Lough Ramor have been determined, within the 3rd cycle Catchment Report, as invasive species, agriculture, and urban waste water.

The EPA monitor biological water quality at Station LS070015906000050 which is located *ca.* 800m downstream of the primary discharge (SW001) at Lough Ramor. There are no Q-values for water quality stations in lakes. The Q value at Station RS07B010800, which is *ca.* 0.3km upstream of the existing primary discharge (SW001), reported a Q value of 4 (Good) for the 2020 monitoring period. In comparison, the Q value at Station RS07B010900, which is *ca.* 4.2km downstream of the primary discharge, reported a Q value of 3 for the 2006 monitoring period, indicating '*Poor*' water quality conditions.

The Lough Ramor waterbody trends on the 2013 – 2018 at Station LS070015906000050 (downstream of the operational discharges) for Ammonia and Total Phosphorous (as P) are downwards (*i.e.,* decreasing concentrations) with an indicative water quality of *'High'* and *'Moderate'* for each parameter respectively, under WFD status for 2016-2021.

Recent ambient monitoring data for Lough Ramor at Station LS070015906000050 can be found in **Table 37** of the Application Form. Based on UÉ Compliance Data from March 2021 – February 2024 at Station LS070015906000050, which is *ca*. 800m downstream of the primary discharge location, for Ammonia concentrations, the operational discharges are indicative of '*Good'* water quality, and '*High'* water quality for the 95%ile EQS. In terms of Total Phosphorus (as P) concentrations, the operational discharges are not indicative of '*Good*' water quality.

There are no designated Salmonid Rivers, Nutrient Sensitive Areas, Freshwater Pearl Mussel Waterbodies or Shellfish Areas in the vicinity of the operational discharges.

Although Lough Ramor is not a designated salmonid water body, River Boyne and River Blackwater SAC is selected for a number of species listed on Annex I/II of the E.U. Habitats Directive including Atlantic Salmon (*Salmo salar*). For this reason, an ELV of 25mg/l for Suspended Solids is being proposed as part of this Licence (D0255-01) Review, keeping with the protection required under the WFD for salmonid waters designated on the Register of Protected Areas.

Although Lough Ramor is a designated drinking water lake (IE_EA_07_275), the operational discharges are located downstream of the Virginia drinking water abstraction points, and therefore do not pose a risk to drinking water abstractions.

Lough Ramor is a proposed Natural Heritage Area (pHNA) (Site Code: 000008). The lake supports nationally important numbers of Cormorant and notable concentrations of Whooper Swan, Wigeon, Teal, Mallard and Lapwing. Snipe, Lapwing and Curlew also nest in the fringing marshes around the lake. The plant communities along the lake margins are of note and, combined with the over-wintering bird numbers, make Lough Ramor an important wetland site.

European sites within the surrounding environment include River Boyne and River Blackwater Special Area of Conservation (SAC) (Site Code: 002299) and Special Protection Area (SPA) (Site Code: 004232). The primary discharge (SW001) discharges into Lough Ramor which drains to the River Boyne and River Blackwater SAC and SPA (*ca*. 4.2km downstream).

The River Boyne and River Blackwater SAC is selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive, [7230] Alkaline Fens, [91E0] Alluvial Forests, [1099] River Lamprey (*Lampetra fluviatilis*), [1106] Atlantic Salmon (*Salmo salar*), [1355] Otter (*Lutra lutra*). The conservation interest of the River Boyne and River Blackwater SPA is the Kingfisher which is listed on Annex I of the E.U. Birds Directive. Refer to **Attachment D.2.2** for a copy of the combined AA Screening & Natura Impact Statement Report for further details on the receiving environment.

In 2024, UÉ carried out a Water Quality Impact Assessment to inform this Licence Review (D0255-01). On completion, it was determined that existing ELVs as per D0255-01 (*i.e.*, the proposed effluent standards for this Licence Review) for the primary discharge point (SW001) from the proposed 6,000 p.e. WwTP were deemed appropriate to support the water quality objectives of Lough Ramor. Refer to **Section 3** below.

The proposed effluent discharge standards and the design of the overflows will ensure that the operational discharges from the Virginia agglomeration (i) contribute towards achieving the "*Good*" WFD Status of Lough Ramor in accordance with the European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and (ii) will ensure that there is no environmental risk posed to the receiving water environment as a result of the discharges from the agglomeration.

3. Water Quality Impact Assessment

A 2-dimensional model of Lough Ramor was developed by MSN Hydro Int. Ltd. and applied to perform a Tier 3 mixing zone assessment for the future upgraded primary discharge (SW001). The industry standard model MIKE21 was used. The model simulates lake hydrodynamics and five nutrients: Organic Nitrogen, Ammonia and Nitrate Nitrogen and Organic Phosphorus and Inorganic Phosphorus. Model suitability was assessed by simulating hydrodynamic and water quality conditions in the lake for the year 2018 and comparing the results with measured data. The model was deemed suitable for use for mixing zone assessment.

The mixing zone assessment involved the simulation of three flow conditions: (1) mean river flows for comparison of nutrient concentrations with mean EQS criteria, (2) low (Q95) river flows for comparison of nutrient concentrations with 95%ile EQS criteria and (3) full flow-to-treatment, where the discharge is increased from mean flow rate to max flow rate for a 24 hour period, which is used to assess the impact of the WwTP when running at maximum flow. Seven water quality scenarios were simulated in total:

- mean and low river flows with the current WwTP discharge and existing lake and river conditions;
- mean and low river flows with the future upgraded WwTP discharge and existing lake and river conditions;
- mean and low river flows with the future upgraded WwTP discharge and notionally-clean lake and river conditions;
- mean river flows with full flow-to-treatment for the future upgraded WwTP and notionally-clean lake and river conditions;

All model simulations were run for 180 days so that steady state conditions were achieved. 2D spatial concentration maps for Ammonia and Total Phosphorus (as P) were compared with EQS criteria and the resulting water quality status maps were used to identify the presence and extents of any mixing zones that were formed.

The following are the main conclusions from the mixing zone assessment study based on the model results:

- The rivers are currently the primary factor influencing lake chemistry; the WwTP has a negligible impact.
- If river nutrient loads remain as they are, the upgraded WwTP will have a negligible effect on water quality in the lake. The model results show that Ammonia and Total Phosphorus (as P) concentrations will either remain the same or slightly improve due to the improved chemistry of the WwTP's future effluent from the primary discharge (SW001).
- Based on the water quality status maps, a WwTP mixing zone was not identified for any of the modelled mean or low-flow scenarios.
- Based on the full flow-to-treatment (FFT) scenario results, it can be concluded that increasing the WwTP to maximum discharge has a relatively small impact on nutrient levels. Compared with the mean flow scenario, Ammonia and Total Phosphorus (as P) concentrations in the FFT scenario temporarily increase in the vicinity of the outfall but very quickly return to the same levels as the mean flow scenario, this occurs within 3 days for Ammonia and within 1 day for Total Phosphorus (as P).
- The modelling results demonstrate that the proposed primary discharge (SW001) and associated ELVs (as per D0255-01 and as proposed in this licence review) are compatible with the achievement of WFD objectives, *i.e.*, '*Good*' status of receiving waters, Lough Ramor by 2027.

Refer to **Attachment D.2.3** for a copy of Water Quality Impact Assessment Report (September 2024).

4. Appropriate Assessment

A combined Appropriate Assessment (AA) Screening Report and Natura Impact Statement (NIS) was prepared in November 2024 to accompany this WWDL Review application. This Report will enable the EPA as Competent Authority to conduct an AA Screening Determination, and Stage 2 AA in respect of the Virginia agglomeration operational discharges, for the purposes of the European Union (Waste Water Discharge) Regulations 2007 to 2020.

The AA Screening assessed whether the Viriginia WwTP Upgrade Project and proposed operational discharges, alone or in combination with other plans and projects, are likely to have significant effects on a European Site(s) in view of best scientific knowledge and the conservation objectives of the site(s).

Based on the information set out in the AA Screening, and the documentation referenced therein, it was concluded that the likelihood of significant effects to the River Boyne and River Blackwater SAC (Site Code: 002299) and River Boyne and River Blackwater SPA (Site Code: 004232) could not be excluded, and a Stage Two AA was deemed required.

On foot of the conclusion on the AA Screening Report, a Natura Impact Statement (NIS) was prepared. The NIS concludes that '*the Viriginia WwTP Upgrade Project and proposed operational discharges, alone or in-combination with other plans and / or projects will not give rise to adverse effects on the integrity of the River Boyne and River Blackwater SAC and SPA, or any other European Site*' once the mitigation measures, as detailed in the NIS, are implemented in full and that the Competent Authority, *i.e.*, EPA, will not need to proceed past Stage 2.

Please refer to **Attachment D.2.2** for a copy the combined AA Screening & NIS Report prepared to inform this WWDL review process.

5. Environmental Impact Assessment

An Environmental Impact Assessment (EIA) Screening Report (November 2024) has been prepared to form an opinion as to whether or not the operational activities from the Virginia agglomeration should be subject to Environmental Impact Assessment (EIA) and if so, whether an Environmental Impact Assessment Report (EIAR) should be prepared in respect of it.

Based on the information as contained in the EIA Screening Report (see **Attachment B.5**), it is Uisce Éireann's opinion that there is no significant and realistic doubt in regard to the likelihood of significant effects on the environment arising from the operational discharges from the Virginia WwTW in so far as they relate to the risk of environmental pollution of the receiving waters) and it is considered that an EIA is not required for the authorisation to which this application relates by virtue of its nature, size and location.

In addition, as part of the Planning Application for the proposed WwTP Upgrade Project the Competent Planning Authority, Cavan County Council, conducted an EIA screening in respect of the proposed development, and they determined that there was no requirement on Uisce Éireann to either prepare or submit an EIAR in relation to the proposed development (refer to **Attachment B.3.2** – Planners Report, February & October 2023).

6. Priority Substance Assessment Report

An assessment of the potential for impacts on receiving waters from priority substances in the primary discharge (SW001) has been carried out to inform this licence review application.

Wastewater effluent sampling at Virginia was undertaken on 14th September 2021 as part of Uisce Éireann's (UÉ) Dangerous Substances Effluent Monitoring Programme. The results of this monitoring, where applicable, were used to inform this assessment. Estimated data from the PRTR reporting tool was required for this desktop assessment as measured data was unavailable for all parameters.

The assessment considered the primary discharge relevant to the surface waters Environmental Quality Standards (EQS) for priority substances (as per the Surface Waters Regulations), as listed in the EPA Guidance on the Screening for Priority Substances for Waste Water Discharge Licences (2011) and those which are listed in the PRTR tool. It should be noted that not all substances that are listed in the Surface Waters Regulations are included in the PRTR tool.

The assessment concluded that, after dilution, none of the substances listed in the PRTR tool and EPA Guidance are likely to be present in the effluent discharge to Lough Ramor, above the standards in European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended.

Based on the results of this study and the nature of the discharge, it can be confidently determined that no for further analysis of the primary discharge is required, based on the EPA Guidance on the Screening for Priority Substances for Waste Water Discharge Licences.

This Report is contained in **Attachment D.2.4**: Priority Substance Assessment Report.

7. Drinking Water Abstractions

Lough Ramor is a designated drinking water lake (IE_EA_07_275). However, the operational discharges are located downstream of the Virginia drinking water abstraction points, and therefore do not pose a risk to drinking water abstractions.

8. Shellfish Waters

There are no designated shellfish waters located downstream in the vicinity of the discharges.

9. Bathing Waters

There are no designated bathing waters located downstream in the vicinity of the discharges.

10. River Flow Estimation

Not applicable as primary discharge (SW001) is to a lake.

11. Combined Approach

The Waste Water Discharge Authorisation under the European Union (Waste Water Discharge) Regulations 2007 to 2020, specify that a '*combined approach'* in relation to licensing of waste water works must be taken, whereby the emission limits for the discharge are established on the basis of the stricter of either or both, the limits and controls required under the Urban Waste Water Treatment Regulations, 2001, as amended, and the limits determined under statute or Directive for the purpose of achieving the environmental objectives established for surface waters, groundwater or protected areas for the water body into which the discharge is made.

Article 4 of the Directive states *"Member States shall ensure that urban waste water entering a collecting system shall before discharge be subject to secondary treatment or an equivalent treatment […] for discharges to freshwater from agglomerations of between 2,000 and 10,000 pe*". In line with the above, the upgraded Virginia WwTP (6,000 p.e) will provide tertiary treatment with P removal which will allow the receiving waterbody to meet the relevant water quality objectives.

The proposed effluent standards give effect to the principle of the Combined Approach as defined in Waste Water Discharge (Authorisation) Regulations, 2007 to 2020 in that they accommodate the Urban Waste Water Regulations and the relevant designations / status of the receiving waterbody, Lough Ramor.

12. Compliance with Relevant National or EU Legislation

As per **Attachment B.6,** the Virginia Waste Water Treatment Works (WwTW) has been designed to ensure that the emissions from the agglomeration will comply with and will not result in the contravention of EU Legislation and National Regulations.

The proposed effluent discharge standards/ELVs (as per D0255-01), and the design of the overflows will ensure that the operational discharges from the Virginia agglomeration (i) contribute towards maintaining the "*Good*" Status of Lough Ramor in accordance with the European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, and (ii) will ensure that there is no environmental risk posed to the receiving water environment as a result of the discharges from the agglomeration.

The proposed effluent discharge standards/ELVs will not cause a deterioration in the chemical status in the relevant receiving waterbody and will not compromise the achievement of the objectives and EQSs established for any European sites water dependant species and natural habitats, or any other designations. The operation of the upgraded WwTP is expected to have a positive impact in terms of a higher quality final effluent being discharged to Lough Ramor.

13. Data Sources

The following data sources were used to complete this application.

- Online data available on held by the NPWS, the EPA and Uisce Éireann:
    - www.npws.ie
    - epawebapp.epa.ie
    - gis.epa.ie/EPAMaps

- catchments.ie

- GIS data for European site boundaries obtained in digital format online from European Environmental Agency
- Uisce Éireann/Cavan County Council Monitoring & Sampling Data

14. Cumulative and In Combination Effects

The combined Appropriate Assessment Screening & NIS Report addresses in combination effects. Refer to **Attachment D.2.2**.

15. Mixing zone or transitional areas of exceedance

A mixing zone assessment is provided in **Attachment D.2.3** Water Quality Impact Assessment Report (September 2024). Based on the water quality status maps contained therein, mixing zones were not identified for Ammonia or Total Phosphorus (as P) for any of the modelled mean or low-flow scenarios.

16. Dilutions and retention times for lakes

Dilution factor in receiving water: 15.5 dilution estimated immediately in the proximity of the primary discharge point, for the receiving waterbody, Lough Ramor (based on an Average Daily Effluent Flow (1.25 DWF) of 1,687.5m^3/day and 95%ile flow 0.302 m^3/s (Flow data from Station no. 07004 (Stramatt) (1986-2021)).

17. The impact of the discharges on any environmental media other than those into which the emissions are to be made

Not applicable. No other relevant media into which the emissions are to be made.

18. Groundwater Details

Not applicable. No discharge to ground waters.

19. High Status Waterbodies

Not applicable. No '*High*' WFD status waterbodies within the region of the Virginia WwTP and/or the operational discharges.

20. Fresh Water Pearl Mussels

Not applicable. No Fresh Water Pearl Mussels within the region of the Virginia WwTW and/or the operational discharges.

21. Impacts on Transboundary / Territory of other States

The operational discharges to which this application relates will not result in transboundary impacts or impacts on the territory of other states.

22. For waste water treatment plants with coastal discharges, provide evidence that the end of the discharge pipe is below the mean spring tide low water line

Not applicable. Discharge is not to coastal water.

ATTACHMENT D.2.2:

AA SCREENING & NIS REPORT
NOVEMBER 2024

Uisce Éireann Report

AA Screening & Natura Impact Statement Report as part of the Virginia Waste Water Discharge Licence Review
November 2024

Contents

Introduction

This report provides information to enable the Environmental Protection Agency (EPA), as the competent authority, to conduct an Appropriate Assessment (AA) Screening Determination and Stage 2 AA in respect of the Virginia agglomeration Operational Discharges, for the purposes of the European Union (Waste Water Discharge) Regulations 2007 to 2020. It considers whether the operational discharges from the Virginia agglomeration, alone or in combination with other plans and projects, could adversely affect the integrity of European Site(s) in view of best scientific knowledge and the conservation objectives of the site(s). European Sites are those identified as sites of European Community importance designated as Special Areas of Conservation (SACs) under Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the "Habitats Directive") or as Special Protection Areas (SPAs) under the Conservation of Wild Birds Directive (79/409/ECC) as codified by Directive 2009/147/EC (the "Birds Directive").

This report takes account of the guidance for AA published by the EPA '*Note on Appropriate Assessments for the purposes of the Waste Water Discharge (Authorisation) Regulations, 2007 (S.I. No. 684 of 2007)*' (EPA, 2009), the Office of the Planning Regulator (OPR) guidance on Appropriate Assessment Screening for Development Management, OPR Practice Note PN01 (OPR, 2021) and the Department of the Environment, Heritage and Local Government's guidelines '*Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities*' (DoEHLG, 2009), together with subsequent case law.

This assessment was completed by Kate Harrington MSc MCIEEM, an Ecologist who has over 20 years' experience in undertaking ecological surveys and assessments in Ireland and abroad. Ms Harrington's experience includes the preparation of AA Screening, Natura Impact Statements (NIS), Ecological Impact Assessments, biodiversity studies and water quality studies for a range of infrastructure projects. She has extensive experience of reviewing and undertaking ecological assessments for Uisce Éireann (UÉ) projects and activities as well as developing guidance documents and advising consultant engineers and ecologists regarding best practice. She currently works as a freelance ecologist and is pursuing a PhD in ecology.

Legislative Context

The Habitats Directive provides legal protection for habitats and species of European importance. Articles 3 to 9 provide the legislative means to protect habitats and species of Community interest through the establishment and conservation of an EU-wide network of sites known as Natura 2000. These are SACs designated under the Habitats Directive and SPAs designated under the Birds Directive.

Articles 6(3) and 6(4) of the Habitats Directive set out the decision-making tests for plans and projects likely to affect European sites (Annex 1.1). Article 6(3) establishes the requirement for Appropriate Assessment (AA):

> *Any plan or project not directly connected with or necessary to the management of the [Natura 2000] site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subjected to appropriate assessment of its implications for the site in view of the site's conservation objectives. In light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.*

Article 6(4) states:

> *If, in spite of a negative assessment of the implications for the [Natura 2000] site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, Member States shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted.*

Article 7 of the Habitats Directive provides that the provisions of Article 6(3) and 6(4) (among other provisions) are to apply to SPAs designated under the Birds Directive.

Article 6(3) provides for a two-stage process. The first stage involves a screening for AA and the second stage arises where, having screened the application for the development, the competent authority determines that AA is required, in which case it must then carry out that AA. A competent authority does not have jurisdiction to grant development consent unless the AA provisions are correctly applied.

The Habitats and Birds Directives are transposed in Ireland under the European Communities (Birds and Natural Habitats) Regulations 2011, as amended (2011 Regulations). In relation to the assessments to be carried out under the Habitats Directive, the provisions of Regulation 42 of the 2011 Regulations require "a screening for AA of a… project for which an application for consent is received". Following that screening, if the relevant public authority determines that an AA is required, then a Natura Impact Statement [NIS] must be submitted and "a public authority shall give consent for a… project, only after having determined that the… project shall not adversely affect the integrity of a European site".

Methodology

Guidance Followed

Both EU and national guidance exists in relation to Member States fulfilling their requirements under the EU Habitats Directive, with particular reference to Article 6(3) and 6(4) of that Directive. The methodology followed in relation to this NIS has had regard to the following guidance:

- Office of the Planning Regulator (OPR). Appropriate Assessment Screening for Development Management. OPR Practice Note PN01. (OPR, 2021)

- Note on Appropriate Assessments for the purposes of the Waste Water Discharge (Authorisation) Regulations, 2007 (S.I. No. 684 of 2007). Environmental Protection Agency, (EPA, 2009).

- Appropriate Assessment of Plans and Projects in Ireland: Guidance for Planning Authorities. Department of Environment, Heritage and Local Government, (DoEHLG, 2010).

- Circular L8/08 – Water Services Investment and Rural Water Programmes – Protection of Natural Heritage and National Monuments. Department of Environment, Heritage and Local Government, (DoEHLG, 2008).

- Communication from the Commission on the Precautionary Principle. Office for Official Publications of the European Communities, Luxembourg, (EC, 2000).

- Managing Natura 2000 Sites: the provisions of Article 6 of the 'Habitats' Directive 92/43/EEC, Office for Official Publications of the European Communities, Luxembourg, (EC, 2018).

- Assessment of plans and projects significantly affecting Natura 2000 sites: Methodological guidance on the provisions of Articles 6(3) and (4) of the Habitats Directive 92/43/EEC. Office for Official Publications of the European Communities, Brussels (EC, 2001).

- Assessment of plans and projects in relation to Natura 2000 sites - Methodological guidance on Article 6(3) and (4) of the Habitats Directive 92/43/EEC. European Commission, Brussels (EC, 2021).

- Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC – Clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the Commission. Office for Official Publications of the European Communities, Luxembourg, (EC, 2007).

- Nature and biodiversity cases: Ruling of the European Court of Justice. Office for Official Publications of the European Communities, Luxembourg (EC, 2006).

- Interpretation Manual of European Union Habitats. Version EUR 28. European Commission (EC, 2013).

- Marine Natura Impact Statements in Irish Special Areas of Conservation: A working document, National Parks and Wildlife Service, Dublin (NPWS, 2012).

- EPA Guidance for Uisce Éireann on Requests for Alterations to a Wastewater Discharge Licence or Certificate of Authorisation" (Revised March 2019).

Stages Involved in the Appropriate Assessment Process

Stage 1: Screening / Test of Significance
This process identifies whether the agglomeration operational discharges are directly connected to or necessary for the management of a European Site(s); and identifies whether the Virginia operational discharges are likely to have significant impacts upon a European Site(s) either alone or in combination with other projects or plans.

In essence, upon conducting a Stage 1 Screening, the competent authority is required to determine whether or not it can be excluded, on the basis of objective scientific information, that the project, individually or in combination with other plans or projects, will have a significant effect on a European site.

The output from this stage is a determination for each European Site(s) of not significant, significant, potentially significant, or uncertain effects. The latter three determinations will cause that site to be brought forward to Stage 2.

Stage 2: Appropriate Assessment
This stage considers the impact of the Operational Discharges on the integrity of a European Site(s), either alone or in combination with other projects or plans, with respect to (1) the site's conservation objectives; and (2) the site's structure and function and its overall integrity. The potential impacts of the Virginia Operational Discharges are examined with respect to the attributes and targets which define the favourable conservation condition of each qualifying interest in the European sites, and the extent, if any, to which meeting those targets could be affected. Additionally, where there are adverse impacts, an assessment of the potential mitigation of those impacts may be carried out at Stage 2.

To assist the competent authority to carry out the Stage 2 AA, the developer must prepare a Natura Impact Statement (NIS). This document must include sufficient information for the EPA to carry out the Appropriate Assessment. If the assessment is negative, *i.e.,* adverse effects on the integrity of a European site cannot be excluded, then the process must consider alternatives (Stage 3) or proceed to Stage 4.

Stage 3: Assessment of Alternatives
This process examines alternative ways of achieving the objectives of the project or plan that avoid adverse impacts on the integrity of the European Site. This assessment may be carried out concurrently with Stage 2 in order to find the most appropriate solution. If no alternatives exist or all alternatives would result in negative impacts to the integrity of the European sites, then the process either moves to Stage 4 or the project is abandoned.

Stage 4: Assessment Where Adverse Impacts Remain
An assessment of compensatory measures where, in the light of an assessment of Imperative Reasons of Overriding Public Interest (IROPI), it is deemed that the project or plan should proceed.

Consultation

The EPA, as the competent authority, will seek National Parks and Wildlife Service (NPWS) advice as may be required in reaching their decision on a WwTP discharge. The NPWS can only communicate with the applicant (*i.e.* Uisce Éireann) on request from the competent authority, when the formal application process to the competent authority has already commenced.

Desk Study

The sources of available desktop information used to inform the assessment included:

- The National Parks and Wildlife Service (NPWS) natural heritage database (www.npws.ie) was consulted for designated sites of nature conservation interest in the study area;
- The National Biodiversity Data Centre (NBDC) species database (http://www.biodiversityireland.ie/) and BSBI database https://database.bsbi.org/ were consulted to obtain species records in the study area;
- The Environmental Protection Agency mapping system (https://gis.epa.ie/EPAMaps/), and www.catchments.ie website for data related to water quality;
- The Inland Fisheries Ireland (IFI) website and www.wfdfish.ie website for fisheries data;
- Ordnance Survey Ireland mapping and aerial photography from https://webapps.geohive.ie/mapviewer/index.html;
- Geological Survey Ireland (GSI) data and maps https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228; and
- Information on the conservation status of birds in Ireland from Birds of Conservation Concern in Ireland https://birdwatchireland.ie/birds-of-conservation-concern-in-ireland/.

Field Study

A walkover survey was carried out by the author on January 3rd 2024. The Operational Discharges locations were visited with the aim of identifying the aquatic habitats in the receiving waters, and determining what qualifying interests occur, or have the potential to occur, within the zone of influence (ZoI) of the operational discharges. Habitats were classified with reference to The Heritage Council's 'A Guide to Habitats in Ireland' (Fossitt, 2000)[1] and the Annex I interpretation manual[2]. Searches for protected species followed National Roads Authority (NRA) (2009)[3] guidance.

[1] https://www.npws.ie/sites/default/files/publications/pdf/A%20Guide%20to%20Habitats%20in%20Ireland%20-%20Fossitt.pdf
[2] Interpretation Manual of European Union Habitats – EUR28 https://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf
[3] NRA (2009) Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes https://www.tii.ie/technical-services/environment/planning/Ecological-Surveying-Techniques-for-Protected-Flora-and-Fauna-during-the-Planning-of-National-Road-Schemes.pdf

Description of the Project

Project Context

Virginia is a town located *ca.* 30km south east of Cavan town. The agglomeration is spread over 5 townlands namely, Virginia, Rahardrum, Deerpark, Ballaghanea and Crannadillon.

The Waste Water Treatment Works (WwTW) at Virginia Town serves a catchment that includes the main town centre and surrounding residential areas. The agglomeration is served by a sewerage system that comprises of gravity sewers, Pumping Stations, rising mains, and a Waste Water Treatment Plant (WwTP). The WwTP is located on the banks of Lough Ramor.

Virginia WwTP
The existing Virginia WwTP located at NGR 260528E, 287144N adjacent to Lough Ramor, *ca.* 500 meters from Virginia Town Centre.

The existing WwTP was constructed in 1998 has a current design capacity of 3,800 p.e. and currently receives 3,715 p.e. (Organic Capacity (p.e) - Collected Load as per 2023 AER) and is therefore close to exceeding its design capacity. The current WWDL for the agglomeration is for 2,363 p.e.

The Primary Discharge Point (SW001) from the WwTP is located at 260521E, 286736N (SW001) and discharges *via* a 300mm dia. upvc diffuser pipe to Lough Ramor which is part of the Boyne Catchment (HA 07). There are no secondary discharges in the agglomeration.

The current Virginia WwTP provides primary treatment (aeration System); secondary treatment (clarification); and nutrient removal (chemical dosing for phosphate removal).=

Terminal Pumping Station & Associated Storm Water Overflows
The WwTP is fed *via* a rising main beneath the River Blackwater from the Terminal Pumping Station located on New Street.

There is currently one licenced Storm Water Overflow (SWO) at the Terminal Pumping Station (TPS), which discharges to Lough Ramor *via* SW002 at NGR 260410E, 287031N. This SWO will be decommissioned as part of the upgrade works.

Network Pumping Stations and Overflows
There are no network overflows associated with the Virginia agglomeration.

On the 5th December 2022, a planning application for the Virginia WwTP and the Terminal Pumping Station Upgrade Project was submitted to Cavan County Council for determination (Planning Ref: 22489). Permission was granted for the Project in November 2023.

The project objectives are to:

- Alleviate current hydraulic overloading;
- Provide headroom to treat future predicted catchment growth;

Virginia WwTP Upgrade

The upgrade works to the WwTP, with a design capacity of 6,000 p.e., will consist of the following elements:

- Provision of inlet works;
- Provision of a Control SWO Chamber;
- Provision for stormwater storage tank;
- Proposed Dual Function Overflow outfall from WwTP to Lough Ramor (SW003) to replace the existing SWO outfall at the TPS (SW002), which will be decommissioned;
- Provision of tertiary treatment system (tanks and a filter) together with all associated ancillary works;
- Provision of outfall Pumping Station;
- Demolition of existing sludge tank and replacement with sludge thickening unit and sludge holding tank;
- Provision of biological treatment tank;
- Provision of a back-up generator with diesel tank bunded to be used in an emergency/power cut.

A new Dual Function Overflow (SW003) will be installed from the upgraded WwTP to Lough Ramor in close proximity to the existing primary effluent discharge point from the WwTP. The new Dual Function Overflow (SW003) will function as a SWO or EO depending on the event. The volume of stormwater storage and the selection of the SWO significance for the Virginia WwTP upgrade have been determined by the design p.e. of the WwTP, the receiving water classification, and the dilution factor for surface waters in accordance with the criteria set out in the DoEHLG '*Procedures and Criteria in Relation to Storm Water Overflows'*, 1995, and Uisce Éireann's Design Standard for SWOs (UÉ-TEC-800-03).

The total storm storage at the WwTP will be 1,225m^3, as provided in two tanks. Storm Tank 1 is the inlet works storm tank and will provide a storage capacity of 505m^3 which is slightly higher than the 2 hours of (Formula A - Forward for Treatment) required by the procedures. Storm Tank 2 is the network storm tank and provides for 720m^3 of storage based on 120 litres per p.e. as required by UÉ-TEC-800-03.

All flows that exceed the Full Flow to Treatment (FFT) will be screened *via* a 6mm screen at the Control SWO Chamber and subsequently flow to the storm water storage tanks. The stormwater storage tanks would be full before any overflow to Lough Ramor occurs. Storm water flows will be returned to treatment should the inflow to the WwTP be less than FFT to facilitate the return flows. This upgrade will ensure that all SWOs are screened. All flows from the WwTP will be monitored with event logging and flow measurement.

All flows from the WwTP will be monitored with electromagnetic flow meters.

The upgraded WwTP (6,000 p.e) has been designed to meet the below effluent design standards:

Table 1.0: Proposed Effluent Design Standards

Parameter	Proposed Effluent Design Standards/ELVs
pH	6-9

Parameter	Proposed Effluent Design Standards/ELVs
cBOD	25 mg/l
COD	125 mg/l
Suspended Solids	25 mg/l
Ammonia (as N)	1.0 mg/l
Total Phosphorus (as P) (mg/l))	0.2 mg/l

In 2024, UÉ carried out a Water Quality Modelling assessment to inform this licence review. On completion, it was determined that existing ELVs as per D0255-01 *(i.e.,* the proposed effluent standards/ELVs for this licence review) for the primary discharge point (SW001) from the proposed 6,000 p.e. WwTP were deemed appropriate to support the water quality objectives of Lough Ramor.

Terminal Pumping Station (TPS)

Along with the upgrade to the WwTP, an upgrade to the TPS is proposed. The upgrade of the Virginia TPS is essential to ensure it is sized adequately to pump forward all flows up to the current and projected p.e of 6,000.

As part of the upgrade to the TPS there is a requirement to increase the stormwater storage capacity. This will be facilitated at the main WwTP. All flows, including any combined flows, will be pumped from the Terminal Pumping Station to the WwTP *via* a rising main. The existing SWO (currently SW002 under D0255-01) from the TPS which discharges to Lough Ramor (NGR 260410E, 287031N), will be decommissioned. A new Dual Function Overflow (proposed SW003 SWO and EO) will be installed from the WwTP to Lough Ramor (terminating at *ca.* NGR 260505E, 286731N) in general proximity to the existing primary effluent discharge point from the WwTP.

The only overflow proposed from the TPS upon completion of the upgrade will be an EO to the River Blackwater at NGR 260426E, 287221N (SW004). This EO has been designed and will operate in accordance with UÉ for Emergency Overflows at pumping stations.

A final grant of planning from Cavan County Council for the works to upgrade the Virginia WwTP and the Terminal Pumping Station was obtained by Uisce Éireann on the 24th November 2023 (Planning Ref: 22489). It is currently programmed for the upgraded plant to be fully operational by 31st December 2027.

Discharges as per Subject Matter of Licence Review

Proposed Primary Discharge (SW001):

Treated effluent from the WwTP will continue to be discharged *via* the existing diffuser pipe direct to Lough Ramor River at NGR 260521E, 286736N.

Proposed Secondary Discharges:

There will be no secondary discharge points associated with the waste water works.

Network Overflows:

Proposed New Dual Function Overflow (SWO/EO) - SW003:
There will be a new Dual Function Overflow (SW003) from the upgraded WwTP (*i.e.,* an overflow which can act as a SWO or as an EO depending on the event) and will discharge *via* an outfall pipe which will extend *ca.* 330m into Lough Ramor. SW003 will be designed to meet the definition of '*Storm Water Overflow*' as per Regulation 3 of the Waste Water Discharge (Authorisation) Regulations, 2007, as amended and the criteria as set out in the DoEHLG '*Procedures and Criteria in Relation to Storm Water Overflows'*, 1995.

The Emergency Overflow (SW003) at the WwTP will be activated only under an emergency event *i.e.,* prolonged power failure. The likelihood of an emergency event is low, and there is provision for the connection of a mobile power generator facility at the WwTP in the event of a power failure. In the very rare event of an EO activation, the effluent will have been screened *via* a 6mm screen at the Control SWO chamber prior to discharging to Lough Ramor.

All flows at the WwTP will be monitored continuously and recorded with flowmeters.

Proposed New EO at the Upgraded TPS – SW004:
There will be a new EO, SW004, which will be associated with the upgraded Terminal Pumping Station will discharge to the River Blackwater at NGR 260426E, 287221N in the unlikely occurrence of an emergency event. This EO has been designed and will operate in accordance with Uisce Éireann requirements for Emergency Overflows at pumping stations.

Tabled below are the 2 no. of overflows associated with this licence review:

Table 2.0: Overflows Associated with the WWDL Review

Overflow	Asset	Type	Discharge Location NGR	Receiving Waterbody
SW003*,**	Located at Virginia WwTP	SWO/EO	260505, 286731	Lough Ramor
SW004**	Located at the TPS	EO	260426, 287221	Blackwater (Kells)_070

**Meet criteria as set out in the DoEHLG 'Procedures and Criteria in Relation to Storm Water Overflows', 1995.*
*** Overflows to be regularised as part of the D0255-01 WWDL review.*

The risks of sewer or outfall failure associated with extreme events resulting in the activation of EO's, while a theoretical risk (as the failure of any infrastructure in catastrophic situations is theoretically possible), is not reasonably predicted to occur. Their inclusion in the agglomeration prevents the risk of uncontrolled emissions arising from other points in the network and spilling onto land or water in an unpredictable manner. All appropriate design measures and mitigation to prevent EOs that can be applied has been incorporated in the design and operation of the agglomeration.

Effluent data from 2023-2024 is presented in **Table 3.0** together with the design standard/ELVs. It can be seen that the current discharge exceeds the Ammonia and Total Phosphorus ELV's.

Table 3.0: Effluent Monitoring Data at Virginia Primary Discharge 2023-2024

Sample Date	Ammonia mg/l	BOD mg/l	COD mg/l	pH	Suspended Solids mg/l	Total Phosphorus mg/l
Design Standards/ELV's	**1.0 mg/l**	**25 mg/l**	**125 mg/l**	**6-9**	**25 mg/l**	**0.2 mg/l**
19/05/2023	1.76	1.3	34	6.1	7	3.05
30/06/2023	0.71	23.5	102	7.2	49	2.75
14/07/2023	0.07	3.7	55	6.8	13	1.8
11/08/2023	2.14	2.5	36	7.2	6	1.12
18/08/2023	9.22	3.4	46	7.5	2	3.95
29/09/2023	0.2	0.5	24	7.4	12	0.74
19/10/2023	2.95	33	43	7.2	9	0.6
24/11/2023	0.99	1.5	32	7.3	7	1
01/12/2024	0.72	6.5	43	6.4	14	1.9
05/01/2024	0.16	0.5	15	7.3	5	0.66
20/02/2024	15.9	3.5	36	7.6	9	0.99
12/03/2024	0.08	1.7	33	6.9	11	2.25

Description of the Receiving Environment and Monitoring Results

Water Quality

The Primary Discharge (SW001) is to Lough Ramor waterbody, which has been assigned '*Poor*' Water Framework Directive (WFD) (2016-2021) status, with the status driven by '*Poor'* 'Macrophyte status or potential. Phosphorus conditions are indicative of '*Moderate*', while other support chemistry conditions are indicative of '*High*'.

The WwTP is identified as a significant pressure on Lough Ramor in the latest 3rd cycle Boyne catchment report (May 2024), together with Agriculture and Invasive Species (Zebra mussel).

Approximately 4.2km downstream of the primary discharge point, Lough Ramor outflows to the River Blackwater and the Blackwater(Kells)_080 waterbody which has been assigned '*Moderate*' Water Framework Directive (WFD) (2016-2021) status.

Water chemistry is monitored by Cavan Co. Co./EPA at a number of stations in Lough Ramor. The closest station to the primary discharge point is Ramor Station 3, located *ca.* 300m east. Recent monitoring data is only available for this station for April 2023 to August 2024 as a surrogate station for 2022 was used which is over 2km away. Data for January 2022 to August 2024 is available for the next-closest monitoring location, Station 5, which is *ca.* 800m to the east of the primary discharge point. Monitoring data for key parameters are shown below in **Table 4.0**, with monitoring locations are shown on **Figure 1.0.**

Results were compared with the Environmental Quality Standards (EQS) for lakes specified in the Surface Waters Regulations 2009 (as amended). '*Good*' status water chemistry conditions are exceeded for Total Phosphorus, and occasionally for DO.

Table 4.0: Monitoring Results at Station LS070015906000030 (Apr 2023 – Aug 2024) and LS070015906000050 (Jan 2022 - Aug 2024)

	Ammonia mg/l	BOD mg/l	DO % Sat	pH	Suspended Solids mg/l	Total Phosphorus mg/l	Chlorophyll µg/l	ortho-Phosphate mg/l	Total Oxidised Nitrogen mg/l
EQS	**High status ≤ 0.040 (mean) and ≤ 0.090 (95%ile)** **Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)**		**80-120% Sat**	**4.5-9.0**		**High status ≤ 0.010(mean)** **Good status ≤ 0.025(mean)**			
LS070015906000030 Ramor Station 3									
17/04/2023	<0.02	ns	98	7.5	ns	0.055	2.9	0.023	0.9
13/07/2023	<0.02	ns	110	8.3	ns	0.044	9.5	0.01	<0.2
03/08/2023	0.028	ns	93	7.5	ns	0.088	6.5	0.031	0.4
10/10/2023	0.043	ns	95	7.6	ns	0.096	6	0.055	0.61
30/04/2024	<0.02	ns	123	7.7	ns	0.034	4	0.012	0.59
02/07/2024	0.088	ns	90	8	ns	0.062	1.6	0.037	0.24
01/08/2024	0.032	ns	101	8.1	ns	0.046	2.7	<0.01	<0.2
LS070015906000050 Ramor Station 5									
11/01/2022	0.055	1.4	107.2	7.4	5	0.1	ns	ns	ns
08/06/2022	ns	ns	118.1	ns	ns	ns	ns	ns	ns
14/07/2022	0.07	3.4	73.01	8	12	0.2	ns	ns	ns
09/08/2022	0.05	3.1	69.46	8.8	5	0.2	ns	ns	ns
16/08/2022	0.05	2.4	59.49	7.7	5	0.2	ns	ns	ns
23/08/2022	0.05	2.9	73.8	7.5	5	0.2	ns	ns	ns
11/11/2022	0.07	2	62.19	7.1	7	0.2	ns	ns	ns
17/04/2023	0.02	ns	97	7.5	ns	0.057	4.1	0.026	0.93
13/07/2023	0.01	ns	104	8.1	ns	0.05	3.9	0.013	0.01
03/08/2023	0.056	ns	91	7.4	ns	0.087	3.1	0.038	0.44
10/10/2023	0.061	ns	95	7.6	ns	0.096	2.8	0.057	0.72

	Ammonia mg/l	BOD mg/l	DO % Sat	pH	Suspended Solids mg/l	Total Phosphorus mg/l	Chlorophyll µg/l	ortho-Phosphate mg/l	Total Oxidised Nitrogen mg/l
EQS	**High status ≤ 0.040 (mean) and ≤ 0.090 (95%ile)** **Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)**		**80-120% Sat**	**4.5-9.0**		**High status ≤ 0.010(mean)** **Good status ≤ 0.025(mean)**			
30/04/2024	<0.02	ns	125	7.7	ns	0.031	2.4	0.012	0.61
02/07/2024	0.098	ns	90	8	ns	0.063	1.7	0.037	0.21
01/08/2024	0.03	ns	102	8.2	ns	0.045	3.3	<0.01	<0.2

Water Quality Modelling

A 2-dimensional model of Lough Ramor was developed by MSN Hydro Int. Ltd and applied to perform a Tier 3 mixing zone assessment for the future upgraded primary discharge (SW001) (Refer to **Attachment D.2.3**). The industry standard model MIKE21 was used. The model simulates lake hydrodynamics and five nutrients: organic, ammonia and nitrate nitrogen and organic and inorganic phosphorus. Model suitability was assessed by simulating hydrodynamic and water quality conditions in the lake for the year 2018 and comparing the results with measured data. The model was deemed suitable for use for mixing zone assessment.

The mixing zone assessment involved the simulation of three flow conditions: (1) mean river flows for comparison of nutrient concentrations with mean EQS criteria, (2) low (Q95) river flows for comparison of nutrient concentrations with 95%ile EQS criteria and (3) full flow-to-treatment, where the discharge is increased from mean flow rate to max flow rate for a 24 hour period, which is used to assess the impact of the WwTP when running at maximum flow. Seven water quality scenarios were simulated in total:

- mean and low river flows with the current WWTP discharge and existing lake and river conditions;
- mean and low river flows with the future upgraded WWTP discharge and existing lake and river water conditions;
- mean and low river flows with the future upgraded WWTP discharge and notionally-clean lake and river water conditions;
- mean river flows with full flow-to-treatment for the future upgraded WWTP and notionally-clean lake and river water conditions;

All model simulations were run for 180 days so that steady state conditions were achieved. 2D spatial concentration maps for Ammonia and Total Phosphorus (as P) were compared with EQS criteria and the resulting water quality status maps were used to identify the presence and extents of any mixing zones that were formed.

The following are the main conclusions from the mixing zone assessment study based on the model results:

- The rivers are currently the primary factor influencing lake chemistry; the WwTP has a negligible impact.
- If river nutrient loads remain as they are, the upgraded WwTP will have a negligible effect on water quality in the lake. The model results show that Ammonia and Total Phosphorus (as P) concentrations will either remain the same or slightly improve due to the improved chemistry of the WwTP's future effluent from the primary discharge (SW001).
- Based on the water quality status maps, produced by comparing final steady-state nutrient concentrations with EQS values for High, Good, Moderate, Poor and Bad status, a WwTP mixing zone was not identified for any of the modelled mean or low-flow scenarios.
- Based on the full flow-to-treatment scenario results, it can be concluded that increasing the WwTP to maximum discharge has a relatively small impact on nutrient levels. Compared with the mean flow scenario, Ammonia and Total Phosphorus (as P) concentrations in the FFT scenario temporarily increase in the vicinity of the outfall but

very quickly return to the same levels as the mean flow scenario, this occurs within 3 days for Ammonia and within 1 day for Total Phosphorus (as P).

- The modelling results demonstrate that the proposed primary discharge (SW001) and associated ELVs are compatible with the achievement of WFD objectives, *i.e.*, '*Good*' status of receiving waters, Lough Ramor by 2027.

Refer to **Attachment D.2.3** for a copy of Water Quality Impact Assessment Report (September 2024).

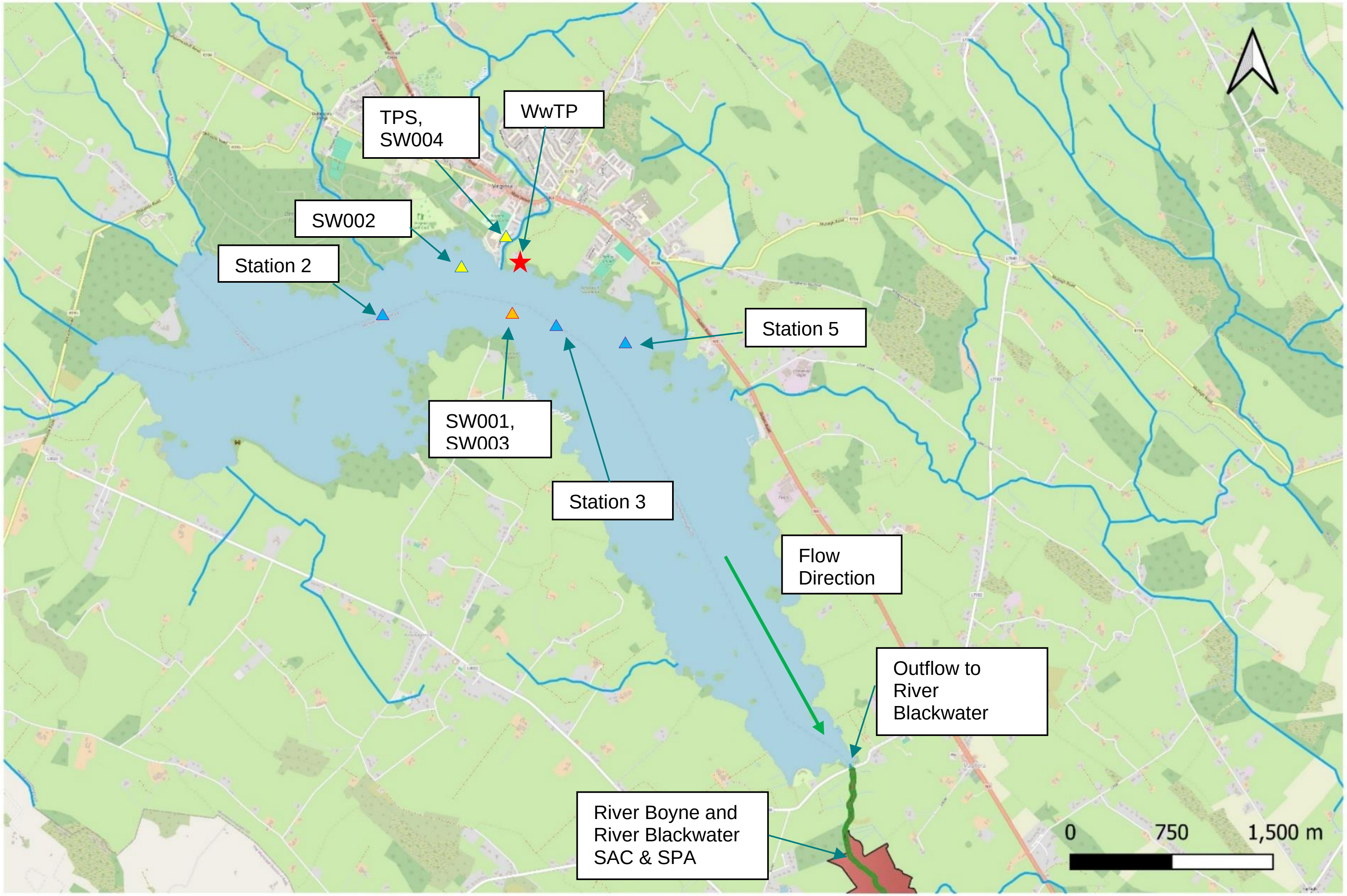

Figure 1.0 Virginia Operational Discharges and Monitoring Locations (flow direction arrows shown in green)

Ecological Desktop & Field Survey

The ecological receptors of the site and surrounding area are described below, informed by the desk study and site visit. In the context of this assessment, the survey focused on aquatic habitats and species, or those terrestrial species which may interact with the aquatic environment. Particular attention was paid to identifying habitats or species listed in the Habitats or Birds directives.

The primary discharge (SW001) and proposed Dual Function Overflow (SW003) are to a mid-lake location (Figure 1, Photo 1). Overflow SW004 from Virginia TPS discharges to the Rampart River, just upstream of its confluence with the lake (Photo 2). The river was experiencing high flows on the survey date. At a location *ca.* 90m south of the outfall location along the right hand bank, sewage debris was noted on the bank from a pipe directed up onto the grass. An IFI officer who was in the locality noted that this is a frequent occurrence at this location after heavy rain.

Photo 1 Lough Ramor (primary discharge mid-lake)

Photo 2 Rampart River

A dive survey of the proposed overflow outfall route (SW003) was undertaken by EirEco (2022)[4] as part of the ecological reports for the upgrade project. A range of macrophytes were recorded along the shallow lake edge to *ca.* 1m depth including *Potamogeton perfoliatus*, *Elodea canadensis*, *Sparganium demersum, Potamogeton berchtholdii, Myriophyllum spicatum* and *Nuphar lutea*. The survey recorded a euphotic depth (limit of submerged plant growth) of 3m, and poor water quality was noted as a factor likely to be contributing to a lower diversity and depth of plant growth. Abundant invasive Zebra mussel (*Dreissena polymorpha*) was observed on hard substrates but becomes isolated to clumps in softer substrates.

The NBDC holds records for otter and crayfish in the lake and surrounding catchments. No signs of otter were observed in the surveyed areas, however the area has high suitability for otter and abundant fish stocks.

With regard to aquatic invasive species, NBDC records of both Nutall's waterweed *Elodea nuttallii* and Canadian waterweed *Elodea canadensis* are found in Lough Ramor (the latter also recorded in the dive survey). Zebra mussel is also an issue for the lake, as noted above. American mink has been recorded at the confluence of Ramparts river and the lake (2017) and in the surrounding river catchments .

There are records of Kingfisher on the NBDC from Lough Ramor and the downstream River Blackwater_080. Cummins *et al (*2010)[5] identified Kingfisher territories throughout the River Blackwater and the wider Boyne system.

Lough Ramor is an important coarse and pike fishery, with excellent catches of bream, roach and roach x bream hybrids possible[6]. IFI undertook a fish stock survey of Lough Ramor in 2019 (Corcoran *et al*, 2020[7]). A total of seven fish species and one type of hybrid (roach x bream) were recorded. A broadly similar species mix was recorded when the lake was last surveyed in 2005, with the exception of tench and rudd which were not captured in 2019. No round goby were recorded in any of the survey nets or traps that were deployed in the lake. Perch was the dominant fish species in terms of abundance. Roach x bream hybrids had the highest biomass captured during the 2019 survey, but relatively high biomasses of other species, notably bream, were also recorded. In terms of Lough Ramor WFD status, using a multimetric fish tool developed for the island of Ireland, Lough Ramor has been assigned an ecological status of '*Bad*' for 2019 based on the fish populations present. The potentially invasive fish species (Round goby (*Neogobius melanostomus*)) was reportedly captured on Lough Ramor in 2018. IFI also undertook a catchment-wide survey of the Kells Blackwater in 2021 (Fleming *et al,* 2022[8]) including monitoring stations upstream and downstream of Lough Ramor. Trout were present in 22 of 23 surveys sites, however salmon were only captured in the lower end of the

[4] EirEco (2022) Virginia Wastewater Treatment Plant Upgrade – AA Screening and NIS. December 2022. (Available on Cavan Co. Co. Planning website Ref 22489
[5] Cummins, S et al (2010) Assessment of the distribution and abundance of Kingfisher Alcedo atthis and other riparian birds on six SAC river systems in Ireland. A report commissioned by NPWS and prepared by BirdWatch Ireland.
[6] https://fishinginireland.info/coarse/east/cavan/bailieboro/
[7] Corcoran, W., McLoone, P., Connor, L., Bateman, A., Cierpial, D., Coyne, J., Twomey, C., Rocks, K., Gordon, P., Lopez, S., O' Briain, R., Matson, R. and Kelly, F.L. (2020) Fish Stock Survey of Lough Ramor, August 2019. National Research Survey Programme, Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24.
[8] Fleming, C., McCollom, A. and O'Leary, C. (2022) Environmental River Enhancement Programme Report 2021. Inland Fisheries Ireland, 3044 Lake Drive, Citywest, Dublin 24, Ireland.

catchment. Crayfish and lamprey were also only found in lower catchment tributaries. The Rampart River adjacent to the TPS has suitable habitat for all salmonid life stages.

Gargan *et al* (2021[9]) reported that salmon stocks in the Boyne catchment as a whole (inclusive of the Kells Blackwater) do not meet their conservation limits.

O'Connor (2006) surveyed juvenile lamprey in the Boyne catchment, within the Kells Blackwater he found the conservation status of lamprey populations (both river and brook) to be favourable downstream of Lough Ramor, but upstream brook lamprey were present at an unsatisfactory conservation status.

[9] Gargan, P., Fitzgerald, C., Kennedy, R., Maxwell, H., McLean, S. and Millane, M. (2021). The Status of Irish Salmon Stocks in 2020 with Catch Advice for 2021. Report of the Technical Expert Group on Salmon (TEGOS) to the North-South Standing Scientific Committee for Inland Fisheries. 53 pp.

Screening for AA

European Sites within the potential zone of influence of the Operational Discharges

The Virginia agglomeration Operational Discharges enter Lough Ramor directly or indirectly. All European Sites which could potentially interact with this waterbody are considered for source-pathway-receptor connectivity in order to establish the potential ZoI of the discharges. This ZoI encompasses European Sites within any potential dilution/dispersion zone or those with mobile species for which any potential *ex-situ* effects must be considered. These sites are presented below in **Table 5.0** and shown in **Figure 2.0**.

Terrestrial sites which do not interact with the receiving waterbody have no potential to support connectivity. Short-form habitat names follow NPWS (2019a[10]).

Table 5.0: European Sites considered in defining the potential zone of influence

Site Code	Site Name	Qualifying Interests	Pathway and Distance from Primary Discharge
002299	River Boyne and River Blackwater SAC	Alkaline fens [7230] Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0] *Lampetra fluviatilis* (River Lamprey) [1099] *Salmo salar* (Salmon) [1106] *Lutra lutra* (Otter) [1355]	4.2km downstream *via* Lough Ramor
004232	River Boyne and River Blackwater SPA	Kingfisher (*Alcedo atthis*) [A229]	4.2km downstream *via* Lough Ramor
000006	Killyconny Bog (Cloghbally) SAC	Active raised bogs [7110] Degraded raised bogs still capable of natural regeneration [7120]	*ca.* 8km directly southeast. There is no surface water pathway. The site is within a separate groundwater body to Lough Ramor and the River Blackwater, and is identified as a GWDTE[11].
001957	Boyne Coast and Estuary SAC	Estuaries [1130] Mudflats and sandflats not covered by seawater at low tide [1140] Annual vegetation of drift lines [1210]	70km downstream *via* River Blackwater and River Boyne

[10] NPWS (2019a). The Status of EU Protected Habitats and Species in Ireland. Volume 2: Habitat Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill
[11] Groundwater Dependant Terrestrial Ecosystem

Site Code	Site Name	Qualifying Interests	Pathway and Distance from Primary Discharge
		Salicornia and other annuals colonising mud and sand [1310] Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) [1330] Embryonic shifting dunes [2110] Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) [2120] Fixed coastal dunes with herbaceous vegetation (grey dunes) [2130]	
004080	Boyne Estuary SPA	Shelduck (Tadorna) [A048] Oystercatcher (*Haematopus ostralegus*) [A130] Golden Plover (*Pluvialis apricaria*) [A140] Grey Plover (*Pluvialis squatarola*) [A141] Lapwing (*Vanellus vanellus*) [A142] Knot (*Calidris canutus*) [A143] Sanderling (*Calidris alba*) [A144] Black-tailed Godwit (*Limosa limosa*) [A156] Redshank (*Tringa totanus*) [A162] Turnstone (*Arenaria interpres*) [A169] Little Tern (*Sterna albifrons*) [A195] Wetland and Waterbirds [A999]	70km downstream *via* River Blackwater and River Boyne

The Virginia agglomeration Operational Discharges to Lough Ramor pose no threat to the bog habitats of Killyconny Bog SAC due to their physical and hydrogeological separation. Owing to the extensive 70km distance to the estuarine habitats and species associated with the Boyne Coast and Estuary SAC and the Boyne Estuary SPA, and the intervening '*Good*' status waters, the discharges pose no risk to these qualifying interests.

Considering the source-pathway-receptor model, only the qualifying interests of the River Boyne and River Blackwater SAC (Site Code 001957) and SPA (Site Code: 004080) are considered to lie within the ZoI of the Virginia Operational Discharges. The potential impacts that could arise for the qualifying interests, and likely significant effects that could result, are considered further below.

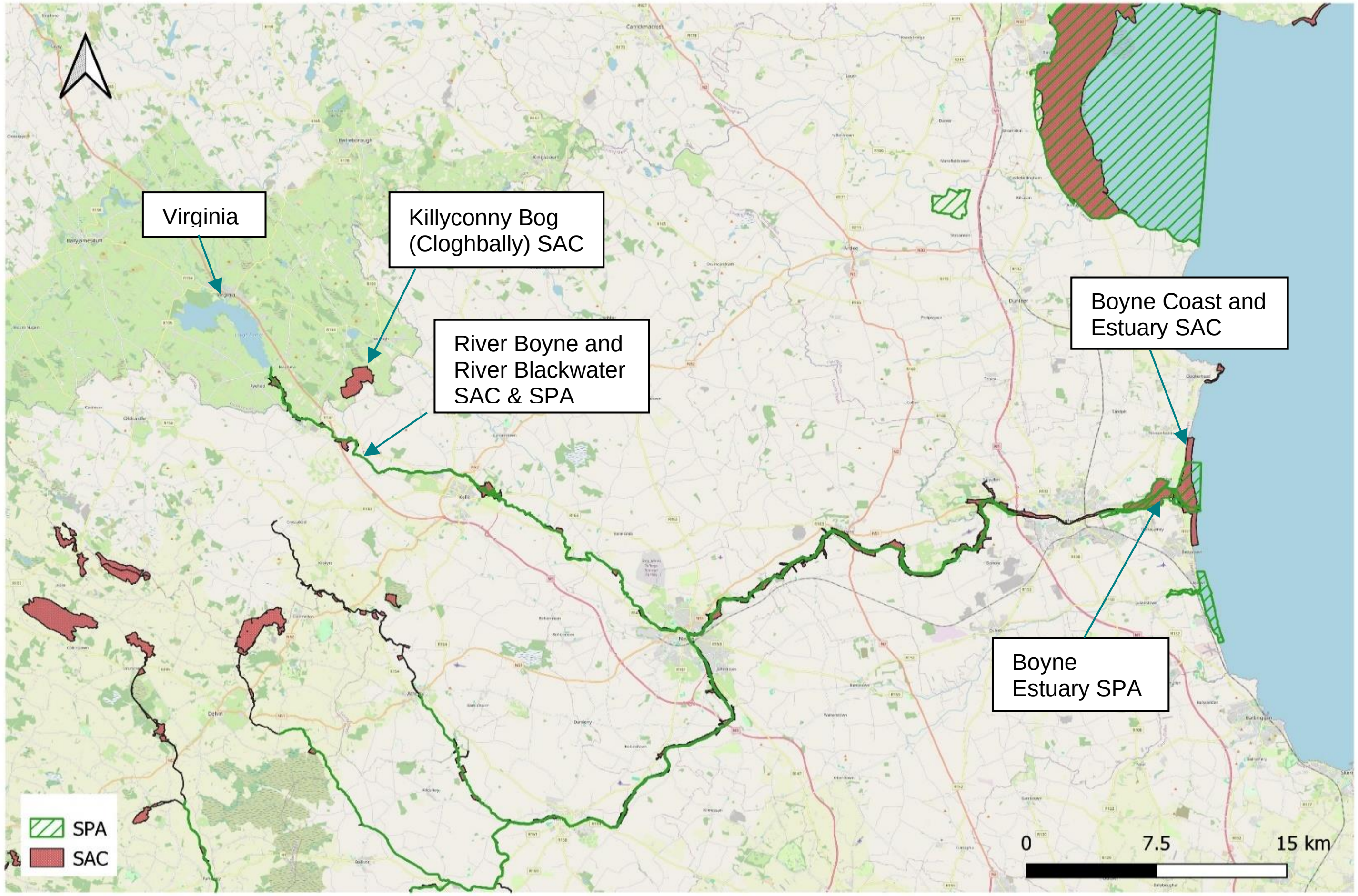

Figure 2.0 European Sites

Identification & Description of Potential Impacts

Elevated nutrient input from wastewater effluent into aquatic environments can lead to an altered nutrient balance (eutrophication), increased primary productivity, and the potential for algal blooms. Such impacts have the potential to affect the qualifying interests of European sites directly, indirectly or cumulatively with other activities, projects or plans.

Water quality data and model findings need to be considered in the context of the attributes and targets of the conservation objectives of the River Boyne and River Blackwater SAC (Site Code: 002299) and SPA (Site Code:004242). The potential impacts to water quality from the overflow discharges on Lough Ramor, in the context of the conservation objectives of the European Site, also needs further consideration.

The likely significant effects to the qualifying interests of the River Boyne and River Blackwater SAC and SPA that may directly or indirectly arise from the ongoing discharges are considered below.

Likely Significant Effects

The purpose of this section of the Screening is to examine the possibility whether the Virginia Operational Discharges, either individually or in combination other plans and projects, are likely to result in significant effects to any European Site. It further considers the water dependent qualifying interests which may be sensitive to the potential impacts of the operational discharges, in the context of the nature and scale of these discharges.

The Conservation Objectives and associated Supporting Documents of the relevant European Sites were reviewed as part of this Screening Assessment:

- NPWS (2021) Conservation Objectives: River Boyne and River Blackwater SAC 002299. Version 1. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage.
- NPWS (2024) Conservation Objectives: River Boyne and River Blackwater SPA 004232. Version 1. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage

The discharges are not directly connected with or necessary to the management of any site for nature conservation.

While the treated discharges to Lough Ramor do not directly enter a designated area, the downstream SAC and SPA are designated for species which depend on the aquatic environment. The extent to which these species may interact with the mixing zone of the discharge on an ex-situ basis needs to be considered, as well as potential downstream effects on water quality from the nutrient input into the lake. The discharges and treatment standards, together with water quality data, therefore, need to be assessed in the context of the conservation objectives for the qualifying interests of the SAC and SPA.

Potential Cumulative or In-combination Effects

As part of AA Screening, in addition to the Virginia operational discharges, other relevant projects and plans in the region must also be considered. This report aims to identify at this early stage any likely significant effects on the European Sites from the existing discharge in-combination or cumulatively with other plans and projects.

Plans

Plans of relevance include Uisce Eireann's WSSP, the Cavan County Development Plan, and the National River Basin Management Plan.

In 2015, Uisce Éireann published the **Water Services Strategic Plan**, a 25-year Plan which as well as detailing current and future challenges affecting water services, identifies priorities to be addressed in the medium term. Solutions in these priority areas are delivered through capital and other projects outlined in Uisce Eireann's Capital Investment Plan (CIP), a multi annual plan covering a five-year horizon, currently 2020-2024. The Virginia WwTP Upgrade Project is listed on the current CIP. A new draft WSSP to 2050 is currently at public consultation.

The Cavan County Development Plan 2022-2028 has the following relevant objectives relating to wastewater:

- *FDW 01 Collaborate with Irish Water in contributing towards compliance with the relevant provisions of the Urban Wastewater Treatment Regulations 2001 and 2004 and the Waste Water Discharge (Authorisation) Regulations 2007, as amended.*
- *FDW 02 Ensure that development will only be permitted in instances where there is sufficient capacity for appropriate collection, treatment and disposal (in compliance with the Water Framework Directive and River Basin Management Plan) of wastewater.*
- *FDW 03 Liaise with and work in conjunction with Irish Water during the lifetime of the plan for the provision, extension and upgrading of wastewater collection and treatment systems in all towns and villages and Rural Community Nodes of the County, to serve existing populations and facilitate sustainable development of the County, in accordance with the requirements of the Settlement Strategy and associated Core Strategy.*
- *FDW 04 Support strategic wastewater treatment infrastructure investment and provide for the separation of foul and surface networks to accommodate future growth in the County.*
- *FDW 05 Ensure new developments provide a separate foul and surface water drainage system and to incorporate sustainable urban drainage systems where appropriate in new development and the public realm.*
- *FDW 06 Incorporate the requirement for Sustainable Urban Drainage Systems where appropriate in local authority projects and private development sites.*
- *FDW 07 Prohibit the discharge of additional surface water to combined (foul and surface water) sewers in order to maximise the capacity of existing collection for foul water. Support the Assessment of the need for upgrades of drainage systems, including separation of sewer and surface water required to reduce risk of capacity pressure on drainage systems.*
- *FDW 08 Ensure all new developments connect to the public wastewater infrastructure, where available, and to encourage existing developments that are in close proximity to a public sewer to connect to that sewer, subject to connection agreements with Irish*

Water. New developments connecting to Irish Water network shall be assessed through ’s New Connection Process.

- *FDW 12 Support appropriate options for the extraction of energy and other resources from sewerage sludge in the County.*
- *FDW 13 Support the servicing of rural villages (serviced sites) to provide an alternative to one-off housing in the countryside in line with the Regional Spatial and Economic Strategy.*
- *FDW 15 Ensure new developments provide adequate storm water infrastructure in order to accommodate the planned levels of growth and ensure there is appropriate flood management measures implemented to protect property and infrastructure.*
- *FDW 16 Support Irish Water in the promotion of effective management of trade discharges to sewers in order to maximise the capacity of existing sewer networks and minimise detrimental impacts on sewerage treatment works.*
- *FDW 17 Development proposals in close proximity to Wastewater Treatment Plants shall provide, where deemed necessary, for a minimum buffer of 50 metres (for smaller WWTP’s) and greater for WWTP’s that are greater than 1500PE.*
- *FDW 18 Development proposals including those for linear parks and wildlife corridors along riverbanks shall plan for access and maintenance of existing Irish Water Infrastructure.*

The Virginia WwTP upgrade is identified in the Plan as an ongoing project being progressed as part of Uisce Éireann’s current CIP.

Information on **The Water Action Plan 2024**: A River Basin Management Plan for Ireland (2022-2027) (RBMP), and associated information on the catchments available on www.catchments.ie was reviewed:

- The RBMP sets out the measures that are necessary to protect and restore water quality in Ireland. The overall aim of the plan is to ensure that Irelands natural waters are sustainably management and that freshwater resources are protected so as to maintain and improve Ireland’s water environment. The RBMP identifies that based on 2016-2021 data, 54% of surface waters are in good or high ecological status while the remaining 46% are in unsatisfactory ecological status.
- Continued investment in wastewater infrastructure is highlighted as one of the key actions in the plans. The RBMP identifies the Upper Blackwater (Kells) catchment as an Area For Action (AFA) with a Restoration objective. As noted earlier, Virginia WwTP is identified as a pressure on Lough Ramor. Kells WwTP discharges to the River Blackwater downstream of Lough Ramor but is not identified as a pressure. The Tirlán facility in Virginia also discharges to Lough Ramor under the site’s industrial emission licence (P0405-02), though again this is not identified as a pressure on the lake. Several WwTP’s in the Moynalty sub-catchment of the River Boyne are identified as pressures on that catchment. By using background water quality data, the water quality modelling study takes account of all inputs to the waterbody upstream of Lough Ramor and therefore accounts for cumulative effects of WwTP discharges in the context of upstream catchment pressures.

The above plans have themselves been assessed in accordance with Article 6(3) of the Habitats Directive and Part XAB of the Planning and Development Act, 2000 and the implementation of those plans will not result in adverse effects to the integrity of any European site(s). The plans support the continuation of compliant discharges from the Virginia agglomeration. The plans also support the prioritisation of actions to deal with significant pressures affecting the catchment and identify the planned upgrade at Virginia as a measure to address the urban waste water pressure. Hence considered cumulatively with the Project, there is no potential for negative cumulative effects on any qualifying interest.

Projects

The Cavan Co.Co. planning system was reviewed for any recent proposed or permitted projects that could lead to in-combination impacts with the Project. Tirlán have been granted permission for a new water treatment building and storage tanks at their facility on the eastern shore of Lough Ramor, to the south of Virginia town (Ref 2360174). An NIS was submitted with the application finding that with the application of mitigation measures, there would be no adverse effects on the qualifying interests of the downstream SAC or SPA. All other recent developments are for small residential agricultural or business developments or modifications. Single house developments in the area, which have been recently granted or are seeking planning consent, may seek connection to the sewerage network.

UÉ will ensure that prior to the connection of any future local development to the UÉ network, there is sufficient headroom and available capacity within the treatment plant and network to ensure development does not impinge of achieving or maintaining WFD requirements. Hence, considered cumulatively with the Project, there is no potential for negative cumulative effects on any qualifying interest.

Screening Conclusions

The likely impacts that will arise from the Virginia operational discharges have been examined in the context of a number of factors that could potentially affect the integrity of the Natura 2000 network.

The Operational Discharges enter Lough Ramor, which outflows to the Kells Blackwater and the River Boyne and River Blackwater SAC and SPA. The Operational Discharges and treatment standards, together with water quality data, need to be assessed in the context of the conservation objectives for the qualifying interests of the SAC and SPA.

On the basis of the information set out, and documentation referenced, in this AA Screening, the likelihood of significant effects to River Boyne and River Blackwater SAC and SPA cannot be excluded, and a Stage Two Appropriate Assessment is therefore provided.

Appropriate Assessment

The European Site's which have been determined as requiring AA, are described and all the potential impacts resulting from the Virginia Operational Discharges are discussed in relation to the conservation objectives of the River Boyne and River Blackwater SAC and SPA. These European Site's and their qualifying interests are described below.

Description of the European Sites

River Boyne and River Blackwater SAC (Site Code: 002299)[12]

This site comprises the freshwater element of the River Boyne as far as the Boyne Aqueduct, the Blackwater as far as Lough Ramor and the Boyne tributaries including the Deel, Stoneyford and Tremblestown Rivers. These riverine stretches drain a considerable area of Meath and Westmeath, and smaller areas of Cavan and Louth. The underlying geology is Carboniferous Limestone for the most part, with areas of Upper, Lower and Middle well represented. In the vicinity of Kells Silurian Quartzite is present while close to Trim are Carboniferous Shales and Sandstones. There are many large towns adjacent to but not within the site, including Slane, Navan, Kells, Trim, Athboy and Ballivor

The main areas of alkaline fen in this site are concentrated in the vicinity of Lough Shesk, Freehan Lough and Newtown Lough. The hummocky nature of the local terrain produces frequent springs and seepages which are rich in lime. A series of base-rich marshes have developed in the poorly-drained hollows, generally linked with these three lakes.

The rare plant Round-leaved Wintergreen (*Pyrola rotundifolia*) occurs around Newtown Lough. This species is listed in the Red Data Book and this site represents its only occurrence in Co. Meath. Wet woodland fringes many stretches of the Boyne. The Boyne River Islands are a small chain of three islands situated 2.5 km west of Drogheda. The islands were formed by the build-up of alluvial sediment in this part of the river where water movement is sluggish. All of the islands are covered by dense thickets of wet, willow (*Salix* spp.) woodland,

A small area of Alder (*Alnus glutinosa*) woodland is found on soft ground at the edge of the canal in the north-western section of the islands. Along other stretches of the rivers of the site Rusty Willow scrub and pockets of wet woodland dominated by Alder have become established, particularly at the river edge of mature deciduous woodland.

The dominant habitat along the edges of the river is freshwater marsh, the secondary habitat associated with the marsh is wet grassland.

Along much of the Boyne and along tributary stretches are found areas of mature deciduous woodland on the steeper slopes above the floodplain marsh or wet woodland vegetation. Many of these are planted in origin. However the steeper areas of King Williams Glen and Townley Hall wood have been left unmanaged and now have a more natural character. East of Curley Hole the woodland has a natural appearance with few conifers.

[12] Extracted from NPWS site synopsis dated 06.01.2014 Rev.13

Other habitats present along the Boyne and Blackwater include lowland dry grassland, improved grassland, reedswamp, weedy waste ground, scrub, hedge, drainage ditch and canal. In the vicinity of Lough Shesk, the dry slopes of the morainic hummocks support grassland vegetation which, in some places, is partially colonised by Gorse (*Ulex europaeus*) scrub. Those grasslands which remain unimproved for pasture are species-rich

The Boyne and its tributaries form one of Ireland's premier game fisheries and the area offers a wide range of angling, from fishing for spring salmon and grilse to seatrout fishing and extensive brown trout fishing. Atlantic Salmon (*Salmo salar*) use the tributaries and headwaters as spawning grounds. Although this species is still fished commercially in Ireland, it is considered to be endangered or locally threatened elsewhere in Europe and is listed on Annex II of the Habitats Directive. Atlantic Salmon run the Boyne almost every month of the year. The Boyne is most important as it represents an eastern river which holds large three-sea-winter fish from 20-30 lb. These fish generally arrive in February, with smaller spring fish (10 lb) arriving in April/May. The grilse come in July, water permitting. The river gets a further run of fish in late August and this run would appear to last well after the fishing season. The salmon fishing season lasts from 1st March to 30th September. The Blackwater is a medium sized limestone river which is still recovering from the effects of the arterial drainage scheme of the 1970s. Salmon stocks have not recovered to the numbers that existed pre-drainage. The Deel, Riverstown, Stoneyford and Tremblestown Rivers are all spring-fed, with a continuous high volume of water. They are difficult to fish because some areas are overgrown, while others have been affected by drainage with resultant high banks.

This site is also important for the populations of two other species listed on Annex II of the E.U. Habitats Directive which it supports, namely River Lamprey (*Lampetra fluviatilis*), which is present in the lower reaches of the Boyne River, and Otter (*Lutra lutra*), which can be found throughout the site. In addition, the site also supports many more of the mammal species occurring in Ireland. Those which are listed in the Irish Red Data Book include Pine Marten, Badger and Irish Hare. Common Frog, another Red Data Book species, also occurs within the site. All of these animals, with the addition of the Stoat and Red Squirrel, which also occur within the site, are protected under the Wildlife Act, 1976. Whooper Swans winter regularly at several locations along the Boyne and Blackwater Rivers.

Intensive agriculture is the main land use along the site. Much of the grassland is in very large fields and is improved. Silage harvesting is carried out. The spreading of slurry and fertiliser poses a threat to the water quality of this salmonid river and to the lakes. In the more extensive agricultural areas sheep grazing is carried out. Fishing is a main tourist attraction on the Boyne and Blackwater and there are a number of Angler Associations, some with a number of beats.

The site supports populations of several species listed on Annex II of the E.U. Habitats Directive, and habitats listed on Annex I of this Directive, as well as examples of other important habitat types. Although the wet woodland areas appear small there are few similar examples of this type of alluvial wet woodland remaining in the country, particularly in the north-east. The semi-natural habitats, particularly the strips of woodland which extend along the river banks, and the marsh and wet grasslands, increase the overall habitat diversity and add to the ecological value of the site, as does the presence of a range of Red Data Book plant and animal species and the presence of nationally rare plant species.

Qualifying Interests of the SAC:

- Alkaline fens [7230]
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0]
- *Lampetra fluviatilis* (River Lamprey) [1099]
- *Salmo salar* (Salmon) [1106]
- *Lutra lutra* (Otter) [1355]

Alkaline fens

Alkaline fens are wetlands characterised by moss and small sedge communities developed on permanently waterlogged soils. Alkaline fen has not been mapped in detail in the SAC. The main areas of alkaline fen in the SAC are documented to occur in the vicinity of Lough Shesk, Freekan Lough, Newtown Lough in the upper reaches of the Stonyford River. Fen habitats require high groundwater levels for much of the year. The possibility that alkaline fen occurs in areas with suitable hydrogeological regimes along the River Blackwater downstream of Lough Ramor cannot be excluded with certainty. The overall conservation status of Alkaline Fens is Bad (*deteriorating*). Due to the potential for this habitat to occur within the downstream SAC, the conservation objectives for this habitat, together with the information on water quality need to be reviewed further.

Alluvial Forests

Alluvial forests are found in areas subject to flooding along watercourses and water bodies where species tolerant of periodic water logging such as alder *Alnus glutinosa*, ash *Fraxinus excelsior* and willow *Salix* sp. are found. The main pressures/threats noted for this habitat relate to invasive species, clear-cutting and problematic native species. The overall national assessment of conservation status for this habitat is Bad (*deteriorating*). Alluvial woodland is mapped on the northern shore of Lough Ramor in the Deerpark area, which at its closest is *ca.* 700m west of the discharge point, though this site does not fall within the SAC boundary. While the habitat is not mapped along the River Blackwater, unsurveyed areas may be present (NPWS, 2021[13]). Due to the potential for this habitat to occur within the SAC, the conservation objectives for this habitat, together with the information on water quality need to be reviewed further.

River Lamprey

River lamprey are anadromous species, spending part of their life cycle in the marine environment and returning to natal watercourses to spawn. Adult fish can migrate long distances into freshwater but artificial barriers to passage can result in spawning being confined to downstream of these barriers (NPWS, 2019b[14]). Spawning of river lampreys starts when the water temperature reaches 10-11°C, usually in March, while the sea lamprey usually spawns in late May or June, when the water temperature reaches at least 15°C. (Maitland, 2003[15]). Aside from migration barriers, climate change-related rainfall increases, agricultural fertilizer use, land drainage and fish harvesting are recognised as pressures/threats (NPWS, 2019b). As described earlier, River Lamprey occur in the River Blackwater downstream of Lough Ramor. River lamprey

[13] NPWS (2021) Conservation Objectives: River Boyne and River Blackwater SAC 002299. Version 1. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage.
[14] NPWS (2019b). The Status of EU Protected Habitats and Species in Ireland. Volume 3: Species Assessments. Unpublished NPWS report. Edited by: Deirdre Lynn and Fionnuala O'Neill
[15] Maitland, P.S. 2003. Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers. Ecology Series No. 5. English Nature.

are evaluated as being of '*Unknown'* conservation status nationally due to limited data (NPWS, 2019b). The conservation objectives for this species, together with the information on water quality need to be reviewed further in the impact assessment.

Atlantic Salmon

Atlantic salmon are an anadromous species using rivers to reproduce and as nursery areas during their juvenile phase (NPWS, 2019b). Salmon occur in the Blackwater River in low numbers, however they are present throughout the Boyne system (NPWS, 2019b). The species is dependent on good water quality requiring clean (Q4) water for spawning and early life stages. Aside from water pollution, other pressures/threats noted relate to physical alteration of waterbodies, marine aquaculture, hydropower and abstractions (NPWS, 2019b). Atlantic salmon are evaluated as being of overall Inadequate (Stable) conservation status nationally. Salmon are present in the lower Blackwater catchment, with data on salmon fry abundance demonstrating the river is not meeting its conservation limit (IFI, 2022). River habitat in the Ramparts river adjacent to the TPS are suitable for salmonids. The conservation objectives for this species, together with the information on water quality need to be reviewed further in the impact assessment.

Otter

Otter is widespread in the SAC (NPWS, 2021; NPWS, 2019b). Otter are dependent on fish stocks which are ultimately dependent on water quality. There are records of otter throughout the Blackwater/Boyne system including Lough Ramor. No pressures/threats for this species are identified nationally and the overall national assessment of the conservation status of otter is Favourable (Improving) (NPWS, 2019b). The conservation objectives for this species, together with the information on water quality need to be reviewed further in the impact assessment.

River Boyne and River Blackwater SPA (Site Code:004232)[16]

The River Boyne and River Blackwater SPA is a long, linear site that comprises stretches of the River Boyne and several of its tributaries; most of the site is in Co. Meath, but it extends also into Co.s Cavan, Louth and Westmeath. It includes the following river sections: the River Boyne from the M1 motorway bridge, west of Drogheda, to the junction with the Royal Canal, west of Longwood, Co Meath; the River Blackwater from its junction with the River Boyne in Navan to the junction with Lough Ramor in Co. Cavan; the Tremblestown River/Athboy River from the junction with the River Boyne at Kilnagross Bridge west of Trim to the bridge in Athboy, Co. Meath; the Stoneyford River from its junction with the River Boyne to Stonestown Bridge in Co. Westmeath; the River Deel from its junction with the River Boyne to Cummer Bridge, Co. Westmeath. The site includes the river channel and marginal vegetation. Most of the site is underlain by Carboniferous limestone but Silurian quartzite also occurs in the vicinity of Kells and Carboniferous shales and sandstones close to Trim. The site is a Special Protection Area (SPA) under the E.U. Birds Directive of special conservation interest for the following species: Kingfisher. A survey in 2010 recorded 19 pairs of Kingfisher (based on 15 probable and 4 possible territories) in the River Boyne and River Blackwater SPA. A survey conducted in 2008 recorded 20-22 Kingfisher territories within the SPA. Other species which occur within the site include Mute Swan (90), Teal (166), Mallard (219), Cormorant (36), Grey Heron (44), Moorhen

[16] Extracted from NPWS site synopsis dated 25.11.2010

(84), Snipe (32) and Sand Martin (553) – all figures are peak counts recorded during the 2010 survey. The River Boyne and River Blackwater Special Protection Area is of high ornithological importance as it supports a nationally important population of Kingfisher, a species that is listed on Annex I of the E.U. Birds Directive.

Information on populations (where available), requirements and sensitivities of key species are considered in more detail below with data taken from BirdWatch Ireland's website, Gilbert *et al* (2021)[17], and the latest national Kingfisher survey Cummins et al (2010)[18].

<u>Qualifying Interests of the SPA:</u>

- Kingfisher (*Alcedo atthis*) [A229]

<u>Kingfisher</u>

As described earlier, a survey by Cummins *et al* (2010) recorded kingfisher sightings and nesting sites throughout the Blackwater River downstream of Lough Ramor, and records on the NBDC indicate their ongoing use of the river. Kingfisher are an amber-listed species of conservation concern for their breeding population (Gilbert *et al*, 2021). Suitable nesting banks require tall vertical banks with soft material into which they can dig their burrow, while perches adjacent to slow-flowing rivers need to be available for fishing. These habitats are found in the main channel of the Kells Blackwater.

Conservation Objectives

The conservation objectives for the qualifying interests of the SAC and SPA, that could potentially be impacted by the Project, are detailed below.

Article 6 of the Habitats Directive states that:

> *Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications of the site in view of the site's conservation objectives.*

The importance of a site designated under the Habitats Directive is defined by its qualifying features or interests. These habitats and species are listed in the Habitats and Birds Directives and Special Areas of Conservation and Special Protection Areas are designated to afford protection to the most vulnerable of them. The maintenance of habitats and species within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level.
Favourable conservation status of a habitat is achieved when:

[17] Gilbert G, Stanbury A and Lewis L (2021), "Birds of Conservation Concern in Ireland 2020 –2026". Irish Birds 9:523—544
[18] Cummins et al (2010) Assessment of the distribution and abundance of Kingfisher Alcedo atthis and other riprarian birds on six SAC river systems in Ireland. A report commissioned by the NPWS and prepared by Birdwatch Ireland. June 2010.

- Its natural range, and area it covers within that range, are stable or increasing;
- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; and
- The conservation status of its typical species is favourable.

The favourable conservation status of a species is achieved when:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

River Boyne and River Blackwater SAC

Site specific conservation objectives are available for this SAC (NPWS, 2021) and are described below.

Table 6.0 Site-specific Conservation Objectives for the River Boyne and River Blackwater SAC

Qualifying Interest & Conservation Objective	Conservation Objective Attributes & Targets
*To restore the favourable conservation condition of **River lamprey** in the River Boyne and River Blackwater SAC which is defined by the following list of attributes and targets:*	• Attribute: Distribution; Target: Percentage of river accessible. • Attribute: Distribution of larvae; Target: Number of positive sites in 2nd order channels (and greater), downstream of spawning areas. • Attribute: Population structure of larvae; Target: At least three age/size classes of brook/river lamprey present. • Attribute: Larval lamprey density in fine sediment; Target: Mean density of brook/river lamprey in sites with suitable habitat more than 5/m2 • Attribute: Extent and distribution of spawning habitat; Target: No decline in extent and distribution of spawning and nursery beds.
*To restore the favourable conservation condition of **Atlantic Salmon** in the River Boyne and River Blackwater SAC which is defined by the following list of attributes and targets:*	• Attribute: Distribution – extent of anadromy; Target: 100% of river channels down to second order accessible from estuary. • Attribute: Adult spawning fish; Target: Conservation limit (CL) for each system consistently exceeded. • Attribute: Salmon fry abundance; Target: Maintain or exceed 0+ fry mean catchment-wide abundance threshold value. Currently set at 17 salmon fry/5min sampling. • Attribute: Out-migrating smolt abundance; Target: No significant decline. • Attribute: Number and distribution of redds; Target: No decline in number and distribution of spawning redds due to anthropogenic causes. • Attribute: Water quality; Target: At least Q4 at all sites sampled by EPA.
*To maintain the favourable conservation condition of **Otter** in the River Boyne and River*	• Attribute: Distribution; Target: No significant decline. • Attribute: Extent of terrestrial habitat;

Qualifying Interest & Conservation Objective	Conservation Objective Attributes & Targets
Blackwater SAC, which is defined by the following list of attributes and targets:	Target: No significant decline (447.6ha along river banks/lake shoreline/around ponds). • Attribute: Extent of freshwater (lake) habitat; Target: No significant decline (31.6ha). • Attribute: Extent of freshwater lake (river) habitat; Target: No significant decline (263.3km). • Attribute: Couching sites and holts; Target: No significant decline. • Attribute: Fish biomass available; Target: No significant decline. • Attribute: Barriers to connectivity; Target: No significant increase.
*To restore the favourable conservation condition of **Alluvial woodland** in the River Boyne and River Blackwater SAC, which is defined by the following list of attributes and targets:*	• Attribute: Habitat Area; Target: Area stable or increasing subject to natural processes. • Attribute: Habitat Distribution; Target: No decline subject to natural processes. • Attribute: Woodland size; Target: Area stable or increasing. Where topographically possible, “large” woods at least 25ha in size and “small” woods at least 3ha in size. • Attribute: Woodland structure -cover and height; Target: Total canopy cover at least 30%; median canopy height at least 7m; native shrub layer cover 10-75%; native herb/dwarf shrub layer cover at least 20% and height at least 20cm; bryophyte cover at least 4% • Attribute: Woodland structure – community diversity and extent; Target: Maintain diversity and extent of community types. • Attribute: Woodland structure – natural regeneration; Target: Seedlings, saplings and pole age-classes of target species for 91E0* woodlands and other native tree species occur in adequate proportions to ensure survival of woodland canopy • Attribute: Hydrological regime – flooding depth/height of water table; Target: Appropriate hydrological regime necessary for maintenance of alluvial vegetation • Attribute: Woodland structure – dead wood; Target: At least 19 stems/ha of dead wood of at least 20cm diameter • Attribute: Woodland structure – veteran trees; Target: No decline • Attribute: Woodland structure – indicators of local distinctiveness; Target: No decline in distribution and, in the case of red listed and other rare or localised species, population size. • Attribute: Woodland structure – indicators of overgrazing; Target: All five indicators of overgrazing absent. • Attribute: Vegetation composition – native tree cover; Target: No decline. Native trees cover at least 90% of canopy, target species cover at least 50% of canopy. • Attribute: Vegetation composition – typical species; Target At least 1 target species for 91E0* woodlands present; at least 6 positive indicator species for 91E0* woodlands present • Attribute: Vegetation composition – negative indicator species; Target: Negative indicator species cover not greater than 10%; regeneration of negative indicator species absent • Attribute: Vegetation composition – problematic native species; Target Cover of common nettle (Urtica dioica) less than 75%
*To maintain the favourable conservation condition of **Alkaline fens** in the River Boyne and River Blackwater SAC, which is defined by the*	• Attribute: Habitat Area; Target: Area stable or increasing subject to natural processes. • Attribute: Habitat Distribution; Target: No decline subject to natural processes. • Attribute: Ecosystem function – soil nutrients;

Qualifying Interest & Conservation Objective	Conservation Objective Attributes & Targets
following list of attributes and targets:	Target: Maintain soil pH and nutrient status within natural ranges. • Attribute: Ecosystem function – peat formation; Target: Maintain active peat formation, where appropriate. • Attribute: Ecosystem function – hydrology – groundwater levels; Target: Maintain, or where necessary restore, appropriate natural hydrological regimes necessary to support the natural structure and functioning of the habitat. • Attribute: Ecosystem function – hydrology – surface water flow; Target: Maintain, or where necessary restore, as close as possible to natural or semi-natural, drainage conditions. • Attribute: Ecosystem function - water quality; Target: Maintain appropriate water quality, particularly pH and nutrient levels, to support the natural structure and functioning of the habitat. • Attribute: Vegetation composition – community diversity; Target: Maintain variety of vegetation communities subject to natural processes. • Attribute: Vegetation composition – number of positive indicator species (brown mosses); Target: Maintain adequate cover of typical brown moss species. • Attribute: Vegetation composition – typical vascular plants; Target: Maintain adequate cover of typical vascular plant species. • Attribute: Vegetation composition – native negative indicator species; Target: Cover of native negative indicator species at insignificant levels. • Attribute: Vegetation composition – non-native species; Target: Cover of non-native species less than 1%. • Attribute: Vegetation composition – native trees and shrubs; Target: Cover of scattered native trees and shrubs less than 10% • Attribute: Vegetation composition algal cover; Target: Cover of algae less than 2% • Attribute: Vegetation structure – vegetation height; Target: At least 50^ of the live leaves/flowering shoots are more than either 5cm or 15cm above ground surface depending on community type. • Attribute: Physical structure – disturbed bare ground; Target: Cover of disturbed bare ground not more than 10%. • Attribute: Physical structure – tufa formations; Target: Disturbed proportion of vegetation cover where tufa is present is less than 1%. • Attribute: Indicators of local distinctiveness; Target: No decline in distribution or population sizes of rare, threatened or scare species associated with the habitat; maintain features of local distinctiveness subject to natural processes. • Attribute: Transitional areas between fen and adjacent habitats Target: Maintain adequate transitional areas to support/protect the alkaline fen ecosystem and the services it provides.

River Boyne and River Blackwater SPA

The conservation objectives for the River Boyne and Blackwater SPA (NPWS, 2024) are provided below

Table 7.0 Conservation Objectives for The River Boyne and River Blackwater SPA

Qualifying Interest & Conservation Objective	Conservation Objective Attributes & Targets
*To maintain the favourable conservation condition of **Kingfisher** in the River Boyne and River Blackwater SPA, which is defined by the following list of attributes and targets:*	• Attribute: Population size; Target: No significant decline in the long term. • Attribute: Productivity rate; Target: Sufficient productivity to maintain the population trend as stable or increasing. • Attribute: Spatial distribution of territories; Target: No significant loss of distribution in the long term, other than that occurring due to natural patterns of variation. • Attribute: Extent and quality of nesting banks and other suitable nesting features; Target: Sufficient area of high quality nesting habitat to support the population target. • Attribute: Water quality; Target: Both biotic (i.e. Q value) and abiotic indices reflect overall good-high quality status. • Attribute: Barriers to connectivity; Target: No significant decline. • Attribute: Disturbance to breeding sites; Target: Disturbance occurs at levels that do not significantly impact upon breeding Kingfisher.

Impact Prediction

The potential impacts on water quality from the Virginia Operational Discharges, alone and cumulatively with other catchment pressures are discussed below. The potential for water quality impacts to give rise to adverse effects on the integrity of the River Boyne and River Blackwater SAC and SPA, in view of their conservation objectives, is then considered.

Impacts on water quality

The primary impact under consideration is the potential pollution of surface waters arising from the Virginia Operational Discharges. Such impacts could include nutrient enrichment triggering algal or plant growth, deposition of sewage litter, growth of sewage fungus, deposition of organic sediments or zones of altered dissolved oxygen, pH or temperature levels.

On the basis of water quality data and water quality modelling, while the future primary discharge is a nutrient input into the lake, for Ammonia it is seen that modelling the existing discharge conditions resulted in '*Moderate*' status across most of the lake. Modelling the future plant discharge under existing lake and river conditions did not result in any change in status; however, when the future plant discharge was modelled under notionally clean lake and river conditions, *'High'* water quality status was achieved across the whole lake. In terms of Total Phosphorus (as P), it is seen that regardless of the WwTP discharge specifications, using the existing lake and river conditions, resulted in '*Bad*' status throughout the lake. However, when the future plant discharge is modelled under notionally clean lake and river conditions, phosphorus levels are significantly reduced, and the status improves to '*High*' or '*Good*' status. This provides further evidence that river nutrient loads are currently the primary factor influencing lake water quality.

Under existing background conditions, due to the large input of nutrients from the wider catchment, the discharge has a minimal effect on nutrient levels at the nearest monitoring stations indicating it is a small contribution to the overall nutrient load. Based on the water quality status maps, produced by comparing final steady-state nutrient concentrations with EQS values for High, Good, Moderate, Poor and Bad status, WwTP mixing zones were not identified for any of the modelled mean or low-flow scenarios. The potential for any reduction in water quality within the mixing plume of the primary discharge (the mixing the area in the vicinity of a discharge where significant mixing and dilution is occurring at concentration levels that are compliant with applicable EQS targets), or downstream in the Kells Blackwater, to affect the qualifying interests of the SAC or SPA is discussed below.

Compliant SWO's are a necessary part of sewerage networks and serve to prevent uncontrolled spillages arising within the agglomeration and to prevent the biological processes necessary to treat effluent being compromised by inundation with excess water. The principal consideration to take account of in the assessment of the impact of overflows for water quality is that overflows will only occur in the event of sustained rainfall. The initial flushing flow arising from the first 5 mm of rain in a rainfall event is contained in the foul sump initially and will not be passed through to the storm tanks unless the capacity of the foul pumps is exceeded. This initial surface runoff flow will have the highest level of pollutants as it will wash in debris from impermeable surfaces and may dislodge settled solids in the sewer network. Flows entering a storm tank will then pass through a 6 mm upward flow screen between the foul sump and storm sump. This will further retain a significant proportion of the organic matter, solids and rags in the foul sump. Flows will then be retained in the storm tank providing an opportunity for suspended solids to settle out. As flow recedes, the storm tank contents are passed forward to the WwTP for treatment. If the storm tank reaches capacity a highly diluted screened effluent is discharged. It is not possible to fully retain all stormwater due to septicity that arises with storage and the inability of treatment plant biological processes to cater for large volumes of dilute wastewater. In the case of Virginia, one SWO (SW003) will discharge to the centre of the lake alongside the primary discharge. SW003 has been designed to meet the criteria as set out in the DoEHLG '*Procedures and Criteria in Relation to Storm Water Overflows*', 1995. Diluted, settled and screened effluent which could be discharged during storm conditions, will enter a waterbody which will have increased volume and flow driven by sustained rainfall. In this context, the overflow discharges to the receiving waters will be diluted and dispersed effectively.

Adverse effects on Annex I Habitats

This assessment focuses on the qualifying habitats of River Boyne and River Blackwater SAC, considering the nature of the effects that could arise and whether mitigation may be required to avoid these effects.

The primary and SWO discharges to the centre of Lough Ramor are *ca.* 4.2km from any potential unmapped habitat within the SAC designation. The nutrient input from the primary discharge alone has no potential to affect these habitats, as it supports high quality water conditions, and is a minor contribution to the nutrient load in the context of the catchment pressures. The SWO has been designed to be complaint with the required standards and any short-term nutrient loads will be diluted and dispersed within the lake. The discharge does not therefore have the potential to hinder the maintenance/restoration of the conservation objectives of Alkaline fen or Alluvial woodland habitat in the downstream SAC.

Adverse effects on Annex II Species

Annex II qualifying interests under consideration are river lamprey, Atlantic salmon, and otter. Only Atlantic salmon have a specific water quality-related conservation objective target, requiring Q4/Good water quality conditions are maintained in their habitat ranges.

The outflowing Blackwater (Kells)_080 waterbody is assigned '*Moderate*' status, with agriculture and hydromorphology the identified pressures. Salmon have not recently been recorded in the river upstream or immediately downstream of Virginia, though are known to occur further downstream, and habitat in the upstream Ramparts river is physically suitable for this species. Water quality modelling demonstrates that the discharge will not hinder the restoration of '*Good*' status water quality in the lake, and consequently will not cause any deterioration in downstream river water quality status.

Other conservation objective targets for Annex II species may be indirectly impacted where water quality deterioration triggers eutrophication, particularly those targets related to optimal habitat for different life stages, maintaining habitats free of filamentous algae, and maintaining fish biomass (otter). On the basis of the water quality modelling, the future Virginia primary discharge will not alter water quality status in the lake, or in the mixing zone, and will not give rise to eutrophication impacts. Qualifying species could occur on an ex-situ basis in the immediate vicinity of the lake discharges *i.e.,* otter, lamprey or salmon swimming or foraging in the vicinity of the primary discharge and SWO. Given the scale of the discharges in the context of the lake waterbody, the treated nature of the effluent, and the design of the SWO from the upgraded WwTP, any temporary interaction with an area of localised elevated nutrients immediately around the discharge plume does not have the potential to impact these species in terms of their health or fitness or affect habitats for key life stages. The operational discharges therefore have no potential to hinder the maintenance/restoration of the conservation objectives of these species in the SAC.

Adverse effects on Special Conservation Interests

Kingfisher are the only listed Annex I bird species for which the River Boyne and River Blackwater SPA has been designated. There are specific water quality targets requiring Q4/Good water quality conditions are maintained for this species, while conservation objective targets relating to the availability of suitable foraging may be impacted where water quality deterioration triggers eutrophication. There could be consequent effects on targets related to population size, productivity rates and distribution of territories. Kingfisher, potentially associated with the SPA, have been recorded in Lough Ramor. As described above, on the basis of the water quality modelling, the future Virginia primary discharge will not alter water quality status in the lake, or in the mixing zone, and will not give rise to eutrophication impacts. Given the scale of the discharges in the context of the lake waterbody, the treated nature of the effluent, and the design of the SWO from the upgraded WwTP, any temporary interaction with an area of localised elevated nutrients immediately around the discharge plume does not have the potential to impact Kingfisher in terms of their health or fitness or affect their foraging resources. The operational discharges therefore have no potential to hinder the maintenance/restoration of the conservation objectives of Kingfisher in the SPA.

Potential Cumulative or In-combination Effects

As described at AA Screening stage, the County Development Plans and River Basin Management Plan support the prioritisation of actions to deal with significant pressures affecting the catchment. The permitted upgrade scheme has been designed to address the significant pressure of the existing Virginia WwTP. The water quality modelling used as supporting information for this assessment captures the background pressures in the waterbody through use of water quality monitoring data from the catchment, and also indicates that assimilative capacity will remain for additional nutrient inputs to the system. The operation of compliant discharges will meet the relevant water quality standards and will not result in cumulative effects on any qualifying interest.

Mitigation Measures

The assessment has concluded that the discharges from the Virginia agglomeration have no potential to adversely affect the qualifying interests of the River Boyne and River Blackwater SAC and SPA, and hence no specific mitigation measures are required.

To ensure satisfactory operation of the Virginia agglomeration in line with the discharge licence the authors recommend the following:

- Ensure that the capacity of the WwTP is not exceeded;
- Ensure the primary discharge operates in compliance with the proposed ELVs/effluent standards;
- Ensure the proposed SWO (SW003) from the upgraded WwTP operates in compliance with the criteria as set out in the DoEHLG '*Procedures and Criteria in Relation to Storm Water Overflows*', 1995; and
- Continue monitoring the effluent and receiving waters, on a consistent and regular basis.

NIS Conclusion Statement

This NIS has been prepared following the EPA (2009) *'Note on Appropriate Assessments for the purposes of the Waste Water Discharge (Authorisation) Regulations, 2007 (S.I. No. 684 of 2007)*'. The Department of the Environment, Heritage and Local Government guidance '*Appropriate Assessment of Plans and Projects in Ireland. Guidance for Planning Authorities'* (DoEHLG, 2009) has also been taken into account. This NIS for the Waste Water Discharge Licence investigates the potential adverse effects on the aquatic qualifying interests of the Natura 2000 network arising from the plant discharge, in combination with other plans / projects affecting the aquatic environment. The assessment considers whether the Virginia agglomeration Operational Discharges, alone or in combination with other projects or plans, will have adverse effects on the *integrity* of a European site in view of its conservation objectives, and includes consideration of any mitigation measures that may be necessary to avoid, reduce or offset negative effects. Its purpose is to assist the competent authority, the EPA, in carrying out its AA of the proposed licence review.

Based on the assessment herein it has been concluded that there will be no adverse effects on the integrity of the River Boyne and River Blackwater SAC and SPA, or any other European Site, in view of this site's conservation objectives and that the conservation status of the Annex I habitats or Annex II species will not be compromised by the agglomeration Operational Discharges either directly, indirectly or cumulatively.

It is therefore concluded that the Virginia agglomeration Operational Discharges, alone or in-combination with other plans and / or projects will not give rise to adverse effects on the integrity of the River Boyne and River Blackwater SAC and SPA, or any other European Site.

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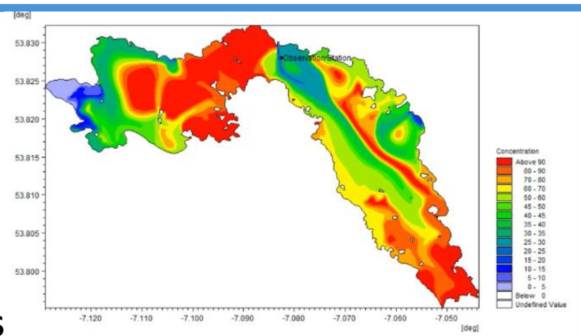
ATTACHMENT D.2.3:

WATER QUALITY MODELLING REPORT
SEPTEMBER 2024

Virginia Waste Water Treatment Plant Upgrade Water Quality Impact Assessment

FINAL REPORT – September 2024



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MSN Hydro Int. Ltd.

Hydro-Environmental Consultants

Limnos Consultancy

Martin McGarrigle

Disclaimer

Model results in this report are based on the inherent assumptions and formulations under which the models have been developed. Any decisions made based on these results must be informed by an understanding of the model assumptions and formulations.

MSN Hydro Ltd. is a registered company with offices in Galway, Ireland.
Company no. 625253 VAT no. 3652174DH

Abbreviations Used

- **AER:** Annual Environmental Report
- **AWS:** Automated Weather Station
- **BOD:** Biological Oxygen Demand
- **CIS:** Common Implementation Strategy
- **CoC:** Contaminant of Concern
- **COD:** Chemical Oxygen Demand
- **DWF:** Dry Weather Flow
- **ELV:** Emission Limit Value
- **EPA:** Environmental Protection Agency
- **EQS:** Environmental Quality Standard
- **FFT:** Full Flow to Treatment
- **IPC:** Integrated Pollution Control
- **mOD:** Metres above Ordnance Datum
- **MRP:** Molybdate Reactive Phosphorus
- **NGR:** National Grid Reference
- **NPWS:** National Parks & Wildlife Service
- **NSA:** Nutrient Sensitive Area
- **OPW:** Office of Public Works
- **PE:** Person Equivalent
- **PIP:** Pollution Impact Potential
- **PIP-P:** Phosphorus Pollution Impact Potential
- **RMSE:** Root Mean Square Error
- **SAC:** Special Areas of Conservation
- **SPA:** Special Protection Area
- **SWO:** Storm Water Overflow
- **TON:** Total Oxidised Nitrogen
- **TP:** Total Phosphorus
- **TPS:** Terminal Pumping Station
- **TSS:** Total Suspended Solids
- **UÉ:** Uisce Éireann
- **WFD:** Water Framework Directive
- **WWTP:** Waste Water Treatment Plant

Contents

1. INTRODUCTION

This report includes a description of the Virginia waste water treatment plant (WWTP), its levels of treatment, future expansion, discharge characteristics and relevant ambient monitoring of the receiving water.

The report includes a section detailing the environmental setting with a catchment-wide assessment of its waterbodies and sub-catchments under a range of Irish and European legislation, existing status, protected areas and an analysis of current environmental information for the relevant catchment waterbodies.

A 2D model of Lough Ramor is included, based on a detailed hydrological model of the lake with inflows, outflows and lake level matched against Office of Public Works (OPW) and Environmental Protection Agency (EPA) hydrometric data. The Virginia WWTP discharge is then modelled using existing lake and inflowing river concentrations for a range of parameters such as ammonia and phosphorus (as available from EDENIreland.ie) – to obtain agreement between modelled data and observed monitoring data for the lake. Because the lake and inflowing rivers exceed some of the environmental quality standards (EQS) set down in legislation such as Statutory Instrument 77 of 2019 it was necessary to take the recommended ‘notionally clean’ approach to assess the impact of the WWTP in isolation from other catchment pressures. The recommended background values from the Uisce Éireann (UÉ) guidance document were used to model the impact of the WWTP in isolation from other pressures such as the background agricultural pressures evident in the upper catchment.

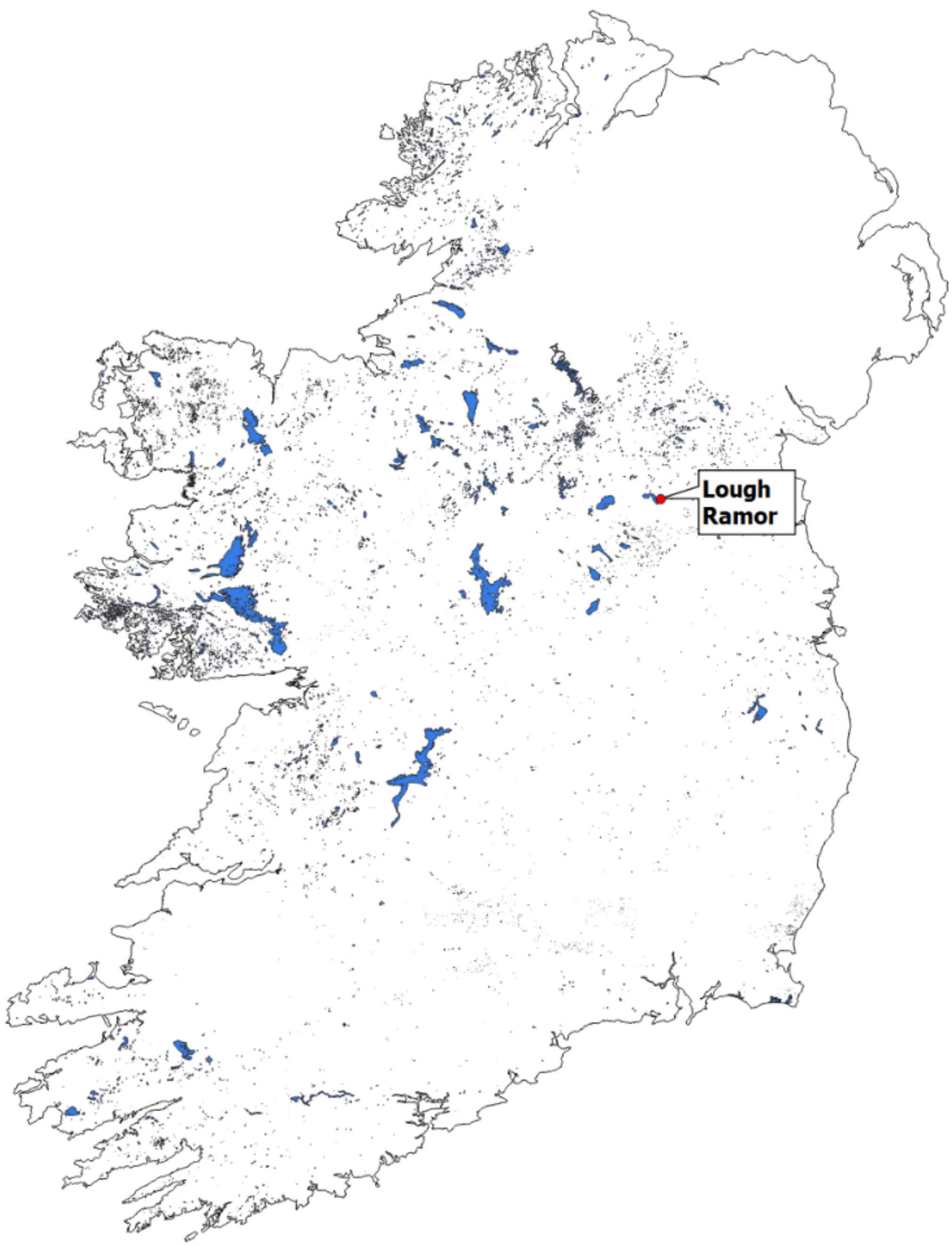
The nature of the mixing zone in the vicinity of the discharge was modelled – using the MIKE21 industry standard modelling software.

The general conclusion reached in each section was that the WWTP discharge at its current and future expanded level using the proposed emission limit values (ELVs) will not cause Lough Ramor to fall below good status for the relevant EQS for ammonia and total phosphorus.

This report follows the Uisce Éireann guidance document: (UÉ, 2024) *UE-AMT-GL-028 Interim Guidance for Water Quality Impact Assessment (Freshwaters).*

2. VIRGINIA WASTE WATER TREATMENT PLANT (WWTP) – DISCHARGE DESCRIPTION

Lough Ramor is the receiving water of the discharge from the WWTP at Virginia; the discharge point is some 330 m offshore at NGR 260521E, 286736N, see yellow stars in Figure 2-1. Currently there is one Storm Water Overflow (SWO) at the Terminal Pumping Station (TPS), which discharges to Lough Ramor at 260410E, 287031N.



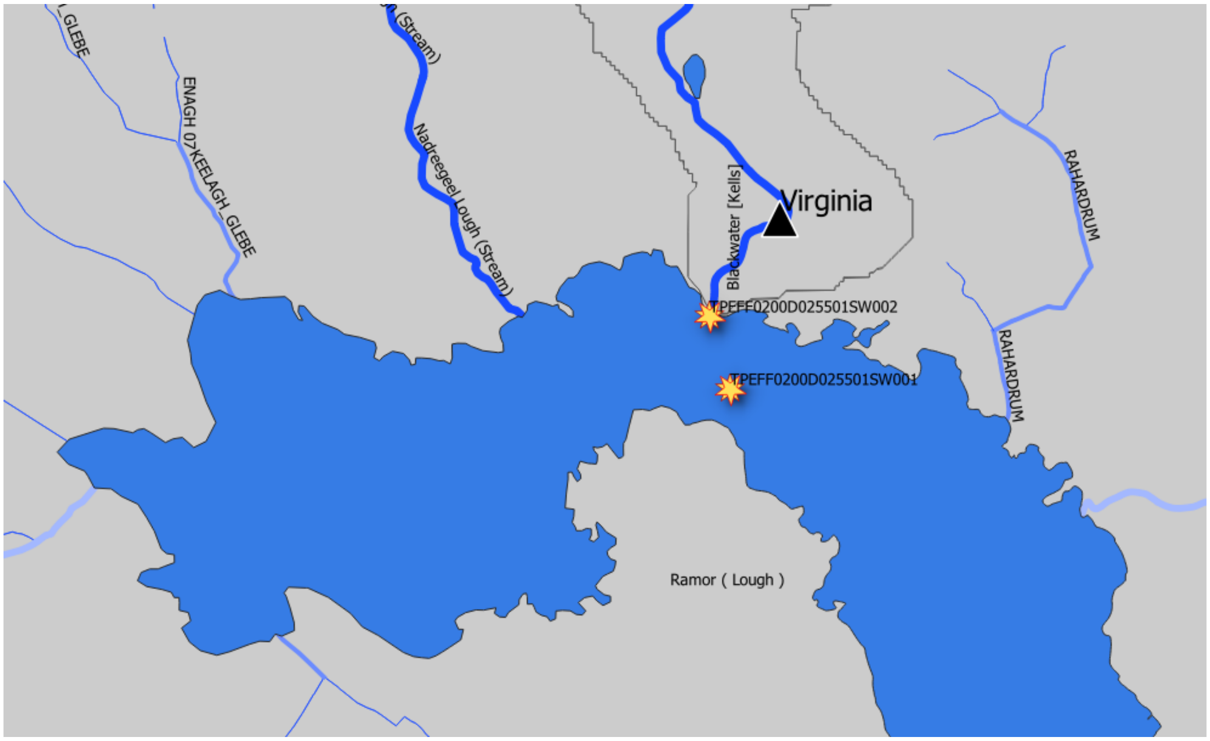


Figure 2-1. Location of Lough Ramor and Virginia WWTP discharge points.

The WWTP for Virginia has a current design capacity of 3,800 person equivalent (PE). Treatment comprises primary treatment (aeration), secondary clarification and tertiary or nutrient removal by chemical dosing for phosphorus removal.

The proposed upgrade to the plant will increase the capacity to a PE of 6,000. The upgraded plant will treat the effluent to a higher standard than at present with a view to enabling Lough Ramor to achieve 'Good' status under the Water Framework Directive (WFD). Table 2-1 gives the proposed ELVs for the upgraded plant.

Table 2-1. Proposed Emission Limit Values for Virginia WWTP Upgrade.

Parameter	Effluent Limit
pH	6-9
cBOD	25 mg/l
COD	125 mg/l
Suspended Solids	25 mg/l
Ammonia (as N)	1.0 mg/l
Total Phosphorus (as P) (mg/l)	0.2 mg

Existing Effluent Characteristics

Table 2-2 gives the current discharge concentrations for the Virginia WWTP. These can be compared with the future proposed concentrations of chemistry constituents in the effluent as per Table 4-8. Appendix C gives results for biological oxygen demand (BOD), chemical oxygen demand (COD), ammonia, total phosphorus, total suspended solids, pH, plus the inflow and outflow volumes for the WWTP discharge over the period January 2021 to November 2023.

The current licence conditions set by the EPA in 2015 are shown in Table 2-3, a screenshot from the licence. The licence is under review by the EPA.

Table 2-2. Current discharge chemistry for Virginia WWTP.

Parameter	Current Effluent Chemistry [mg/l] Mean Concentrations
Organic N	2.73
Ammonia	2.18
Nitrate	10.0
Total P	1.62
Organic P	0.62
MRP	1.00

Table 2-3. Licence conditions for Virginia WWTP D0255-01 issued by EPA on 15 December 2015.

Environmental Protection Agency *Licence Reg. No. D0255-01*

SCHEDULE A: DISCHARGES & DISCHARGE MONITORING

A.1: Primary Waste Water Discharge & Monitoring

A.1.1 Primary Waste Water Discharge(s)					
EDEN Code	Licence Code	Discharge Location	Monitoring Location	Receiving Water Name	WFD Code Receiving Water
TPEFF0200D0255SW001	SW001	E 260521 N 286736	E 260536 N 287106	Lough Ramor	IE_EA_07_275

Discharge Emission Limit Values and Monitoring							
		Discharges			Monitoring		
Parameter	Units	Interim ELV (or Interim % Reduction)	ELV (or % Reduction)	ELV Commencement Date [Note 1]	Monitoring Frequency	Sampling Method	Analysis Method / Technique
Flow Rate	*m3/24 hours*	-	-	-	Continuous	Online	Online Flow Probe Meter with Recorder
pH	*pH units*	-	6-9	-	Monthly	Continuous	pH Meter and recorder
BOD, 5 days with Inhibition (Carbonaceous BOD)	*mg/l*	-	25	-	Monthly	Composite	Standard Method
COD-Cr	*mg/l*	-	125	-	Monthly	Composite	Standard Method
Suspended Solids	*mg/l*	-	25	-	Monthly	Composite	Standard Method
Ammonia-Total (as N)	*mg/l*	-	1	31/12/2021	Monthly	Composite	Standard Method
Total Phosphorus (as P)	*mg/l*	-	0.2	31/12/2021	Monthly	Composite	Standard Method
Visual Inspection	*Descriptive*	-	-	-	Daily	Grab	Standard Method

Note 1 Where no ELV Commencement Date is specified, the ELV shall apply from date of grant of licence.

Ambient Monitoring Results 2007–2023

Table 2-4 gives the results for the ambient monitoring stations as specified in the WWTP's licence. Lake-wide results for all monitoring stations on which the ecological status of the lake is based are given in the Environment Setting Section – see *Phosphorus and Ammonia Concentrations* and the *Phytoplankton / Chlorophyll* section.

Table 2-4. Ambient monitoring results for Lough Ramor Station 3 and Station 5 – the stations closest to the Virginia WWTP discharge. Results for the period 2007 to 2023. Source EDENIreland.ie. Parameters with an EQS for lakes are shown in bold.

Parameter	No. Samples	Minimum	Mean	Maximum	95%ile
Alkalinity-total (as $CaCO_3$) mg/l	109	35.43	57.17	83.03	
pH	**136**	**7.00**	**7.84**	**9.17**	
Conductivity µS/cm	109	125.0	184.4	303.0	
True Colour (Hazen or mg/l Pt Co)	109	1.0	66.4	313.0	
Transparency (m)	96	0.50	1.26	2.00	
Suspended Solids mg/l	26	2.50	3.54	12.00	
Temperature °C	**129**	**3.1**	**12.9**	**25.0**	
Silica (as SiO_2) mg/l	108	0.05	3.67	7.30	
Chlorophyll µg/l (2007-2018)	96	1.00	21.78	110.00	
Chlorophyll µg/l (2018-2023)	13	2.10	6.12	24.00	
BOD - 5 days mg/l O_2	26	0.50	2.39	5.40	
Dissolved Oxygen % Saturation	**120**	**58.8**	**93.1**	**128.0**	**115.5**
Dissolved Oxygen mg/l O_2	73	6.26	9.59	11.66	
Ammonia-Total (mg N/l)	**134**	**0.005**	**0.041**	**0.407**	**0.1294**
Nitrate (mg N/l)	75	0.01	0.42	2.50	
Nitrite (mg N/l	75	0.002	0.005	0.013	
Total Oxidised Nitrogen (mg N/l)	107	0.01	0.40	2.50	
ortho-Phosphate (mg P/l)	61	0.01	0.03	0.08	
Total Phosphorus (mg P/l)	**135**	**0.020**	**0.064**	**0.190**	

Table 2-4 gives the ambient monitoring results for Lough Ramor for the two sites closest to the Virginia WWTP discharge: Station 5 (specified in the WWTP licence); Station 3 data are also included as the number of results available for Station 5 has dropped in recent years. Results for minimum, mean, maximum and where applicable (dissolved oxygen and ammonia) the 95%ile value is included to compare with a relevant EQS for lakes.

Statutory Instrument 77 of 2019 (European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2019) specifies EQS values for total phosphorus, ammonia, pH and oxygen saturation in lakes as follows:

Total Phosphorus (mg P/l)
High status ≤ 0.010 (mean)
Good status ≤ 0.025 (mean)

Total Ammonia (mg N/l)
High status ≤ 0.040 (mean) and ≤ 0.090 (95%ile)
Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)

pH (Individual values**)**
Soft(3)Water 4.5< pH < 9.0
Hard(4)Water 6.0< pH < 9.0

Dissolved Oxygen (% Saturation)
Lower Limit: 95%ile < 80%
Upper Limit: 95%ile > 120%

Temperature
Not greater than a 1.5°C rise in ambient temperature outside the mixing zone

While there are breaches of the Good Status EQS values for lakes in Lough Ramor, the mean concentration for total phosphorus at Station 6 closer to the outflow from the lake and almost 3 km from the WWTP is 0.06 mg/l.

3. ENVIRONMENTAL SETTING

Maps of the Greater Ramor/Blackwater Catchment

The maps shown here extend beyond the immediate downstream receiving water for the Virginia WWTP and include the upper Blackwater (Kells) catchment and that of other rivers flowing into Lough Ramor. This is done to outline the full set of pressures on water quality in Lough Ramor and the outflowing Blackwater (Kells).

Figure 3-1 shows Lough Ramor and the Blackwater (Kells) catchment in the larger River Boyne hydrometric area. Figure 3-2 shows the sub-catchments/river waterbodies in the larger Ramor/Blackwater catchment. (The location of the Virginia WWTP discharge is shown in Figure 2-1.)

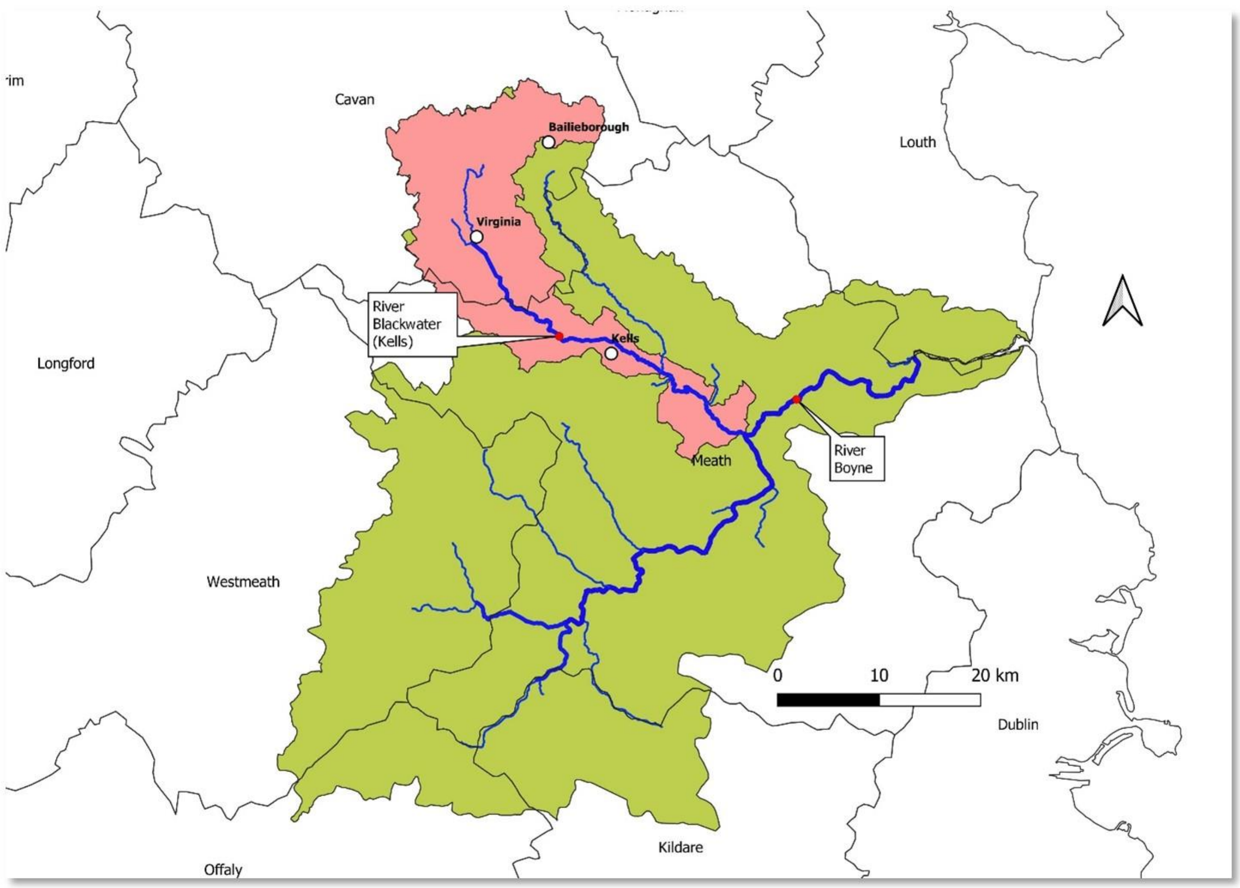


Figure 3-1. Map showing location of the catchments of the River Blackwater (Kells) and Lough Ramor in Hydrometric Area 07, River Boyne.

Sub-Catchments in the Ramor/Blackwater (Kells) Catchment

The 17 sub-catchments in the greater catchment area are mapped in Figure 3-2.

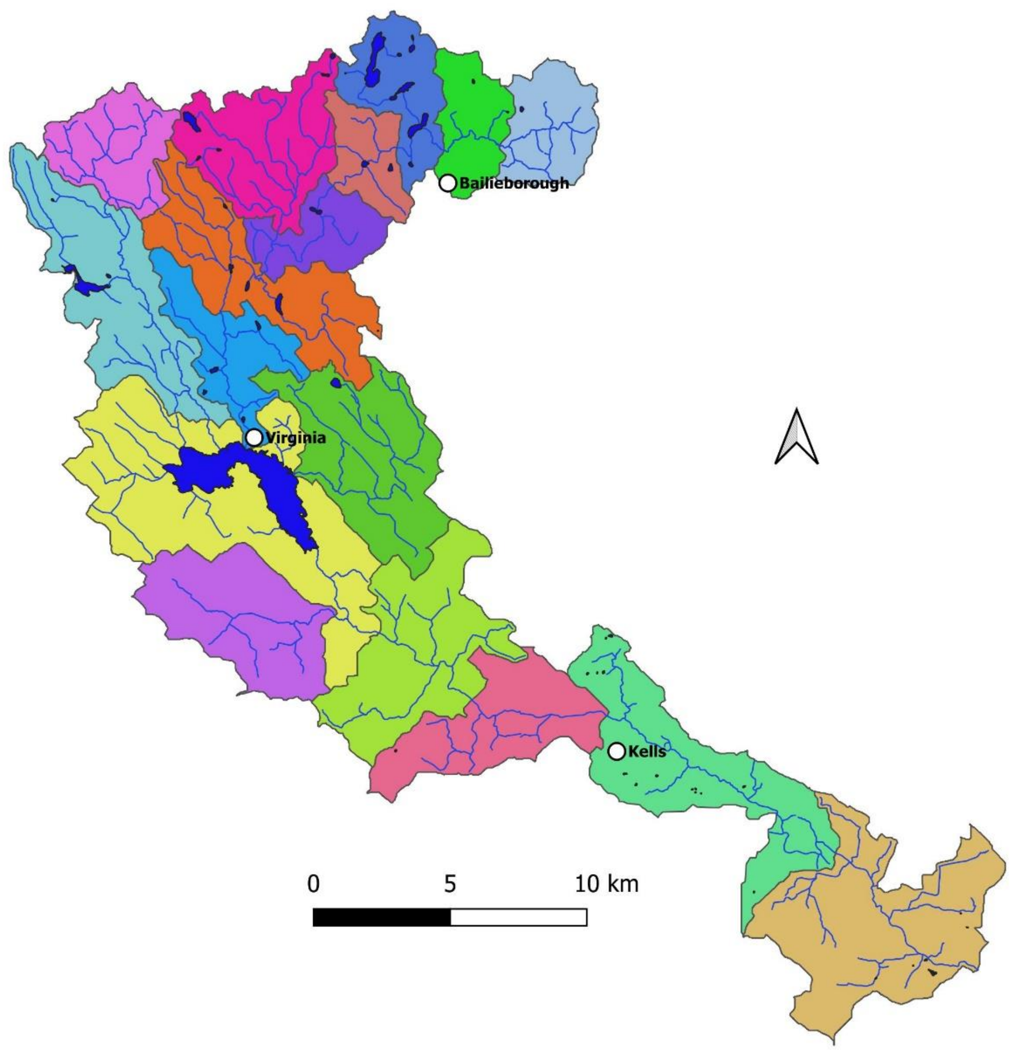


Figure 3-2. River waterbody sub-catchments in the Blackwater (Kells)/Ramor catchment.

Licensed Discharges in the Catchment

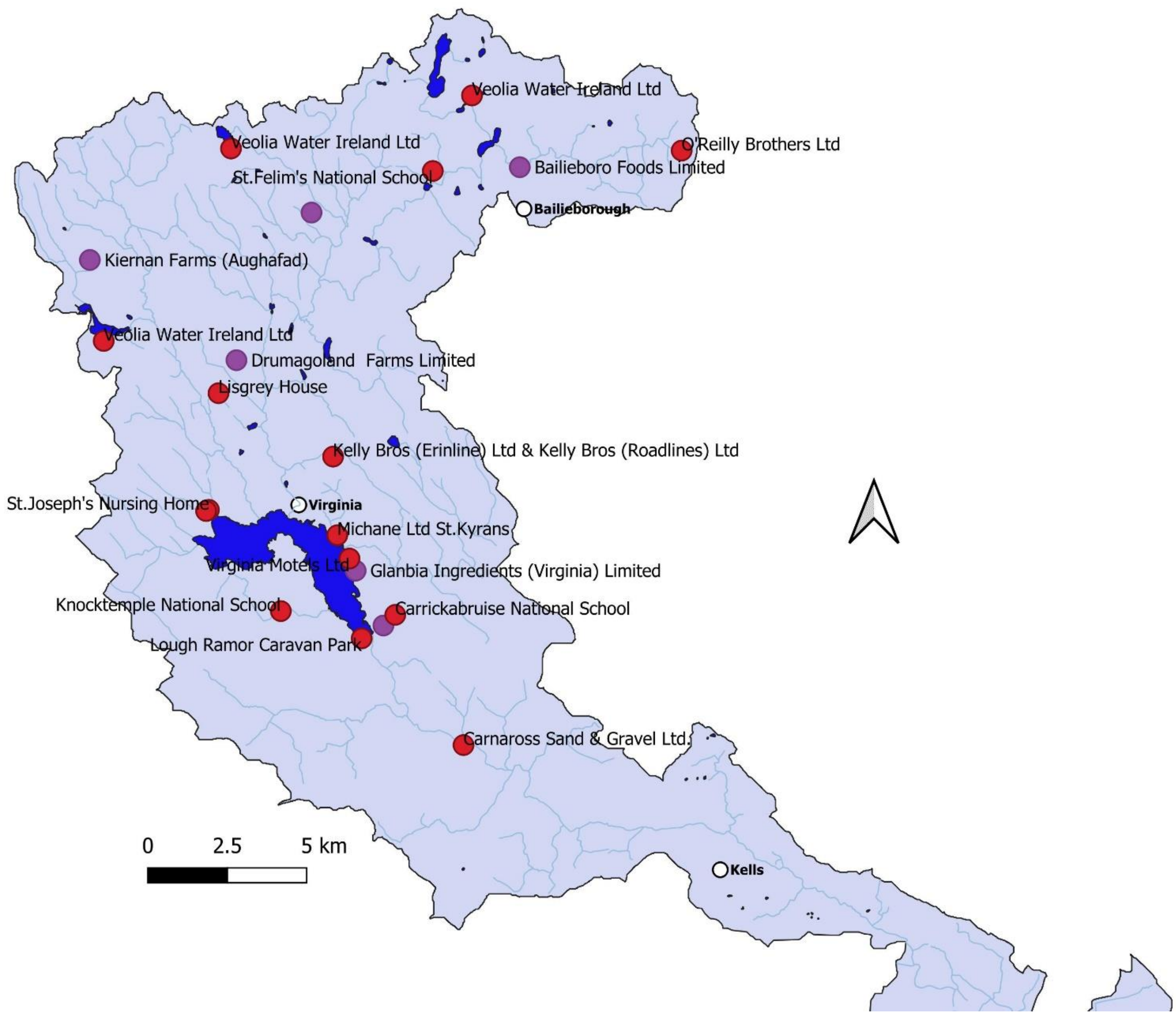


Figure 3-3. EPA and local authority licensed discharges to water in the Blackwater (Kells), Lough Ramor catchment.

Figure 3-3 and Table 3-1 map and list the licensed discharges to water in the catchment. There are six EPA Integrated Pollution Control (IPC) licences and the remaining 15 are local authority Section 4 licences. Of these, the Glanbia discharge is the largest and it discharges directly into Lough Ramor. It is similar in magnitude to the Virginia WWTP especially in terms of its phosphorus loading (see Table 4-9). It discharges mid-way down the lake on the eastern side. The modelling section of this report shows that at that point the flow through the lake is directly towards the outflow point with little or no back flow – see Figure 4-12 and Figure 4-13.

Table 3-1. Licensed discharges to water in the upper Blackwater (Kells), Lough Ramor catchment.

Reference	**Licence Holder**	**Facility Address**	**Licensing Authority**
SS/W001/04	Lough Ramor Caravan Park	Ryefield, Virginia	CN Co Co
SS/W006/06	O'Reilly Brothers Ltd	Taghart Quarry, Taghart South, Shercock	CN Co Co
SS/W019/05	Veolia Water Ireland Ltd	Clifferna GWS	CN Co Co
SS/W008/05	Lisgrey House	Lisgrey, Virginia	CN Co Co
SS/W012/05	Veolia Water Ireland Ltd	Billis Lavey GWS	CN Co Co
SS/W015/05	Veolia Water Ireland Ltd	Drumkerry GWS	CN Co Co
SS/W002/11	St. Felim's National School	Leiter, Bailieborough	CN Co Co
SS/W001/98	Virginia Motels Ltd	Lakeside Manor, Virginia	CN Co Co
SS/W001/11	Carrickabruise National School	Virginia	CN Co Co
SS/W002/14	Kelly Bros (Erinline) Ltd & Kelly Bros (Roadlines) Ltd	Bailieborough Road, Virigina	CN Co Co
SS/W004/12	Michane Ltd St. Kyrans	Ballaghanea, Virginia	CN Co Co
SS/W004/03	St. Joseph's Nursing Home	Lurgan Glebe, Virginia	CN Co Co
SS/W014/06	Masonic Havens Ltd	St. John's Close, Lurgan Glebe, Virginia	CN Co Co
03/01	Carnaross Sand & Gravel Ltd.	Pottlereagh, Carnaross, Kells, Co. Meath.	MH Co Co
SS/W003/11	Knocktemple National School	Knocktemple, Virginia	CN Co Co

Active Licence	**Licence Holder**	**Facility Address**	**Licensing Authority**
P0215-02	Mr John Kiernan (Lismagiril)	Lismagiril Pig Unit, Lismagiril, Killinkere, Virginia, Cavan, A00 AA00	EPA
P0657-01	Drumagoland Farms Limited	Drumagoland Farms Limited, Drumagoland, Virginia, Cavan	EPA
P0679-01	Kiernan Farms (Aughafad)	Finaway Farms (New Inns Pig Farm), Drummanduff, Ballyjamesduff, Cavan	EPA
P0406-05	Bailieboro Foods Limited	Lear, Bailieborough, Cavan	EPA
P0405-02	Glanbia Ingredients (Virginia) Limited	Burrenrea, Kells Road, Virginia, Cavan	EPA
P1019-01	A. W. Ennis Limited	Carrakeeltymore, Virginia, Cavan	EPA

Topography

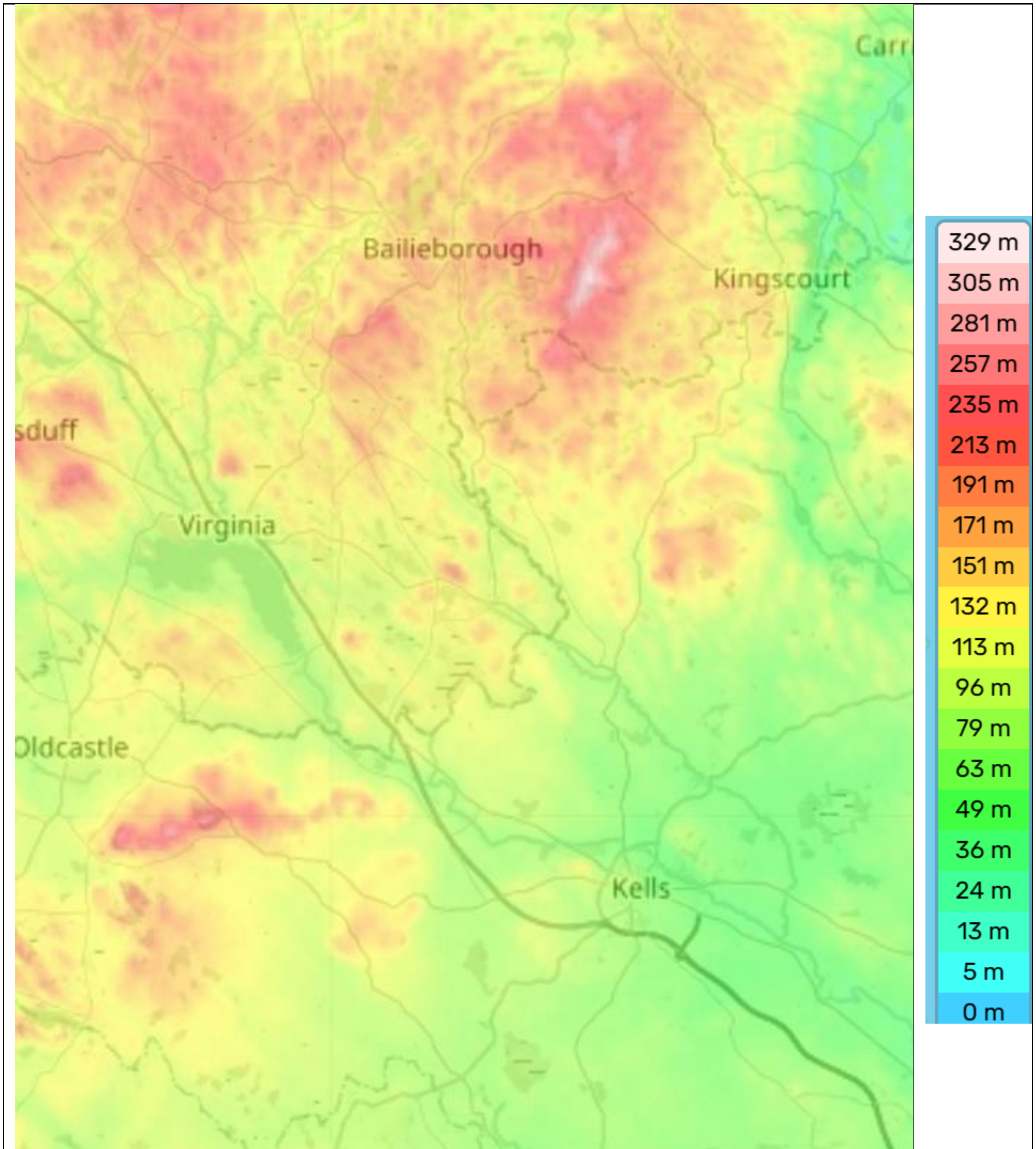


Figure 3-4. Topographic map of Ramor/Blackwater (Kells) region. Source: https://en-ie.topographic-map.com/

Figure 3-4 depicts the topography of the region with the North Midland Hills wrapping around Lough Ramor to the north and southwest. There are peaks to the north and northwest of

Baileborough of some 200 to 300 m and peaks of close to 250 m east of Ballyjamesduff. To the southwest of Lough Ramor there are lower hills of 150 to 175 m. Lough Ramor itself is at 80 m and the low point downstream of Kells is at 40 m. There are 17 river waterbodies in the Ramor/Blackwater catchment under consideration. The heights of the mid-point of these waterbodies ranges from 149 to 40 m. Average slopes range from close to zero to 6.6% in the upper waterbodies.

Geology, Soils, Topography and Land Use

Figure 3-5 depicts the catchment geology with description of the bedrock formations and Table 3-2 gives the corresponding unit names and percentage of the catchment accounted for by each of the major rock formations. Some 93% of the rock formations are various forms of sandstone. Water draining these rocks gives rise to relatively low alkalinity values in the inflowing rivers and in Lough Ramor (average of 57 mg/l for Lough Ramor).

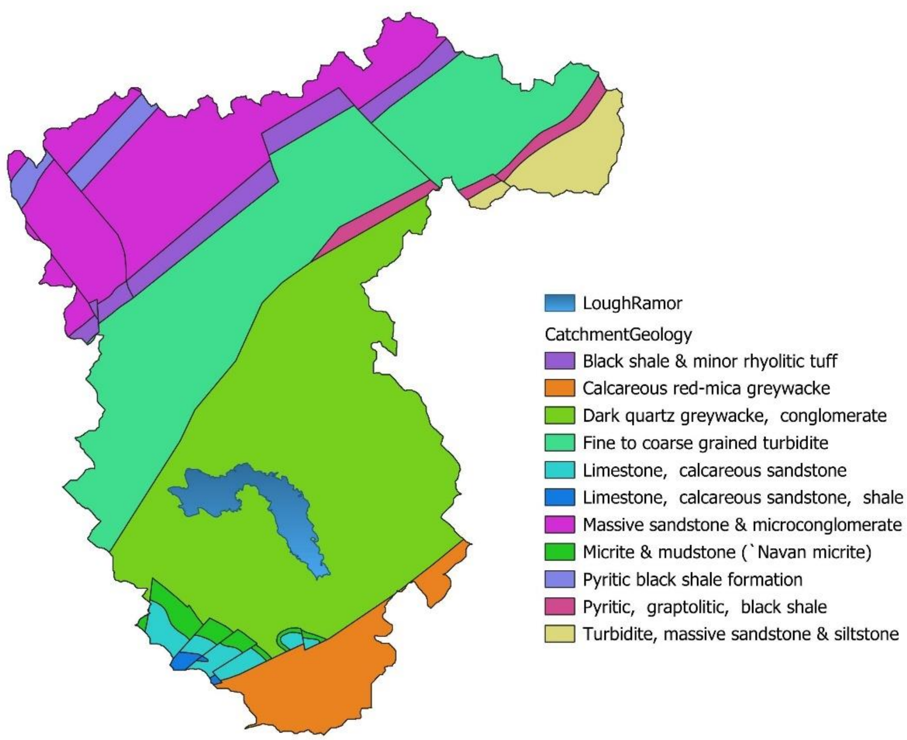


Figure 3-5. Geology of the greater Lough Ramor catchment area (Source: gis.epa.ie).

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Table 3-2. Description of geological formations with unit names and percentage of the catchment area accounted for by each type.

Description	Unit Name	% Catchment Area	Cumulative Area
Dark quartz greywacke, conglomerate	Castlerahan Formation	27.3%	27.3%
Calcareous red-mica greywacke	Clontail Formation	19.5%	46.8%
Massive sandstone & microconglomerate	Oghill Formation	17.3%	64.1%
Fine to coarse grained turbidite	Shercock Formation	15.0%	79.1%
Massive sandstone & microconglomerate	Lough Avaghon Formation	9.2%	88.3%
Turbidite, massive sandstone & siltstone	Taghart Mountain Formation	4.8%	93.1%
Black shale & minor rhyolitic tuff	Kehernaghkilly Formation	4.0%	97.1%
Pyritic black shale formation	Corderrybane Shale Formation	0.9%	98.0%
Micrite & mudstone (`Navan micrite)	Stackallan Member	0.7%	98.7%
Pyritic, graptolitic, black shale	Laragh Formation	0.6%	99.3%
Limestone, calcareous sandstone	Meath Formation	0.6%	99.9%
Limestone, calcareous sandstone, shale	Moathill Formation	0.1%	100.0%

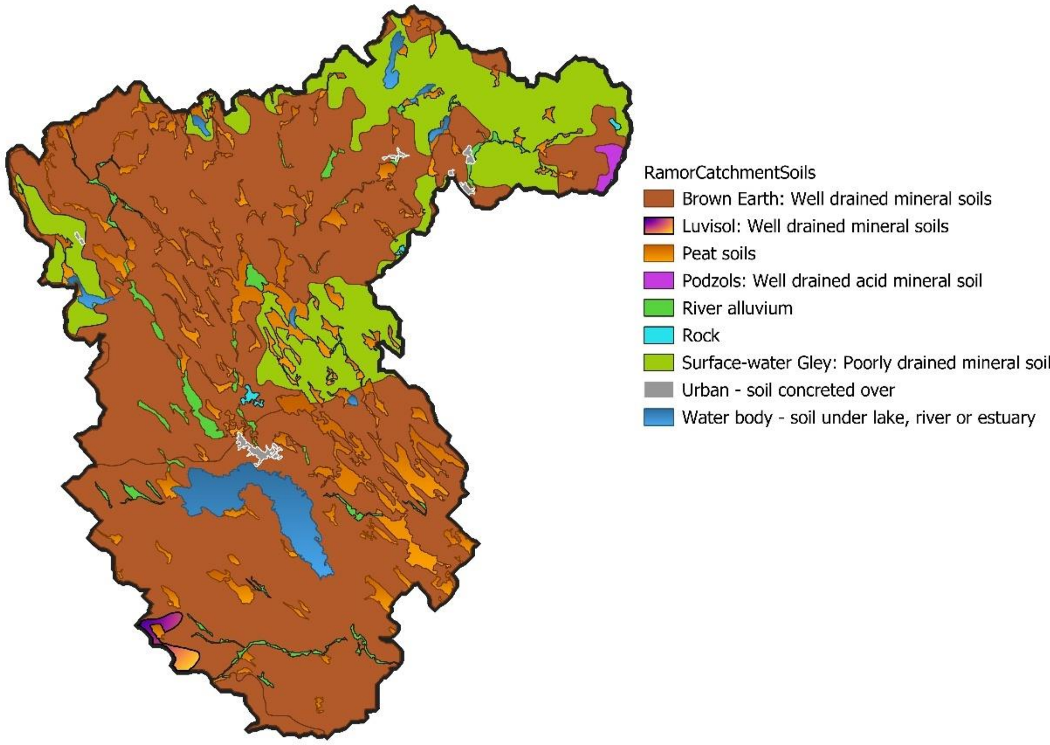


Figure 3-6. Soils in the Lough Ramor Catchment. (Source: gis.epa.ie).

Figure 3-6 maps the soils in the Lough Ramor catchment and Table 3-3 gives the percentage cover for the main types.

Table 3-3. Soil types in the Ramor catchment by area.

Soil	**Area**	**Cumulative Area**
Brown Earth: Well drained mineral soils	41.89%	42%
Luvisol: Well drained mineral soils	30.37%	72%
Surface-water Gley: Poorly drained mineral soil	22.58%	95%
Peat soils	2.66%	97%
River alluvium	1.19%	99%
Waterbody – soil under lake, river or estuary	0.73%	99%
Podzols: Well drained acid mineral soil	0.44%	100%
Urban – soil concreted over	0.10%	100%
Rock	0.04%	100%

In terms of drainage, Table 3-4 provides a breakdown of the broad drainage classification used by Teagasc. Some 73% of soils are well or moderately well drained with 26% classified as poorly drained. The poorly drained soils have implications for phosphorus loss to water from pastures. This links to the next section on phosphorus pollution impact potential

Table 3-4.Breakdown of soil drainage capacity in the Lough Ramor catchment.

Drainage Type	**% Area**
Well	42%
Moderately	31%
Poor	26%
Other	1%

Pollution Impact Potential (PIP) maps

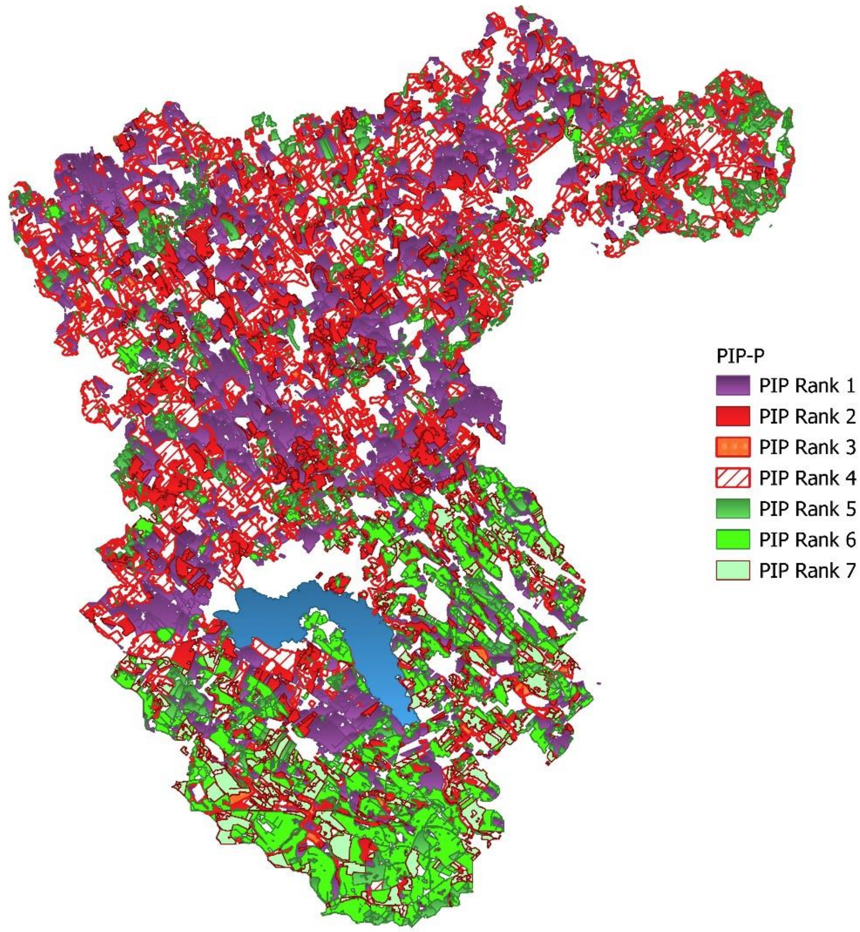


Figure 3-7. Phosphorus Pollution Impact Potential (PIP-P) map of the Lough Ramor catchment. PIP-P is ranked from 1 to 7 with lower rank numbers posing greater risk of phosphorus loss to water.

Figure 3-7 maps the phosphorus pollution impact potential (PIP-P) for the Lough Ramor catchment from https://gis.epa.ie/EPAMaps/Water. Lower PIP-P rank numbers indicate higher risk of phosphorus loss to water from the land. The PIP maps combine soil drainage characteristics with soil P index values to produce a risk of pollution from phosphorus loss. Similar PIP maps are available for nitrogen loss to water. The upstream portion of the catchment draining into Lough Ramor is generally at high risk of phosphorus loss to water from fields. This is relevant in terms of explaining the high phosphorus concentrations in the inflowing River Blackwater (Kells) (see Figure 3-26 and Figure 3-28) and also in the lake itself (Figure 3-14 and Figure 3-15).

Landcover

Almost 90% of the landcover in the catchment area is under pastures with a relatively low proportion of coniferous or broadleaf trees and a small percentage of peat bog and transitional woodland-shrub. Figure 3-8 is a CORINE landcover map of the Lough Ramor catchment.

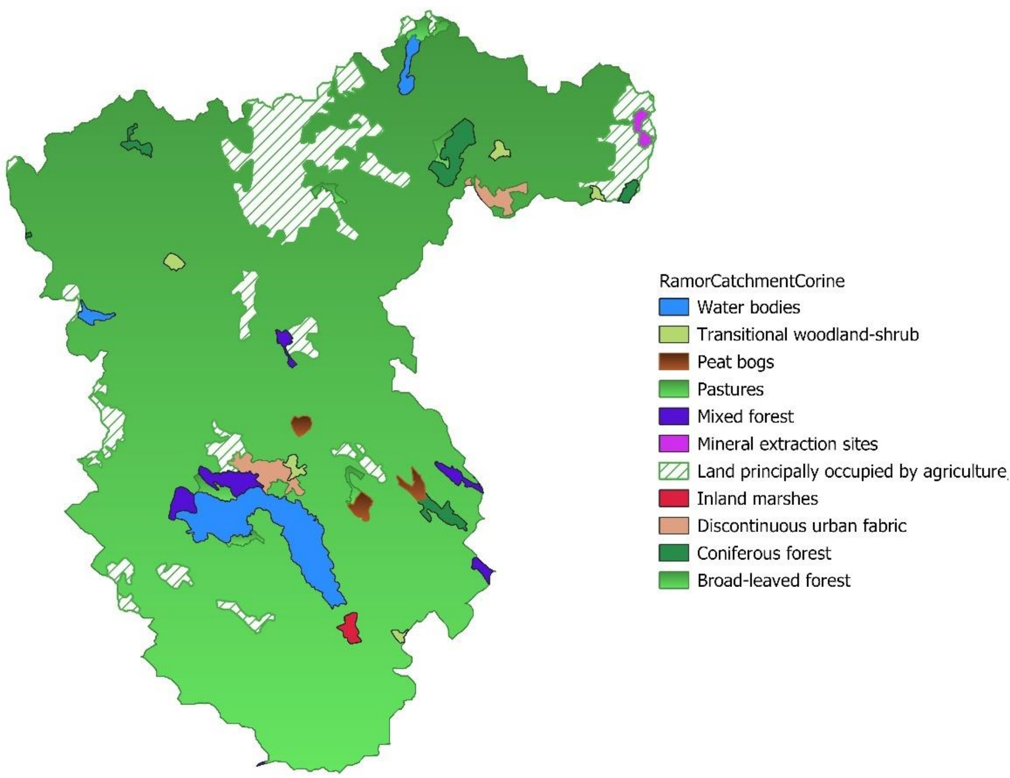


Figure 3-8. CORINE landcover map of the greater Lough Ramor catchment showing predominance of pastures.

Special Protected Areas (SPA)

The River Blackwater (Kells) is a designated SPA from its outflow from Lough Ramor. This designation continues for the River Boyne to the bridge on the M1 motorway.

It includes the following river sections: the River Boyne from the M1 motorway bridge, west of Drogheda, to the junction with the Royal Canal, west of Longwood, Co Meath; the River Blackwater (Kells) from its junction with the River Boyne in Navan to the junction with Lough Ramor in Co. Cavan.

The site is an SPA under the E.U. Birds Directive of special conservation interest for the following species: Kingfisher.

The Boyne Estuary is also an SPA (code 004080) for a range of wetland and water birds.

All of these are a significant distance downstream of the lake outflow and, thus, not likely to be seriously affected by the WWTP.

Special Areas of Conservation (SAC)

The River Boyne and River Blackwater (Kells) is a special area of conservation for river lamprey, salmon, otter and alkaline fens (Table 3-5). The SACs are mapped in Figure 3-9 and Figure 3-10. The synopsis for the SAC mentions intensive agriculture as the main water quality pressure plus the arterial drainage programme carried out on parts of the Boyne and Blackwater (Kells) that badly impacted salmon spawning areas. Among the targets set for the SAC by the National Parks and Wildlife Service (NPWS) is the following related to water quality: *At least Q4 at all sites sampled by the Environmental Protection Agency (EPA). Q-values based on triennial water quality surveys carried out by the Environmental Protection Agency.*

Most of the SACs are not influenced by Lough Ramor but the main Blackwater (Kells) SAC is immediately downstream of the lake. The EPA's risk assessment and latest status for the waterbody Blackwater (Kells)_090 is Moderate and it is classified as being at risk. Both Blackwater (Kells)_100, Blackwater (Kells)_110 waterbodies are classified as Good and not at risk.

Table 3-5. Extract from NPWS (2021) Conservation Objectives: River Boyne and River Blackwater SAC.

Qualifying Interests

**** indicates a priority habitat under the Habitats Directive***

002299	River Boyne and River Blackwater SAC
1099	River Lamprey *Lampetra fluviatilis*
1106	Salmon *Salmo salar*
1355	Otter *Lutra lutra*
7230	Alkaline fens
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)*

Please note that this SAC overlaps with Boyne Estuary SPA (004080) and River Boyne and River Blackwater SPA (004232). The SAC is also adjacent to Boyne Coast and Estuary SAC (001957). The conservation objectives for this site should be used in conjunction with those for the overlapping and adjacent sites as appropriate.

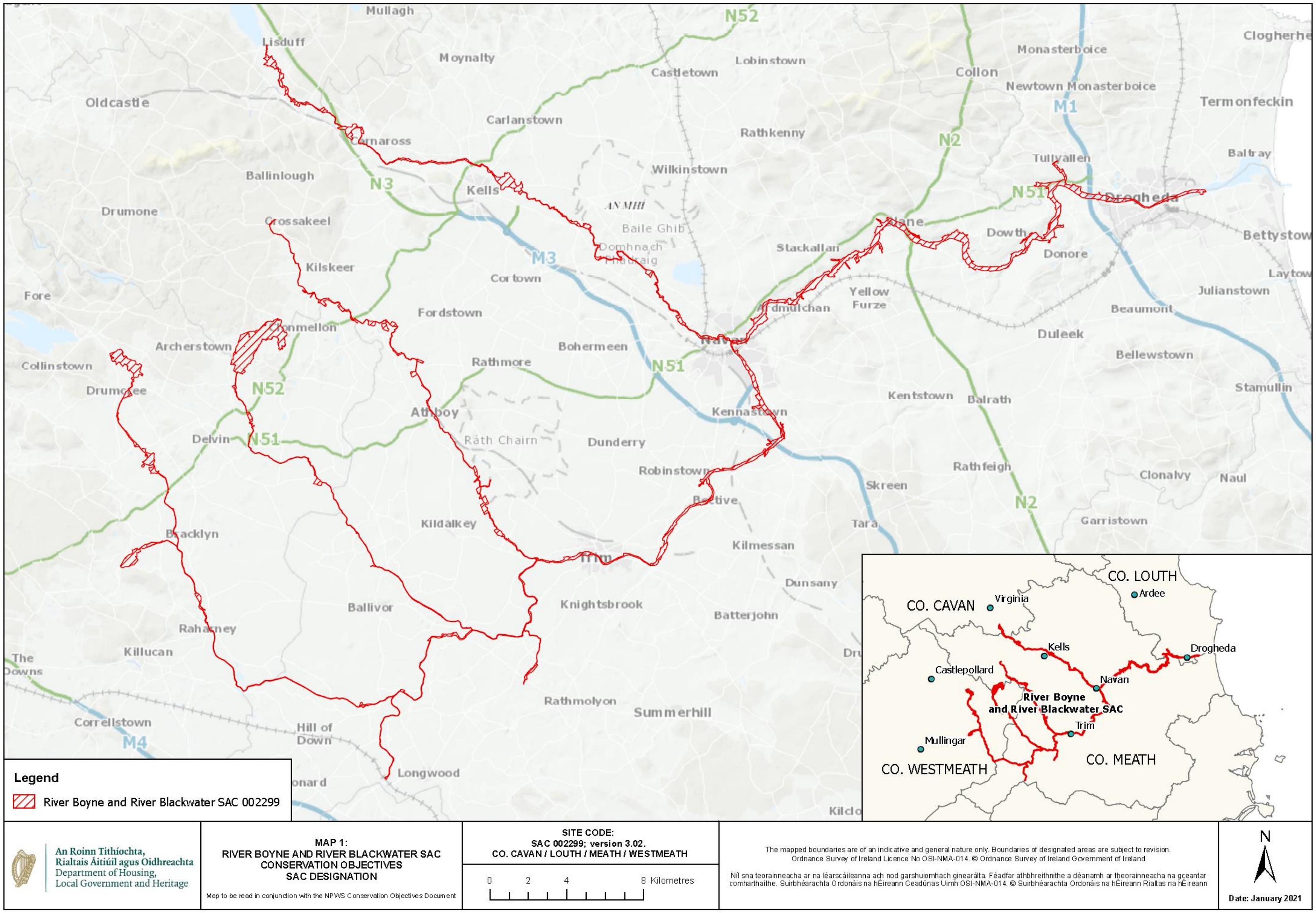


Figure 3-9. River Boyne and River Blackwater SAC conservation objectives, SAC Designation.

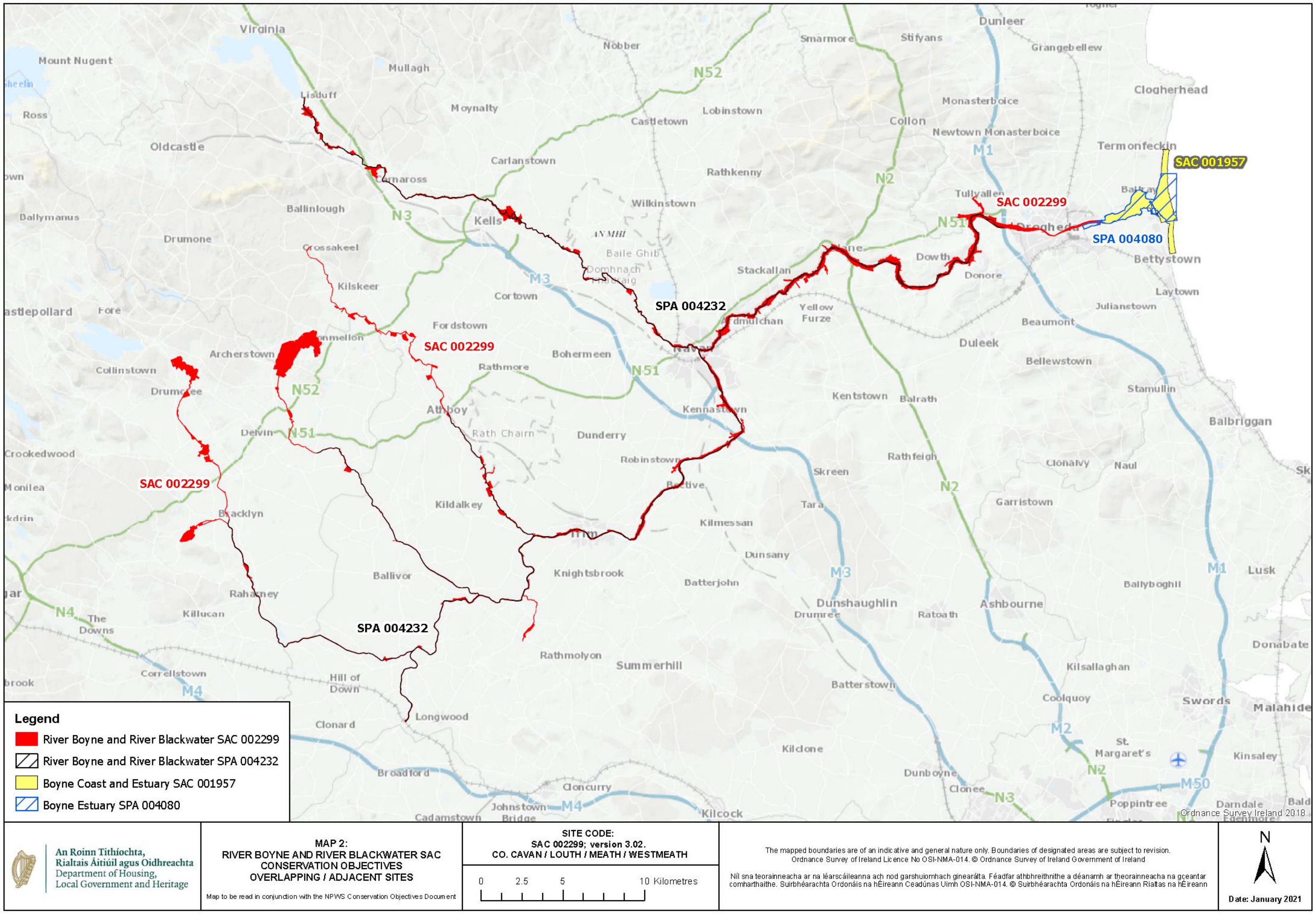


Figure 3-10. River Boyne and River Blackwater SAC conservation objectives overlapping/adjacent sites.

Salmonid Waters

The River Boyne is a designated Salmonid Water under the E.U. Freshwater Fish Directive. The relevant section for the current purposes is that from the confluence of the Blackwater (Kells) and on to the Boyne Estuary (Figure 3-11). The Blackwater (Kells) River is not designated under S.I. No. 293/1988 – European Communities (Quality of Salmonid Waters) Regulations, 1988.

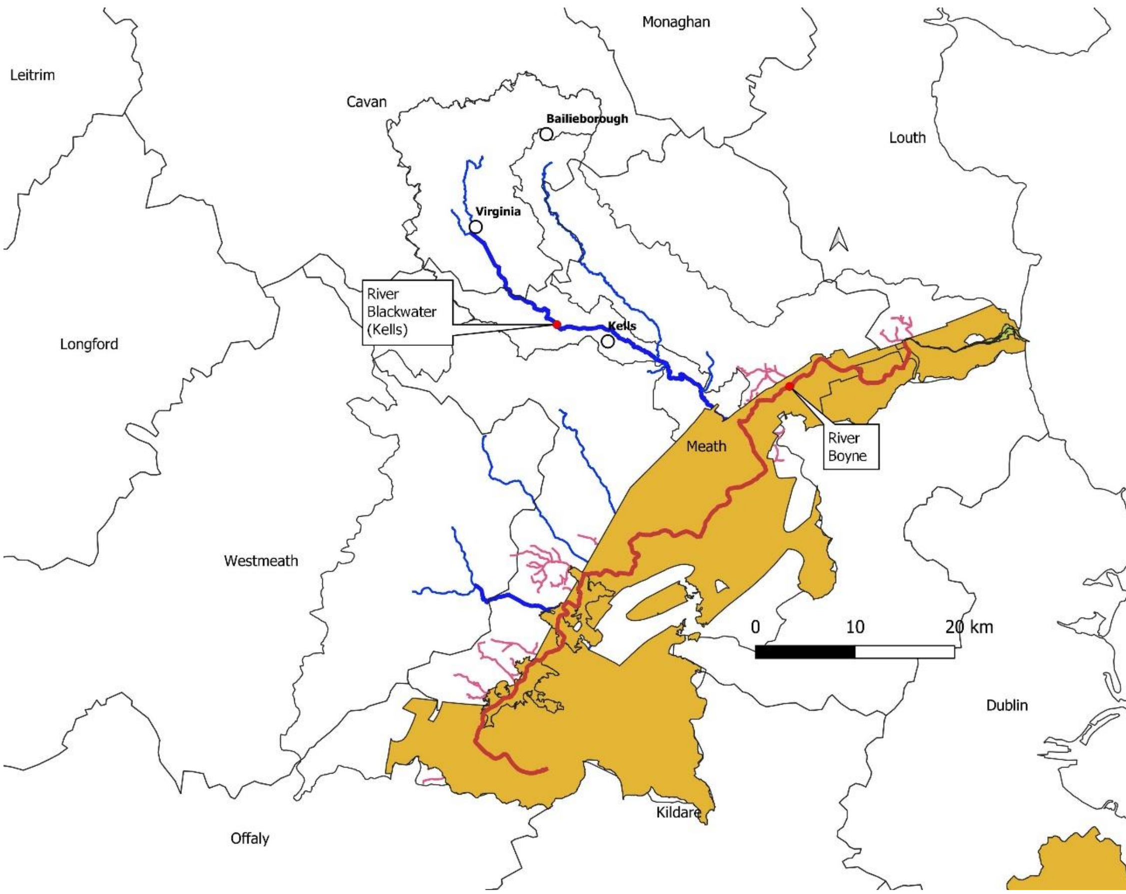


Figure 3-11. Salmonid water designation under the EU Freshwater Fish Directive (area depicted in mustard).

Designated Bathing Waters

There are no designated bathing waters in the immediate catchment likely to be impacted by Lough Ramor. In recent years; however, the practice of 'wild swimming' has become increasingly popular and it is likely that many people swim in the lake all year round.

Water Abstraction Points

There are eight industrial or agricultural water abstractions in the larger catchment area. None of these are regarded as significant in terms of the overall status and risk to the lake.

Nutrient Sensitive Areas (NSAs)

The EPA's Cycle 3 report: *HA 07 Boyne Catchment Report, May 2024* lists the following waterbodies on the River Boyne downstream of Navan: Boyne_140, Boyne_150, Boyne_160, Boyne_170 and Boyne_180 as Nutrient Sensitive Areas. The Blackwater (Kells) joins the river Boyne at the Boyne_140 waterbody – a channel length of some 37 km downstream of Lough Ramor. The Boyne Estuary is also an NSA.

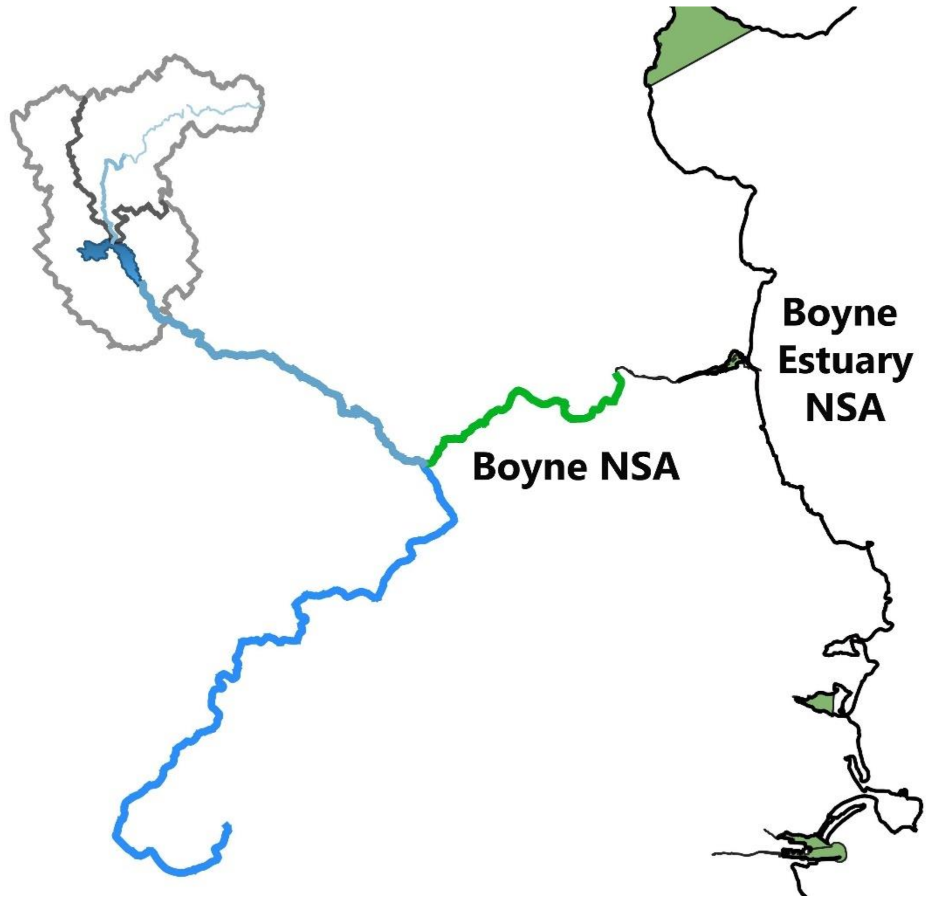


Figure 3-12. Location of River Boyne Nutrient Sensitive Area (green channel) and Boyne Estuary Nutrient Sensitive Area.

Commercial or Recreational Fishing Areas

Inland Fisheries Ireland states: "*Lough Ramor – excellent coarse fishery (800 hectares) for big hybrids, roach and bream in particular. Notable venues on this lake: Virginia, Coronagh, Knocknagartan, Foxes Point and Nine-eyed bridge.*"

The River Boyne and its tributaries are noted salmonid angling rivers. The Blackwater (Kells) joins the Boyne in Navan some 36 km downstream of Lough Ramor. The synopsis of the SAC designation for the Boyne Blackwater SAC includes the following:

> "*The Boyne and its tributaries form one of Ireland's premier game fisheries and the area offers a wide range of angling, from fishing for spring salmon and grilse to seatrout fishing and extensive brown trout fishing.*"

and

> "*The Blackwater is a medium sized limestone river which is still recovering from the effects of the arterial drainage scheme of the 1970s. Salmon stocks have not recovered to the numbers that existed pre-drainage.*"

Lough Ramor is an important site for eel (*Anguilla anguilla*) and has been the site of a scientific survey for this increasingly endangered species, organised by Inland Fisheries Ireland.

There are no commercial fisheries in the lake or downstream of Lough Ramor. There may be still some commercial salmon fishing in the Boyne Estuary, but not in the freshwater reaches of the river.

EPA Catchment Characterisation Data

Table 3-6 lists the waterbodies that are at risk in the catchment together with the pressure category – note that a waterbody may have more than one pressure category. The dominant pressures are agriculture and hydromorphology. Lough Ramor is listed under Urban Waste Water and this presumably refers to the Virginia WWTP. Waterbody risk is mapped in Figure 3-13.

Table 3-6. Waterbodies in the greater Lough Ramor catchment at risk and with significant pressures.

Waterbody Code	Waterbody Name	Type	Risk?	Pressure Category
IE_EA_07_275	Ramor	Lake	At risk	Agriculture
IE_EA_07_275	Ramor	Lake	At risk	Invasive Species
IE_EA_07_275	Ramor	Lake	At risk	Urban Waste Water
IE_EA_07_273	Nadreegeel	Lake	At risk	Agriculture
IE_EA_07B010170	BLACKWATER (KELLS)_020	River	At risk	Hydromorphology
IE_EA_07B010170	BLACKWATER (KELLS)_020	River	At risk	Urban Run-off
IE_EA_07B010170	BLACKWATER (KELLS)_020	River	At risk	Urban Waste Water
IE_EA_07B010280	BLACKWATER (KELLS)_030	River	At risk	Agriculture
IE_EA_07B010420	BLACKWATER (KELLS)_040	River	At risk	Agriculture
IE_EA_07B010420	BLACKWATER (KELLS)_040	River	At risk	Domestic Waste Water
IE_EA_07B010500	BLACKWATER (KELLS)_050	River	At risk	Agriculture
IE_EA_07B010500	BLACKWATER (KELLS)_050	River	At risk	Hydromorphology
IE_EA_07B010600	BLACKWATER (KELLS)_060	River	At risk	Agriculture
IE_EA_07B010600	BLACKWATER (KELLS)_060	River	At risk	Hydromorphology
IE_EA_07B010800	BLACKWATER (KELLS)_070	River	At risk	Anthropogenic Pressures
IE_EA_07B010800	BLACKWATER (KELLS)_070	River	At risk	Hydromorphology
IE_EA_07B011000	BLACKWATER (KELLS)_080	River	At risk	Agriculture
IE_EA_07B011000	BLACKWATER (KELLS)_080	River	At risk	Hydromorphology
IE_EA_07B011200	BLACKWATER (KELLS)_100	River	At risk	Hydromorphology
IE_EA_07B011500	BLACKWATER (KELLS)_110	River	At risk	Agriculture
IE_EA_07B011500	BLACKWATER (KELLS)_110	River	At risk	Hydromorphology
IE_EA_07B011800	BLACKWATER (KELLS)_120	River	At risk	Agriculture
IE_EA_07B011800	BLACKWATER (KELLS)_120	River	At risk	Hydromorphology
IE_EA_07B011800	BLACKWATER (KELLS)_120	River	At risk	Urban Run-off

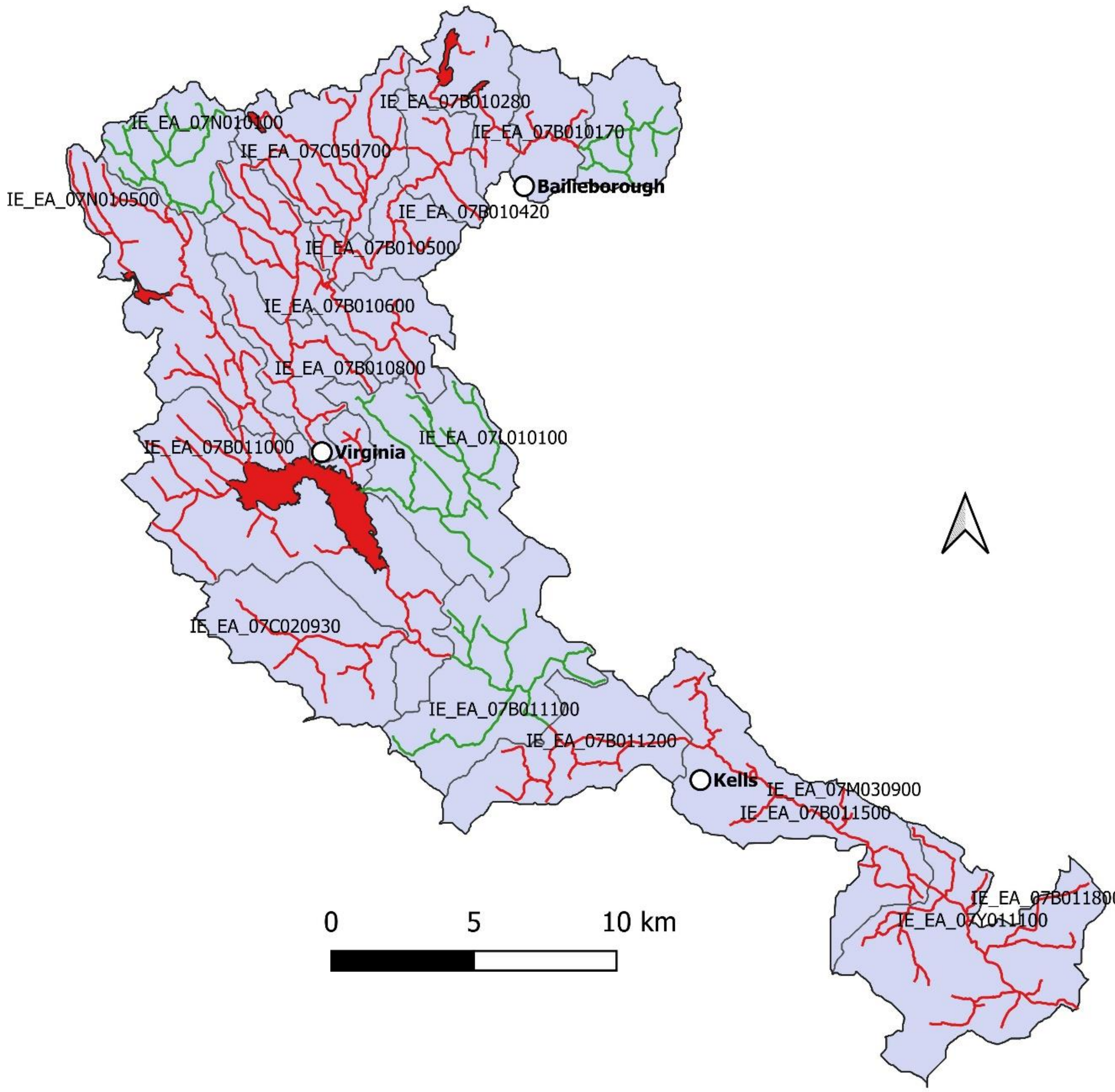


Figure 3-13. WFD risk in the greater Lough Ramor Blackwater (Kells) catchment. Red = At Risk, Green = Not at Risk.

Ecological Status of Lough Ramor and River Blackwater (Kells)

This section outlines the status of Lough Ramor and the River Blackwater (Kells) (inflowing and outflowing) for the 2016–2021 WFD cycle using data from the EPA. It also looks in detail at nitrogen and phosphorus in these waterbodies.

Lough Ramor Status: 2016–2021

Lough Ramor has improved from Bad Status in the 2010–2015 period to Poor Status in both the 2013–2018 and 2016–2021 periods (Table 3-7). It is failing on its macrophytes and total phosphorus in 2016–2021. In the 2013–2018 period it also failed on phytoplankton. In the 2010–2015 period it was assessed as Bad Status due to the condition of its macrophyte communities. It was Moderate for total phosphorus (TP) and phytoplankton in that period. In later periods the introduction of zebra mussels and their rapid growth has impacted the phytoplankton communities due to this species strongly filtering the lake water. Phytoplankton abundance has dropped sharply as a result, particularly since 2018/2019. This accounts for the 'High' Status assignment for phytoplankton in the 2016–2021 period – its assessment is based primarily on chlorophyll concentration.

Table 3-7. Lough Ramor Status 2016–2021.

Status	**Assessment Technique**	**Status Confidence**	**Value**	*
Ecological Status or Potential	Monitoring	Medium confidence	Poor	
Biological Status or Potential			Poor	
Phytoplankton Status or Potential			High	
Other Aquatic Flora Status or Potential			Poor	
Macrophyte Status or Potential			Poor	
Phytobenthos Status or Potential			Not applicable	
Invertebrate Status or Potential			Not applicable	
Fish Status or Potential			Not applicable	
Hydromorphological Conditions			Moderate	
Supporting Chemistry Conditions			Moderate	
General Conditions			Moderate	
Thermal Conditions			High	

Status	Assessment Technique	Status Confidence	Value	*
Water Temperature (C)			High	
Oxygenation Conditions			High	
Dissolved Oxygen (% Sat)			High	
Acidification Conditions			High	
pH			High	
Nutrient Conditions			Moderate	
Other determinand for nutrient conditions			High	
Nitrogen Conditions			High	
Ammonium			High	
Phosphorous Conditions			Moderate	
Total Phosphorus			Moderate	
Specific Pollutant Conditions			Not applicable	
Chemical Surface Water Status			Not applicable	

*The colour-coding used is the standard WFD classification: Blue, Green, Yellow, Orange, Red for High, Good, Moderate, Poor, Bad ecological status.

Blackwater (Kells), (L. Ramor Inflow) Status: 2016–2021

The inflowing River Blackwater (Kells) is sampled at RS07B010800, just u/s L Ramor (RHS). This is a WFD surveillance monitoring site and has been assessed on four biological elements – macroinvertebrates, macrophytes, phytobenthos and fish. It is rated at High Status for its macrophytes but Poor Status for the phytobenthos in 2016 to 2021 (Table 3-8). The macroinvertebrates were at Good Status but fish were at Moderate Status in that period. General supporting chemistry was satisfactory. The site failed on chemical status, however, based on priority substances. The reason for its chemical status failure is due to the occurrence of Benzo(k)fluoranthene at concentrations more than the relevant EQS.

Table 3-8. Blackwater (Kells) Status, Lough Ramor inflow, 2016–2021.

Status	Assessment Technique	Status Confidence	Value	*
Ecological Status or Potential	Monitoring	Medium confidence	Poor	
Biological Status or Potential			Poor	
Other Aquatic Flora Status or Potential			Poor	

Status	Assessment Technique	Status Confidence	Value	*
Macrophyte Status or Potential			High	
Phytobenthos Status or Potential			Poor	
Invertebrate Status or Potential			Good	
Fish Status or Potential			Moderate	
Supporting Chemistry Conditions			Pass	
General Conditions			Pass	
Oxygenation Conditions			Pass	
Dissolved Oxygen (% Sat)			Pass	
Other determinand for oxygenation conditions			High	
Acidification Conditions			Pass	
pH			Pass	
Nutrient Conditions			Pass	
Nitrogen Conditions			High	
Nitrate			High	
Ammonium			High	
Phosphorous Conditions			Good	
Orthophosphate			Good	
Specific Pollutant Conditions			Pass	
Chemical Surface Water Status			Fail	

*The colour-coding used is the standard WFD classification: Blue, Green, Yellow, Orange, Red for High, Good, Moderate, Poor, Bad ecological status.

Status Failures Reasons:

Benzo(k)fluoranthene Failure for Chemical Status IE_EA_07B010800

Blackwater (Kells) (L. Ramor Outflow) Status: 2016–2021

The outflowing River Blackwater (Kells) has been assessed primarily on the macroinvertebrate communities at Daly's Bridge, RS07B011000, using the EPA's Q-Value system. In the 2016–2021 and 2013–2018 periods it has been assessed as being at Moderate Status and at Poor Status in the 2010–2015 period (Table 3-9) The outflowing monitoring site was assessed as being satisfactory for nutrient conditions in the 2010–2015 period but does not appear to have been reassessed for chemistry in the two more recent periods. The chemistry monitoring for the outflow from Lough Ramor has been moved to RS07B011100, Br near Carnaross, in recent years.

Table 3-9. Blackwater(Kells) Status, Lough Ramor outflow, 2016–2021.

Status	**Assessment Technique**	**Status Confidence**	**Value**	*
Ecological Status or Potential	Monitoring	High confidence	Moderate	
Biological Status or Potential			Moderate	
Invertebrate Status or Potential			Moderate	

*The colour-coding used is the standard WFD classification: Blue, Green, Yellow, Orange, Red for High, Good, Moderate, Poor, Bad ecological status.

Waterbody Objectives

The four waterbodies under consideration, Blackwater_07 (IE_EA_07B010800**)**, Lough Ramor (IE_EA_07_275), Blackwater_08 (IE_EA_07B011000)and Blackwater_09 (IE_EA_07B011100) are all at risk and none have a High Status Objective. Good Status is the objective for all four waterbodies.

Phosphorus and Ammonia Concentrations

Lough Ramor

Environmental quality standards (EQS) have been set for ammonia (rivers and lakes) and ortho-phosphate or molybdate reactive phosphorus (MRP) (rivers) and for total phosphorus (TP) in lakes. It is important therefore to examine the status of Lough Ramor and the inflowing and outflowing River Blackwater (Kells) in terms of these N and P determinands and any potential impact of the upgraded WWTP. More detailed modelling is being carried out to provide a more comprehensive understanding of the likely impact of the WWTP on the lake and other receiving waters – particularly when the WWTP is considered in isolation from other pressures on the lake. This modelling is reported on separately. The section here gives a brief overview of ammonia and phosphorus concentrations.

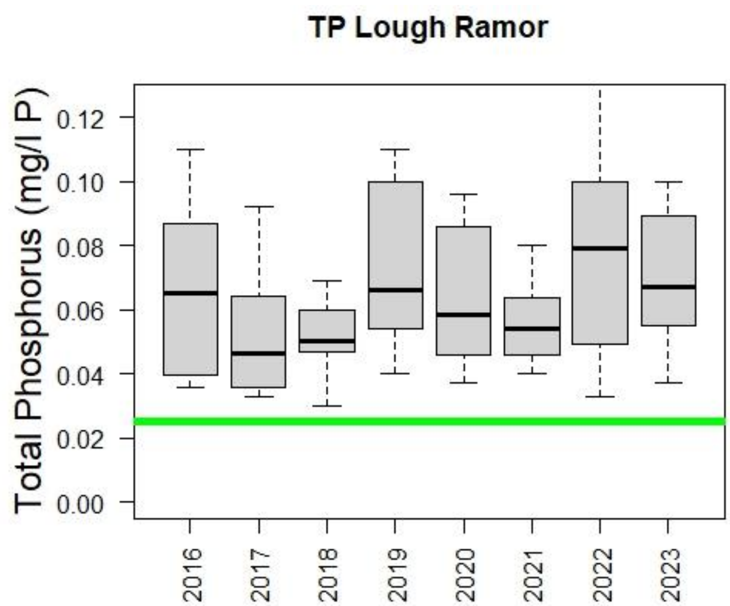


Figure 3-14. Annually averaged total phosphorus concentrations in Lough Ramor 2016 to Oct 2023. The black bar is the median concentration. The shaded box represents the 25%ile to 75%ile band. The green line is the EQS boundary for TP at good status.

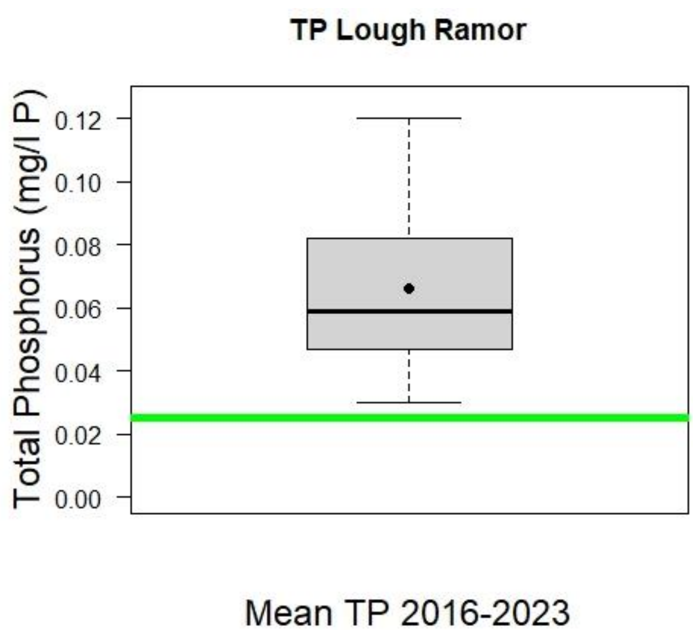


Figure 3-15. Averaged total phosphorus (TP) in L. Ramor 2016 to 2023. The central dot represents the mean and the black bar the median concentration. The shaded box represents the 25%ile to 75%ile band. The green line is the EQS for good status for TP in lakes.

Figure 3-14 gives spatially and temporally averaged TP concentrations for Lough Ramor for each year of the 2016–2023 period. The shaded boxes represent quartiles (25% to 75%iles), the black line is the median value and the green line is the EQS for TP. Figure 3-15 gives the range and mean value (black dot) for the entire period. The mean TP is 0.066 mg/l – which is significantly greater than the good status environmental quality standard for lake TP of 0.025 mg/l P. The inflowing Blackwater (Kells) has high TP concentrations suggesting that it is the main reason for the high in-lake TP concentrations (see Figure 3-21 and Figure 3-22).

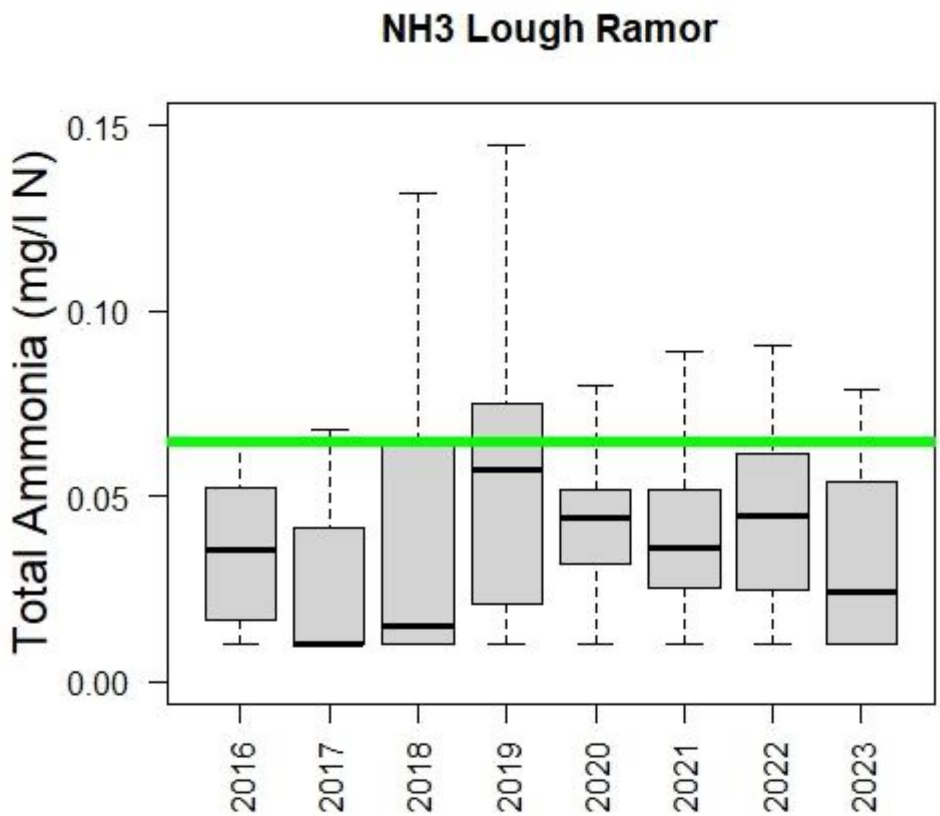


Figure 3-16. Annually averaged ammonia concentrations in Lough Ramor 2016 to Oct 2023. The green line is the EQS boundary for ammonia at good status.

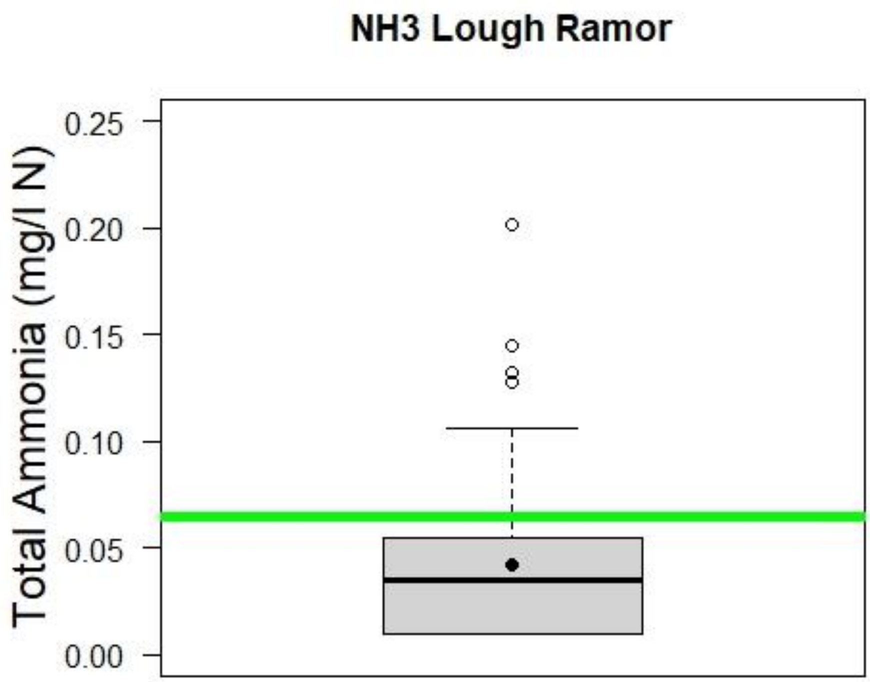


Figure 3-17. Lough Ramor total ammonia averaged over 2016 to 2023. The green line is the EQS for good status and the black dot is the mean concentration (0.042 mg/l N).

Figure 3-16 gives the annually averaged ammonia concentrations in the lake and Figure 3-17 shows quartiles, median and mean value for the full period – the mean concentration is 0.042 mg/l N and this is below the EQS of 0.065 mg/l and only slightly above the High Status EQS of 0.04.

Thus, the main issue appears to be high phosphorus concentrations in the lake.

Inflowing Phosphorus and Ammonia

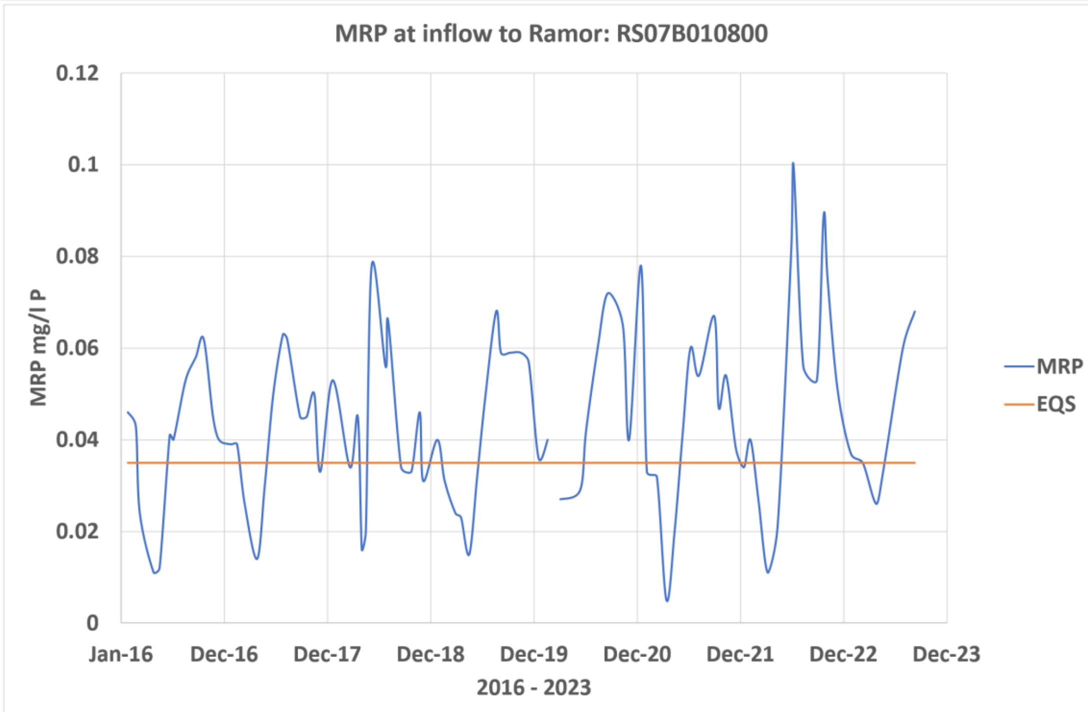


Figure 3-18. MRP concentrations in the inflowing Blackwater (Kells) River at RS07B010800.

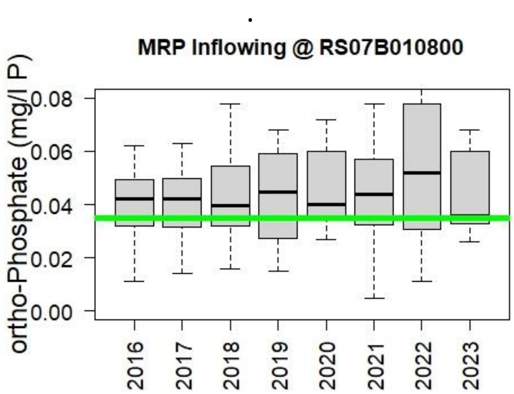


Figure 3-19. Annual averaged MRP concentrations in the inflowing Blackwater (Kells) River at RS07B010800.

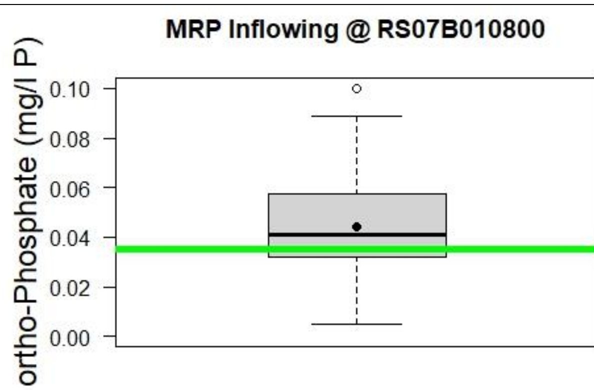


Figure 3-20. Averaged MRP concentration range for 2016 to 2023 in the inflowing Blackwater (Kells) River – with a mean value of 0.044 mg/l P.

The inflowing MRP concentrations in the Blackwater (Kells) just upstream of Lough Ramor (RS07B010800) are graphed in Figure 3-18, Figure 3-19 and Figure 3-20. The mean concentration for the full period is 0.044 mg/l P, which is above the mean EQS of 0.035 mg/l P. A note is required here because the official 2016–2021 status for phosphorus is classified as Good (Table 3-8). The corresponding mean value for 2016–2021 is 0.42 mg/l, which is also above the mean EQS, but the 95%ile concentration was 0.69 mg/l which is below the 95%ile EQS of 0.75 mg/l. The EPA requires that both the mean and 95%ile concentrations must fail against both EQS thresholds before the overall phosphorus condition for the river is deemed to have failed. This is a technical statistical approach to balancing the biological elements against the supporting nutrient conditions specified in Annex V of the WFD (2000/60/EC). The biological elements are the more important elements of ecological status and it was seen as important not to have failures of supporting chemistry conditions when the biological elements were satisfactory. The biological monitoring results for site 07B010800 on the Blackwater (Kells) classified the site as Good in 2015, Moderate in 2018 and Good in 2020, the last year for which results were available at the time of writing.

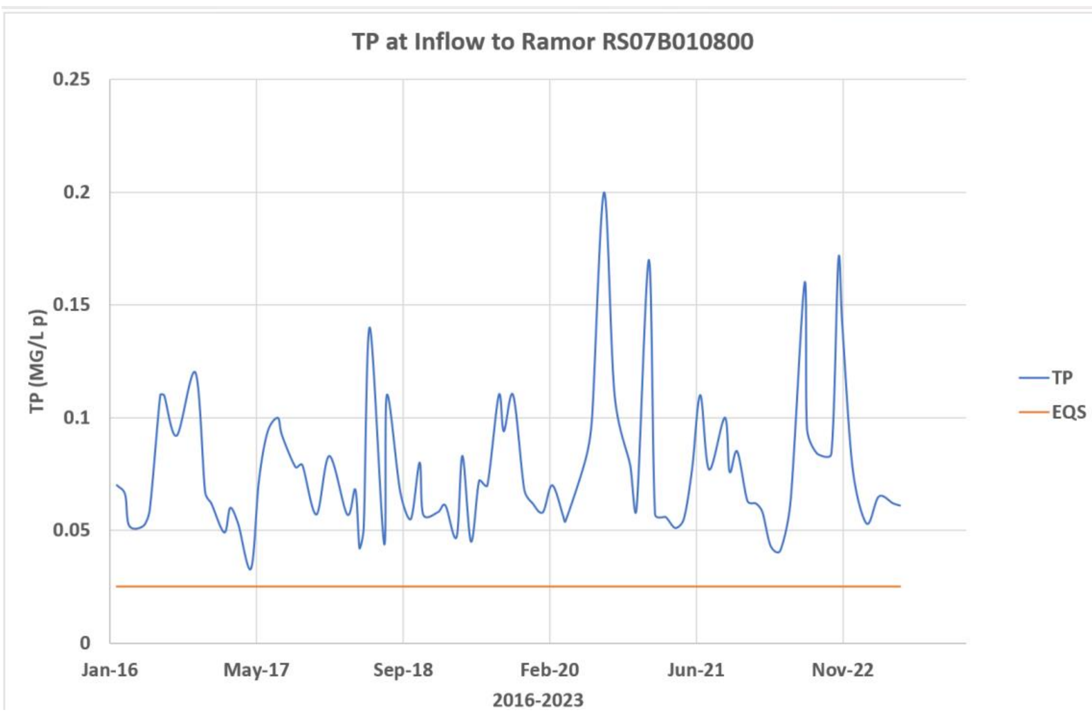


Figure 3-21. Inflowing total phosphorus concentrations at RS07B010800, just upstream of L. Ramor. The EQS shown is the EQS for lakes at 0.025 mg/l for Good status.

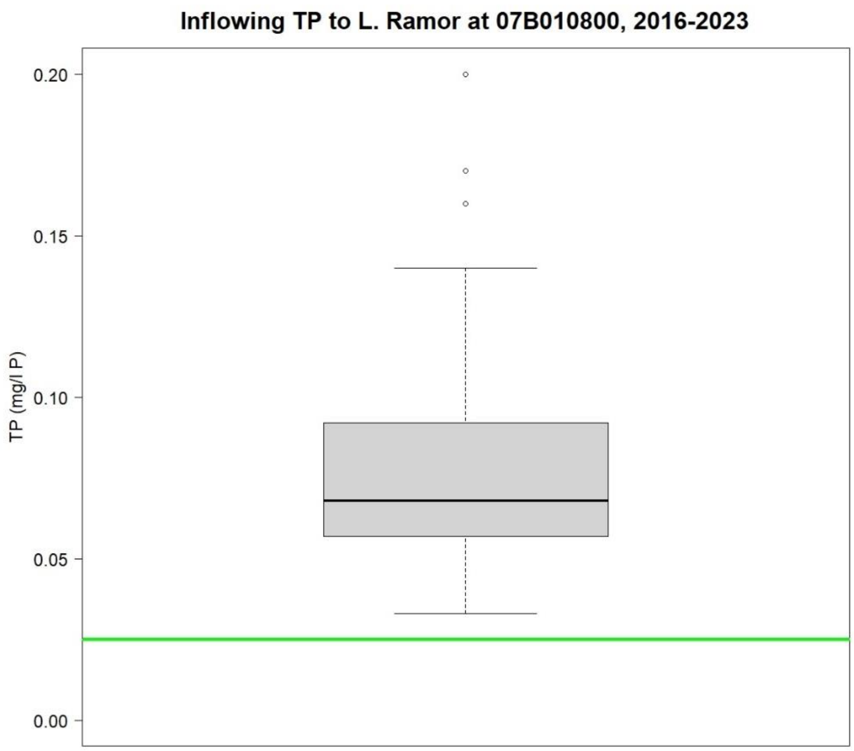


Figure 3-22. Inflowing total phosphorus concentration ranges over the period 2016–2023, just upstream of L. Ramor at 07B010800. The green line at 0.025 is the EQS for lakes.

Figure 3-21 and Figure 3-22 show the inflowing total phosphorus concentrations at the same site on the Blackwater (Kells) River just upstream of Lough Ramor for 2016–2023. This site is a Surveillance Monitoring site and covers many parameters not measured in the Operational Monitoring Programme, including total phosphorus. The results are compared to the EQS for lakes at 0.025 mg/l. As the Blackwater (Kells) accounts for approximately half of the volumetric inflow to the lake this impacts the total phosphorus levels in the lake. The mean inflowing concentration over the period is 0.78 mg/l P.

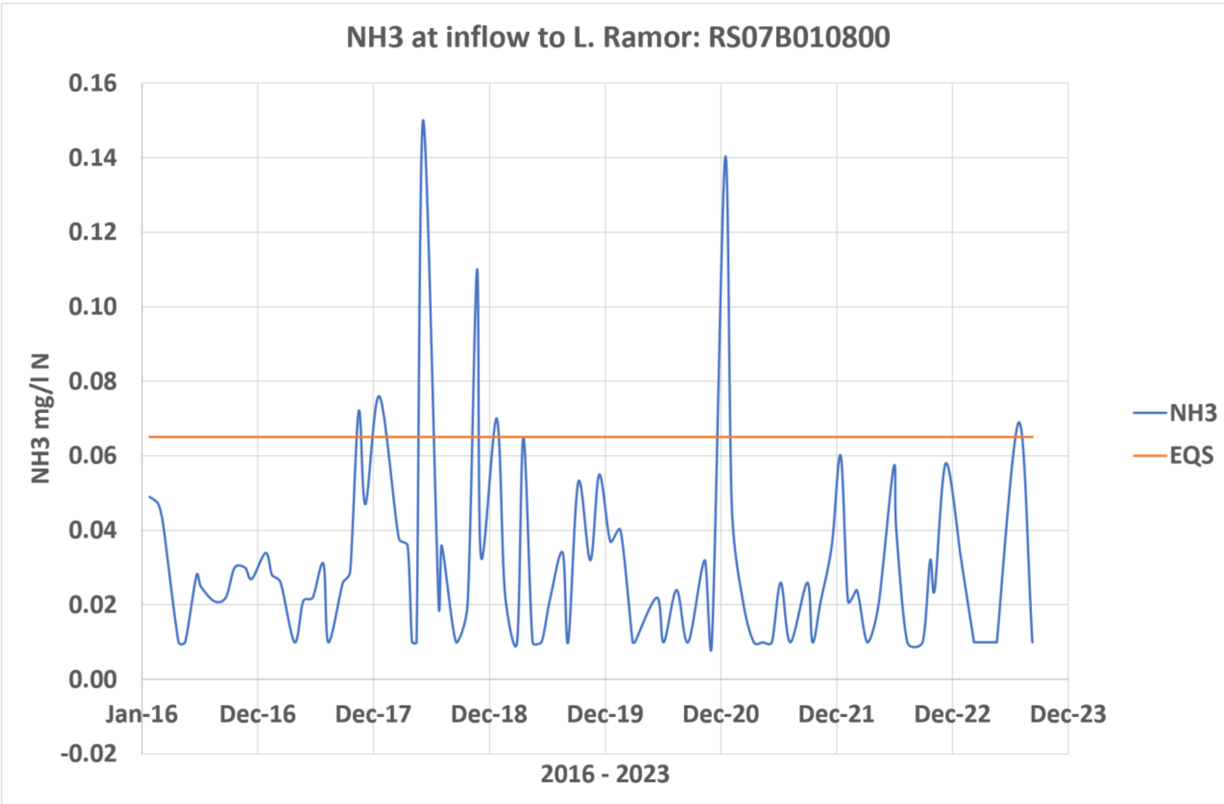


Figure 3-23. NH_3 concentrations in the inflowing Blackwater (Kells) River at RS07B010800.

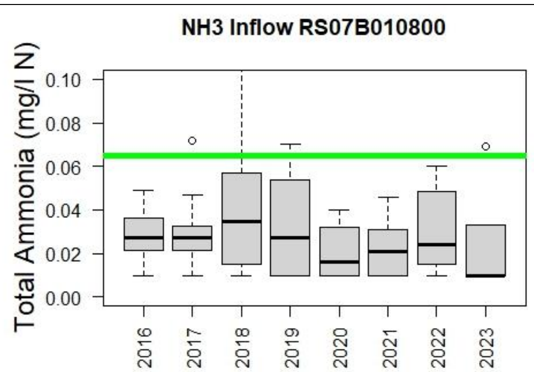


Figure 3-24. Annual averaged NH_3 concentration ranges in the inflowing Blackwater (Kells) River at RS07B010800.

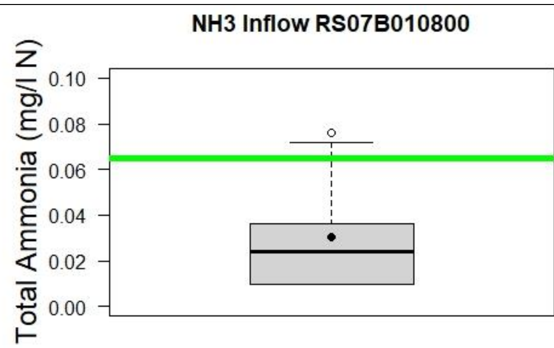


Figure 3-25. Averaged NH_3 concentration range for 2016–2023 in the inflowing Blackwater (Kells) River with a mean value of 0.030 mg/l N.

The inflowing ammonia concentrations are shown in Figure 3-23, Figure 3-24 and Figure 3-25. The overall mean NH_3 concentration for the period is 0.030 mg/l N, which is significantly lower than the EQS of 0.065 mg/l N.

Note on TP versus MRP in Rivers and Lakes

When comparing the in-lake TP with the inflowing and outflowing MRP concentrations an adjustment must be made because MRP is not always measured in lake water samples and TP is not usually measured in rivers. In a lake the phytoplanktonic algae will typically absorb all available free ortho-phosphate such that measuring MRP may give a false impression of nutrient status. If MRP measurements in a lake show concentrations above the level of detection it is likely that the system has sufficient phosphorus and another element is limiting. Laboratory experiments with P-limited algal cultures demonstrate that uptake of phosphorus is very rapid when available phosphate is added to the culture. Measuring TP, however, includes the phosphorus in the algal cells.

Typically, Irish rivers do not have phytoplanktonic algae as the time of travel is too fast – i.e. faster than the normal reproduction time for an algal cell of a day or more. MRP is a sub-fraction of TP and here an estimate is made based on an examination of the EDENIreland.ie datasets for river and lake monitoring. For 4,063 lake samples with both MRP and TP measured in the same sample, MRP accounted for 39.8% of TP and for 1,640 river samples MRP comprised 43.5% of TP. In contrast, a study of the Lough Ramor feeder streams in 1976 and 1977 by An Foras Forbartha gave a figure very close to 50% in both years – but there may be changes in the nature of run-off in the past 40+ years. If the 39.8% figure is used the TP in the outflowing Blackwater (Kells) would be 0.078 mg/l and similarly the 0.044 mg/l MRP converts to 0.100 mg/l P as TP if MRP accounts for 43.5% of TP in the inflowing river. The former, however, corresponds exactly to the measured mean concentration of 0.78 mg/l at the inflow sample site on the Blackwater (Kells) (see Figure 3-21 and Figure 3-22). There is a range of variation in these percentages but the mean TP of 0.066 mg/l P in the lake is not too far from these inflow and outflow concentrations.

Outflowing Phosphorus and Ammonia

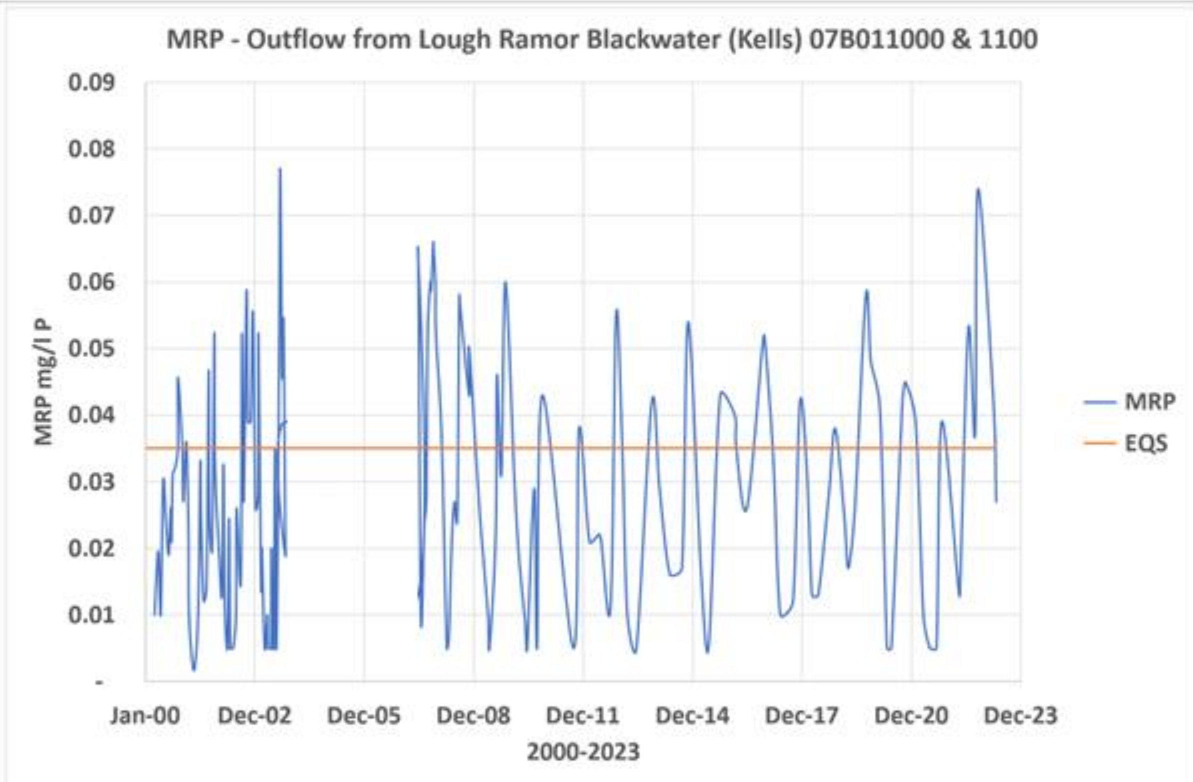


Figure 3-26. MRP concentrations in the outflowing Blackwater (Kells) River at RS07B011100.

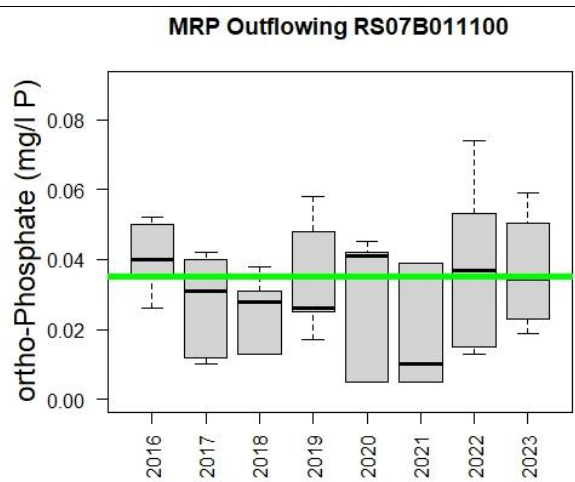


Figure 3-27. Annual averaged MRP concentrations for the outflowing site RS07B011100.

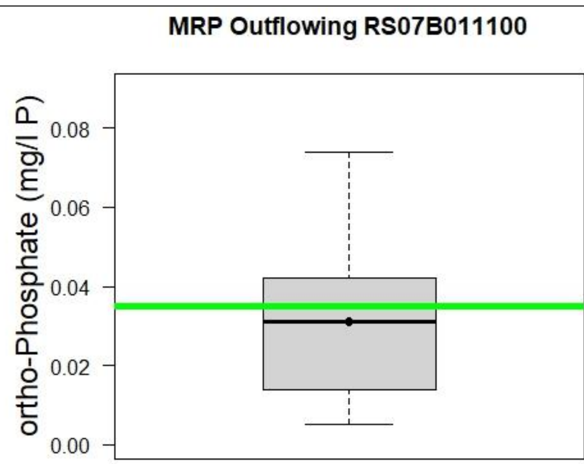


Figure 3-28. Averaged MRP concentration range for 2016–2023 with mean value 0.031 mg/l P.

The outflowing MRP concentrations in the Blackwater (Kells) at Daly's Bridge (RS07B011100) are shown in Figure 3-26, Figure 3-27 and Figure 3-28. The mean MRP concentration for the period is 0.031 mg/l P, which is less than the EQS.

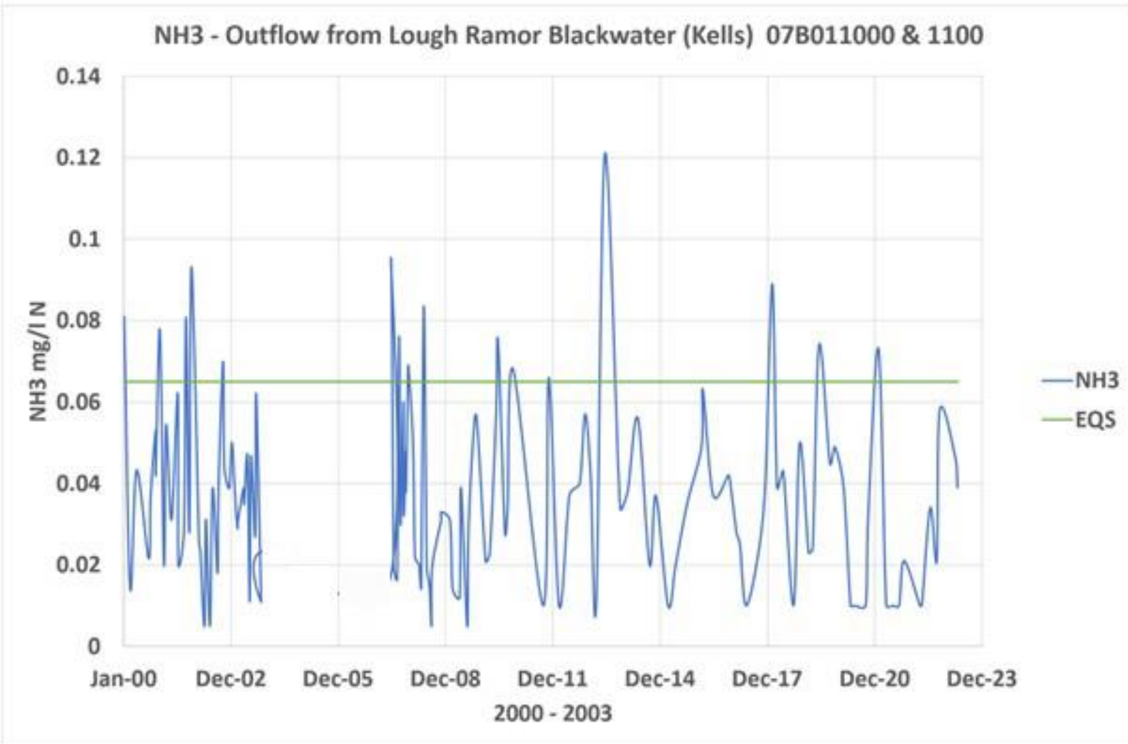


Figure 3-29. NH_3 concentrations in the outflowing Blackwater (Kells) River at RS07B011100.

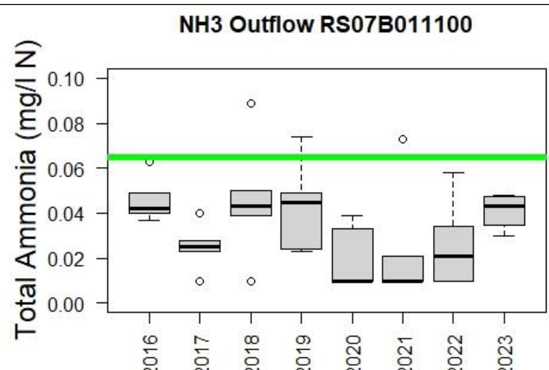


Figure 3-30. Annual averaged NH_3 concentrations for the outflowing site RS07B011100.

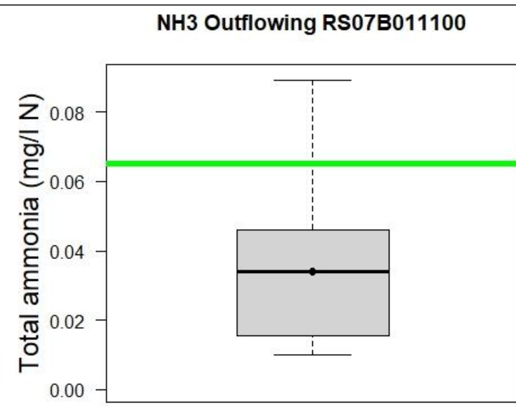


Figure 3-31. Averaged NH_3 concentration range for 2016 to 2023 with mean value 0.034 mg/l N.

The outflowing NH_3 concentrations are shown in Figure 3-29, Figure 3-30 and Figure 3-31. The mean NH_3 concentration for the 2016–2023 period is 0.034 mg/l N – lower than the mean EQS of 0.065 mg/l N.

Phytoplankton / Chlorophyll

Figure 3-32 graphs chlorophyll concentrations in Lough Ramor from 2016 to 2023. Zebra mussels (*Dreissena polymorpha*) have caused chlorophyll levels to drop quite significantly since 2019 as the population reached the stage where it filters very large amounts of water, thus reducing the phytoplankton population. This is a well-known common effect of the early stages of zebra mussel invasions (e.g. Fahnenstiel et al. 1995). Zebra mussels were introduced to Ireland in the mid to late 1990s.

Total phosphorus levels in the lake have remained high, indicating that the reduction in chlorophyll is not a response to reduced nutrient inputs. Chlorophyll concentrations are further considered in the development of the 2D model for Lough Ramor in the section: Water Quality Module – Set-up and Boundary Conditions.

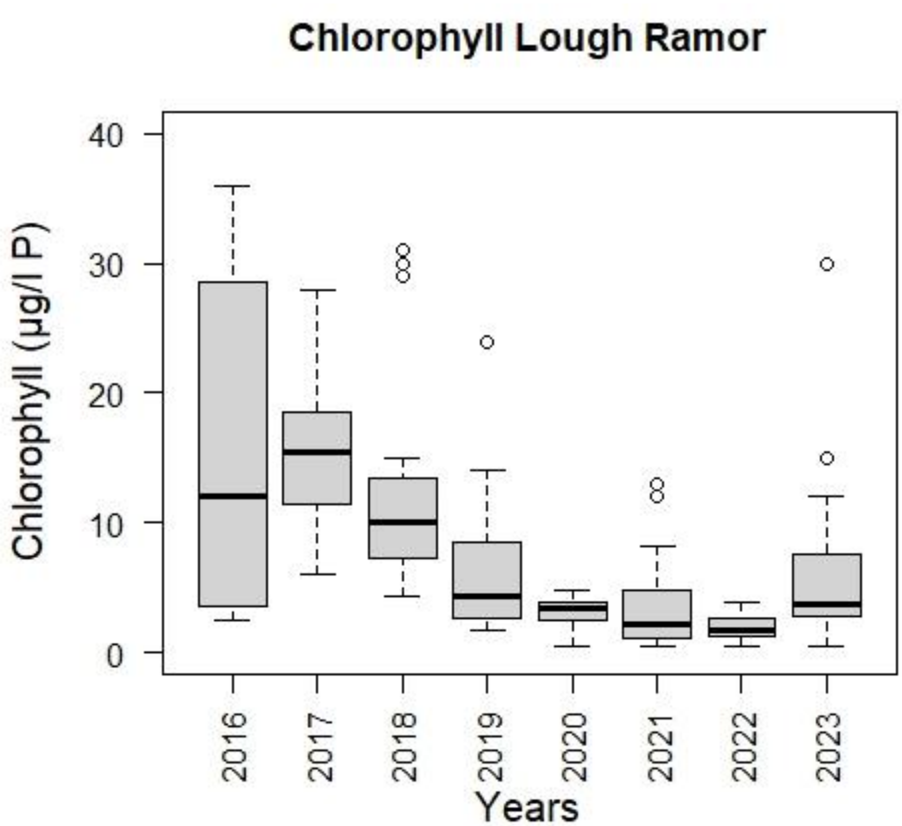


Figure 3-32. Chlorophyll in Lough Ramor 2016–2023.

4. WATER QUALITY MODELLING

Introduction

The WWTP for Virginia, Co. Cavan, currently treats wastewater from a PE of 3,800; it is proposed to upgrade the plant to treat a PE of 6,000. The WWTP discharges treated effluent into Lough Ramor; the discharge point is some 330 m offshore at 260521E, 286736N, see yellow star in Figure 4-1. Details of current and proposed hydraulic discharges and discharge chemistry are presented later.

MSN Hydro International Ltd. was commissioned to undertake a mixing zone assessment associated with the proposed upgraded discharge using a numerical modelling approach. MSN Hydro staff have considerable experience in water quality modelling in Irish and UK waterbodies. They have completed over 50 hydraulic and water quality modelling studies. The assessment, carried out in conjunction with Limnos Consultancy and with assistance from the University of Galway, determines the extent, if any, of the mixing zones around the outfall for a number of scenarios based on concentrations of ammonia and TP in the lake.

Water quality is monitored in the lake. The closest water quality monitoring points on the lake to the discharge point are Ramor Stations 2, 3 and 5 at locations detailed in Table 4-1 and shown on Figure 4-1.

Table 4-1. Coordinates of lake monitoring stations closest to discharge point.

Station	X	Y
Ramor Station 2	259500	286700
Ramor Station 3	260800	286700
Ramor Station 5	261298	286610

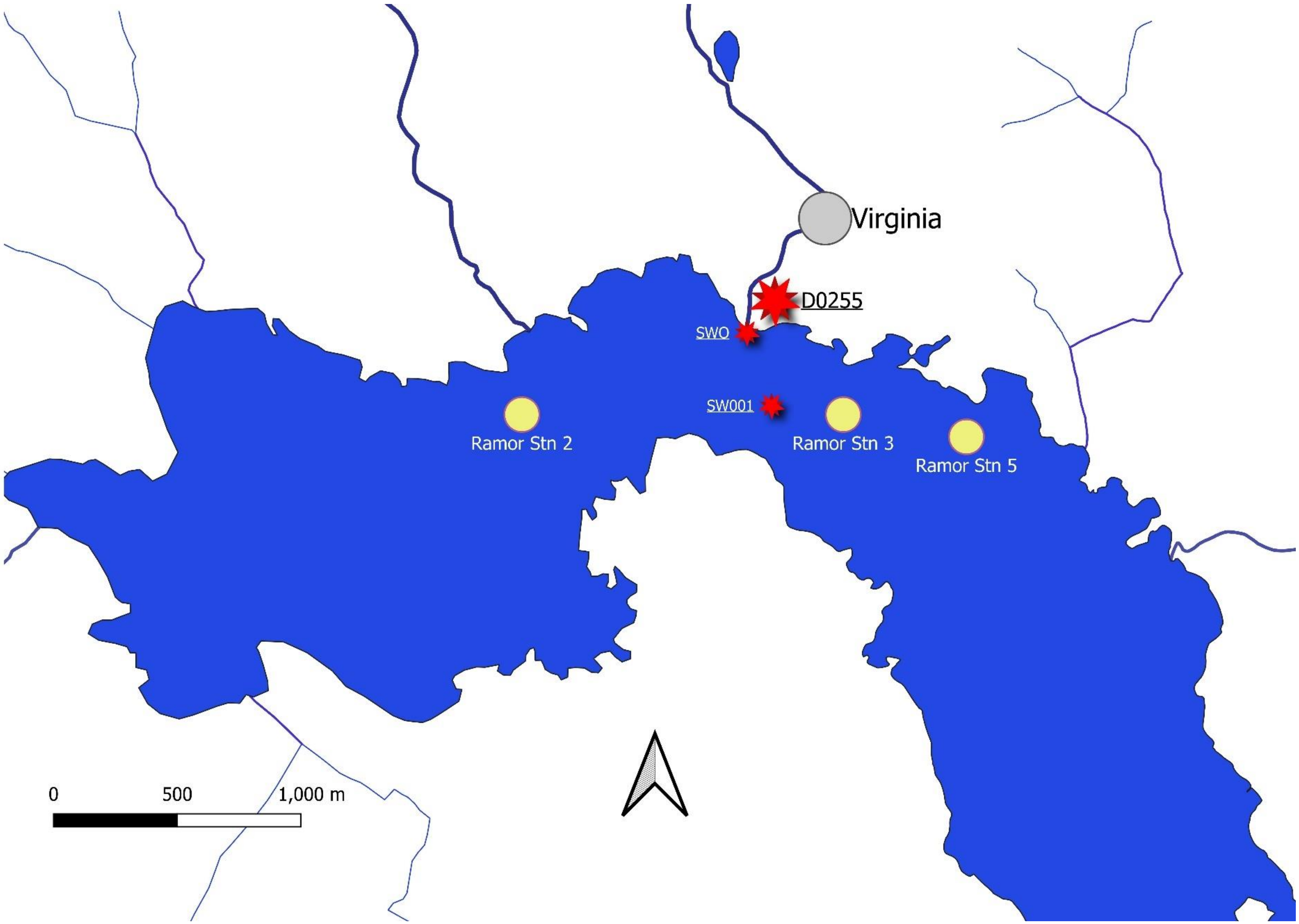


Figure 4-1. Location of lake monitoring stations closest to the discharge point SW001.

Mixing zone assessments are based on the Common Implement Strategy (CIS) recommendations. A Tier 2 assessment, undertaken by applying the Discharge Test, has already been carried out by others to assess the plant at Virginia. Details of the previous Tier 2 assessment and a summary of the tiered approach is presented below in the section: Mixing Zone Assessment Methodology.

Study Area

Lough Ramor is a relatively large natural lake located near Virginia, County Cavan, having a surface area of approximately 7.37 km^2 and draining a catchment of about 248 km^2. The lake is relatively shallow with an average depth of approximately 3.6 m; 78% of the lake's surface area and 87% of the lake's total volume are less than 4m deep.

There are several rivers discharging into the lake; these are shown in Figure 4-2 below. The largest of the inflowing rivers is the Upper Kells-Blackwater; this drains almost 50% of the catchment and enters the lake on the north-east shore at Virginia. The Nadreegeel River is the next most significant river discharging into the lake, and it enters the lake just a few kilometres to the west of Virginia. The Lislea River, which is quite a small river, discharges into the lake a few kilometres to the east of Virginia. The lake is drained by the Kells-Blackwater at its south-eastern boundary.

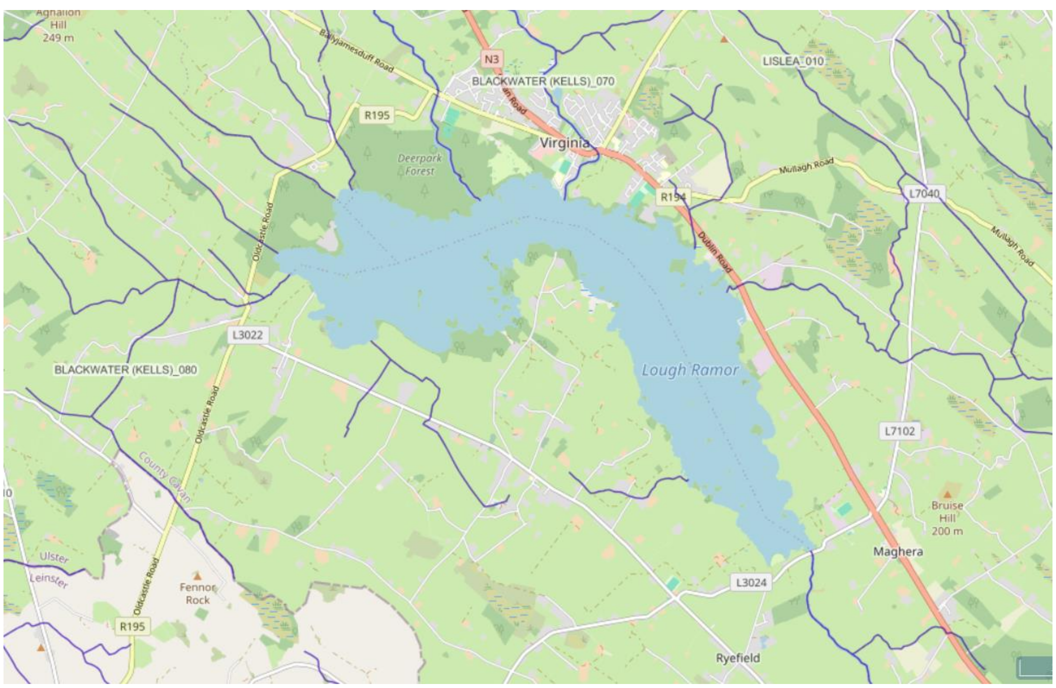


Figure 4-2. Lough Ramor and associated rivers/streams (Source: https://gis.epa.ie/EPAMaps/Water).

Timeseries for some water chemistry parameters for the inflowing and outflowing Kells-Blackwater are given in the section: Phosphorus and Ammonia Concentrations and graphed in Figure 3-18 to Figure 3-26.

The inputs to the lake are from the inflowing rivers, the wastewater treatment plant at Virginia and discharge from the Glanbia milk processing plant on the eastern shore of the lake. There are other licensed discharges to water in the larger catchment region (see section Licensed Discharges in the Catchment).

The gauge at the outflow does not have a consistent, long-term rating curve but the lake level gauge near Virginia provided a continuous record of the lake surface level relative to the Poolbeg OD. Meteorological conditions were obtained from Met Éireann's Weather Station at Mullingar.

WFD water chemistry monitoring data were available for the lake and the inflowing Kells Blackwater and Nadreegeel rivers. Lough Ramor is sampled typically four times per annum at some five stations. The lake is at poor ecological status in part due to high phosphorus and ammonia levels – which are both failing to meet the EQS for good status in lakes in recent years. Timeseries data for the lake ammonia and phosphorus concentrations are given in Figure 3-14 to Figure 3-17.

A 2-dimensional model of Lough Ramor was developed and applied to perform a Tier 3 mixing zone assessment; the industry standard model MIKE21 was used in this analysis. The Lough Ramor model comprises of 2 modules:

1. Hydrodynamic module
2. Transport and Water quality module

The spatial extent of the Lough Ramor model is shown in Figure 4-3.

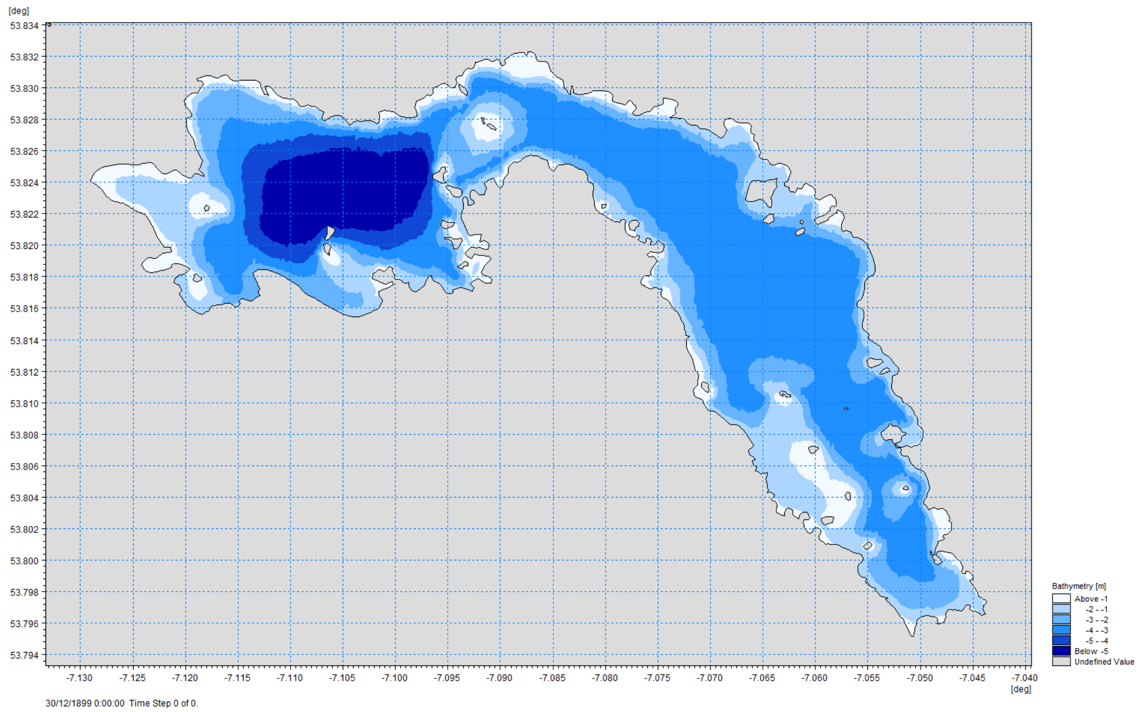


Figure 4-3. Contour map showing extents of Lough Ramor model.

The hydrodynamic module was used to calculate water circulation patterns (currents) in Lough Ramor, due to river inflows, outflows and wind. Using these currents, the water quality and transport module was used to determine the transport of pollutants introduced into Lough Ramor from rivers, the WWTP and effluent from the Glanbia outfall. Results were analysed to determine if mixing zones exist and their extents for a series of simulations.

In particular, the hydrodynamic module was used to simulate (1) mean flow and (2) low flow (95 percentile) conditions and resulting hydrodynamic circulation within the lake. These conditions were used to drive the water quality module in order to determine mixing zone extents with respect to mean and 95%ile EQS targets for existing and future scenarios of contaminants being introduced to the lake from outfalls and river sources.

Assessments were also undertaken to assess water quality impacts due to full flow to treatment.

Mixing Zone Assessment Methodology

A mixing zone is delineated by the area in the immediate vicinity of a discharge within which an applicable EQS target is not met. A mixing plume is the area in the vicinity of a discharge where significant mixing and dilution is occurring at concentration levels that are compliant with applicable EQS targets. The CIS for supporting the implementation of the WFD developed two documents relating to assessment of mixing zones: (1) Technical Guidance on Identification of Mixing Zones and (2) Technical Background on Identification of Mixing Zones, (European Union, 2010a and European Union, 2010b). The above two documents set out a tiered approach to identifying mixing zones in different waterbody types. The approach is based on a 5-tiered hierarchical structure. The purpose of the assessment is to establish if a mixing zone is required, and then to determine its size and acceptability.

The tiered approach may be summarised as follows:

Tier 0 Contaminant of Concern (CoC) present or not

Tier 0 is a high-level filter designed to identify the presence of discharges with the potential to cause EQS exceedance for CoC.

Tier 1 Initial Screening

Tier 1 is designed to establish whether the discharges identified in Tier 0 require further attention, and to remove from further consideration those discharges that are trivial using simple tests.

Tier 2 Simple approximation

The purpose of Tier 2 assessment is to identify those discharges that are clearly either acceptable or unacceptable on the basis of a simple case-specific assessment, using an initial conservative assessment of the size of the extent of EQS exceedance.

Tier 3 Detailed assessment

In complex cases a more detailed assessment may be required; Tier 3 provides this. Tier 3 assessment often involves the use of computer-based modelling techniques, to consider the individual circumstances for the discharge (or groups of discharges) concerned. In this tier, the approach required may be much more sophisticated than that applied at Tier 2, with detailed consideration of the spatial and temporal variation in the extent of EQS exceedance.

Tier 4 Investigative Study/Validation of the models

If, after assessment, there is still uncertainty it may be appropriate to conduct investigative studies to validate the outputs, refine the approach taken or to characterise the actual impacts occurring within extents of EQS exceedance. Where such studies illustrate a potential discrepancy with predicted outputs it may be necessary to return to the appropriate tier and check/refine the approach accordingly.

In 2022 a study was completed by Bedri (2022) to assess the assimilative capacity of Lough Ramor as part of a Tier-2 mixing zone assessment. One of the main objectives of this analysis was the estimation of length of mixing zones associated with proposed discharges from the WWTP due to a PE of 6,000.

The Discharge Test, as recommended in the CIS documentation, was used for this analysis. This test, developed by Deltares, was developed conservatively so as not to under-predict impacts on water quality due to pollutant discharges. Results from applying the Discharge Test will overestimate concentrations of contaminants in receiving waters.

The above Tier-2 study concluded that mixing zones are required for various discharges from the proposed upgrade to the WWTP at Virginia. Mixing zone lengths obtained from this study based on mean flow and low scenarios are as follows:

- 106 m for TP based on EQS (mean) 0.025mg/l – for an ELV of 0.2 mg/l
- 433 m for ammonia based on EQS (mean) 0.065mg/l - for an ELV of 1.0 mg/l
- 1,751 m for ammonia based on EQS (95%ile) 0.14mg/l - for an ELV of 1.0 mg/l

The Discharge Test Tool is relatively simplistic; for example, it does not include water chemistry reactions, detailed lake hydrodynamics, specific advection, solute transport and mixing processes, variable lake depths, river loads or other sources, such as the Glanbia plant in this instance.

In order to provide more certainty to the assessment it was decided to carry out a Tier 3 mixing zone assessment, in accordance with the CIS framework. When we compare the mass loadings of total phosphorous and ammonia from the upgraded WWTP into the lake to the mass loadings from the inflowing rivers during mean flows, we find that the wastewater discharge contributes approximately 2% of total phosphorus and 8% of ammonia. Thus, a Tier 3 assessment is appropriate. The assessment was carried out using a hydrodynamic and water quality model of the lake and entailed assessing several discharge regimes. This is a far more sophisticated approach than Tier 2 and allows for the combined assessment of river and other point source inputs to the lake. Details of the development and assessment of the lake model are presented in the section: Model Development and Assessment.

Tier 3 Assessment Methodology

The objective of the Tier 3 assessment was to determine and delineate the mixing zones for the relevant water quality parameters as set out in the surface water regulations. The following hydrodynamic and water quality model simulations were completed during the assessment.

Hydrodynamic Modelling

Three hydrodynamic simulations were performed:

1. Mean flow conditions
2. Low flow conditions – 95 percentile conditions
3. Full flow to treatment (FFT)

For the above three simulations the level of the lake was initially set at a mean lake level based on records at OPW Station 07081. Mean wind speed and directions were applied to the lake surface based on Met Éireann records at Mullingar Station. Outfall discharges were set to mean flows, except for FFT.

Mean flow and low flow conditions were simulated as EQS values for ammonia and are different for the two flow conditions. FFT was used to assess (1) the impact of the higher pollutant load on water quality, and (2) the time taken to return to mean discharge conditions.

Mean and low flow conditions were determined using the EPA's River Estimate Hydrotool (https://gis.epa.ie/EPAMaps/Water) for both mean and 95 percentile flow values; flow values are presented in Section 5 below.

The FFT scenario was performed using mean flow conditions as specified above, except that the WWTP at Virginia was increased from mean flow to a maximum discharge of 3 × Dry Weather Flow (DWF) for a 24-hour period and subsequently reduced back to mean flow.

All hydrodynamic model simulations were run until steady-state conditions prevailed. The hydrodynamics at steady state were subsequently used to drive the various transport and water quality scenario simulations.

Water Quality Modelling

The Mike21 modelling suite was applied during this project; model details are presented below in the section Model Development and Assessment.

A total of seven water quality modelling scenarios were completed. Three different discharge regimes were simulated during both mean flow and low flow conditions. A further scenario was carried out to simulate full flow to treatment (i.e. 3 × DWF) during mean flow conditions. These are summarised below and full details of the scenarios and associated input data are presented below.

Mean and Low Flow Conditions

The following three scenarios simulations were performed for both mean flow and low flow conditions:

1. Existing WWTP discharge conditions with existing in-lake water chemistry and river contaminant discharge conditions.
2. Future WWTP discharge conditions with existing in-lake water chemistry and river contaminant discharge conditions
3. Future WWTP discharge conditions with notionally clean in-lake water chemistry and river contaminant discharge conditions

The following initial and boundary conditions applied to the above scenarios:

Initial water chemistry conditions – Mean Flow and Low Flow

- Existing in-lake water chemistry based on EPA monitoring data
- Notionally clean water chemistry for lake and rivers based on 20% of EQS

Boundary conditions for water chemistry – Mean Flow

- Existing contaminant discharges based on existing WWTP mean discharge and water chemistry, and mean river flows with existing water chemistry
- Future contaminant discharges based on future WWTP mean discharge and water chemistry, and mean river flows with existing water chemistry
- Future contaminant discharges based on future WWTP mean discharge and water chemistry, and mean river discharges with notionally clean water chemistry

Boundary conditions – Low Flow

- Existing contaminant discharges based on existing WWTP mean discharge and water chemistry and low river flows with existing water chemistry
- Future contaminant discharges based on future WWTP mean discharge and ELV water chemistry and low river flows with existing water chemistry
- Future contaminant discharges based on future WWTP mean discharge and water chemistry, and low river discharges with notionally clean water chemistry

For the above scenario simulations model results were assessed for exceedances of EQS values of ammonia and total phosphorus to determine mixing zones spatial extents, if any.

Full Flow to Treatment

A full flow to treatment discharge analysis was performed. This scenario considered:

Future contaminant discharge conditions with existing in-lake water chemistry and river contaminant discharge conditions for mean flow conditions.

During this simulation, when steady state was achieved, the WWTP discharge was ramped up to 3 × DWF over a 2-h period. The 3 × DWF discharge was then maintained for 24 h; then the WWTP discharge was ramped back down to mean flow over a 2-h period.

The simulation continued until 'normal' steady-state conditions were reached – this was determined by comparison with snapshots from the second scenario above for mean flow conditions.

A comparison was carried out to assess the transient impacts of the 3 × DWF discharge on the receiving waters and to determine the time taken to return to normal plant operating impacts.

Model Development and Assessment

Details are presented here of the development and assessment of the hydrodynamic and quality modules used in the mixing zone assessment of Lough Ramor. Details of the hydrodynamic model development and assessment are presented first, followed by details of the water quality model development and assessment.

Model Software Description

The Danish Hydraulic Institute's (DHI) Mike 21 FM and accompanying Ecolab Module were used to develop the water quality model of Lough Ramor. DHI's MIKE suite of models are well-recognised industry-standard models used worldwide by engineering consultants and academic researchers to model hydrodynamic and water quality processes in coastal waters, estuaries, lakes and rivers.

The Mike 21 FM Hydrodynamic Module allows the simulation of flows and water level changes. It is a 2D model which solves the depth-integrated, incompressible, Reynolds-averaged Navier-Stokes equations. The model therefore consists of continuity, momentum, temperature, salinity and density equations. In the horizontal domain both Cartesian and spherical coordinates can be used. The spatial discretization of the primitive equations is performed using a cell-centred finite volume method. The spatial domain is discretized by subdivision into non-overlapping element/cells using an unstructured grid comprising of triangles or quadrilateral elements. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible to handle discontinuous solutions. For the time integration an explicit scheme is used.

The Mike Ecolab Module allows the simulation of the spatial distribution of water quality state variable concentrations in 2D or 3D, depending on the hydrodynamic module with which it is coupled (here a 2D module). The processes included in the module are advective transport, biological, physical and chemical transformation processes, and transport, settling and resuspension of sediment. The module allows user-specification of the state variables to be included in the model and the formulations used to represent the associated biological, chemical and settling processes. In this study, 5 state variables were included: organic nitrogen, ammonia, nitrate, organic phosphorus and orthophosphate.

Bathymetry Model

The first stage in building a water quality model is to construct a 3D bathymetric model. A lake survey was not undertaken as part of this project. A contoured map of the lake was made available to MSN Hydro; the map is presented in Figure 4-4. The map was prepared for the EPA by Compass Informatics Ltd as part of a wider Irish lake bathymetry project. Summary depth statistics were provided by the EPA but the original was not reduced to ordnance datum.

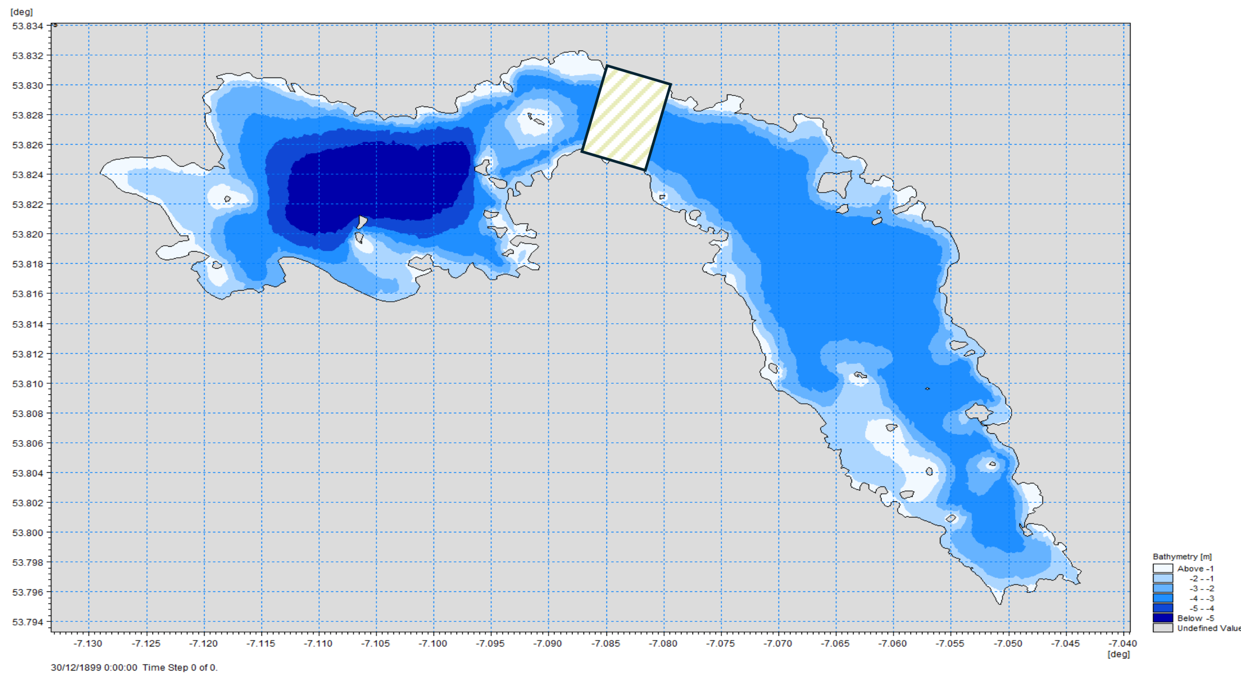


Figure 4-4. Contoured map of Lake Ramor and HSL survey location.

The above map was digitised by MSN Hydro and subsequently the contours were reduced to ordnance datum using a recent limited lake survey undertaken by Hydrographic Surveys Limited (HSL) which had been reduced to Ordnance Datum Malin. The extent of the HSL survey was localised to the area around the Virginia wastewater treatment plant discharge point. The general area of the survey is shown in the cross-hatched box in Figure 4.4 and the detailed area is shown in red in Figure 4-5.

Figure 4-5. Extent of HSL lake bathymetry survey.

The bathymetry within the area of the HSL survey is quite flat, as can be seen from Figure 4-5 and Table 4-2. Four points, shown in white in Figure 4-5, were selected to estimate an average reduced level of the lake water surface based on the contoured map in Figure 4-4. This was obtained by adding the water depths from the contour map to the reduced lakebed levels from the HSL survey at the 4 points and taking an average of the four values. The average reduced level in this region of the water surface was estimated to be 82.12 mOD (m above Ordnance Datum), see Table 4-2. Assuming the lake water surface is a horizontal plane at an elevation of 82.12 mOD, the contour map of Figure 4-4 was used to estimate the lake bathymetry reduced to mOD.

The reduced bathymetry map is shown in Figure 4-6. This map was then used in conjunction with records of water surface levels recorded in the lake and the rivers to develop the hydrodynamic and water quality models.

Table 4-2. Coordinates of lake monitoring stations closest to discharge point.

Datum Point	Longitude	Latitude	Digitised Model Depth	HSL mOD	Water Surface mOD
1	-7.081916	53.828537	-3.33	78.72	82.05
2	-7.082304	53.826937	-3.5	78.82	82.32
3	-7.081004	53.826998	-3.5	78.84	82.34
4	-7.079914	53.828463	-2.76	79.05	81.81
				Average	82.12

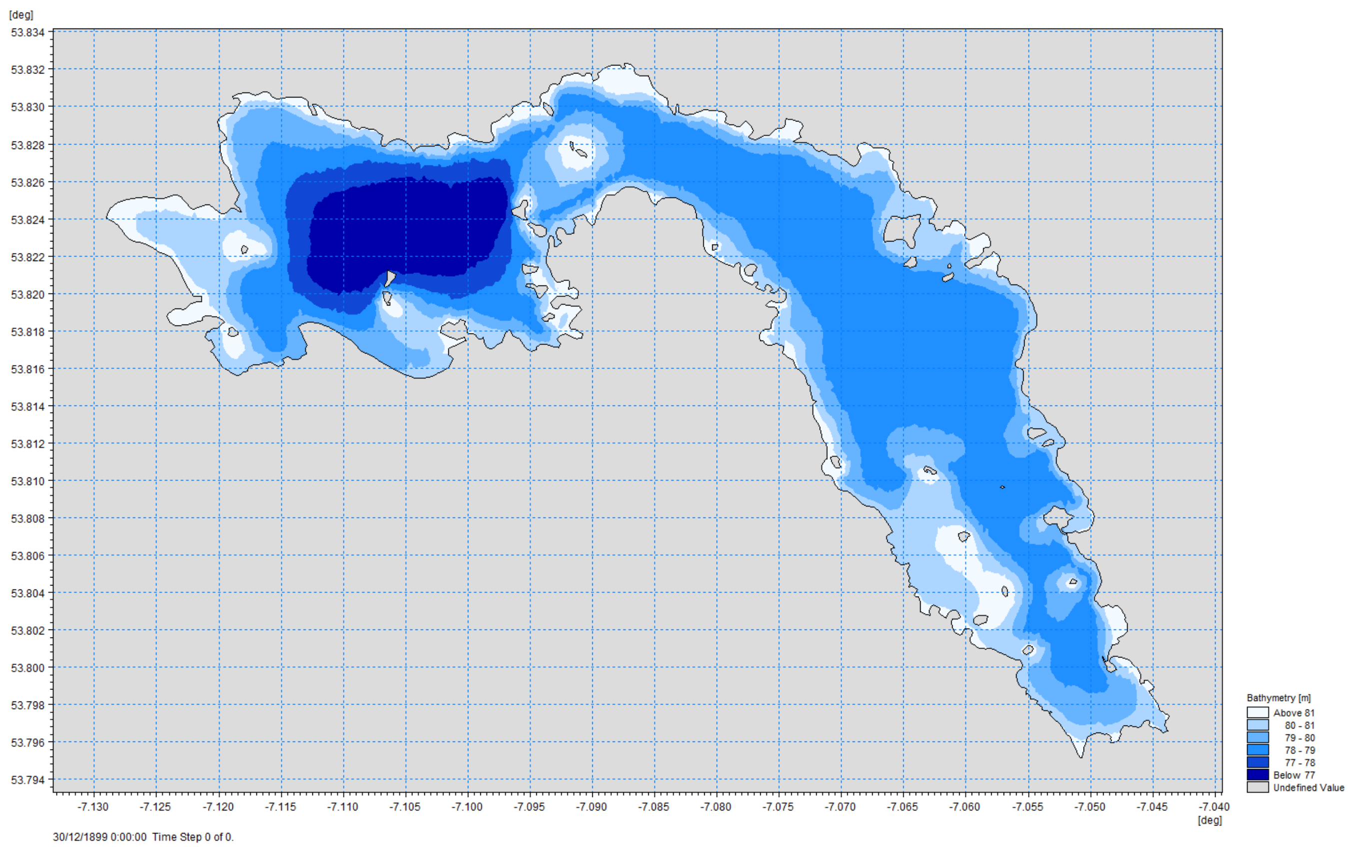


Figure 4-6. Reduced digitised bathymetry map of Lough Ramor.

The digitised map of Lough Ramor was used to develop a bathymetric model within MIKE21. A variable mesh model was developed. The spatial resolution of the mesh typically varied between 15 and 20 m, see Figure 4-7. However, around the two main rivers inflowing to the lake and discharging from the lake, the mesh resolution was further refined to between 3 and 5 m, see Figure 4-8. In total, the bathymetric model was very highly resolved and consisted of 30,994 model elements.

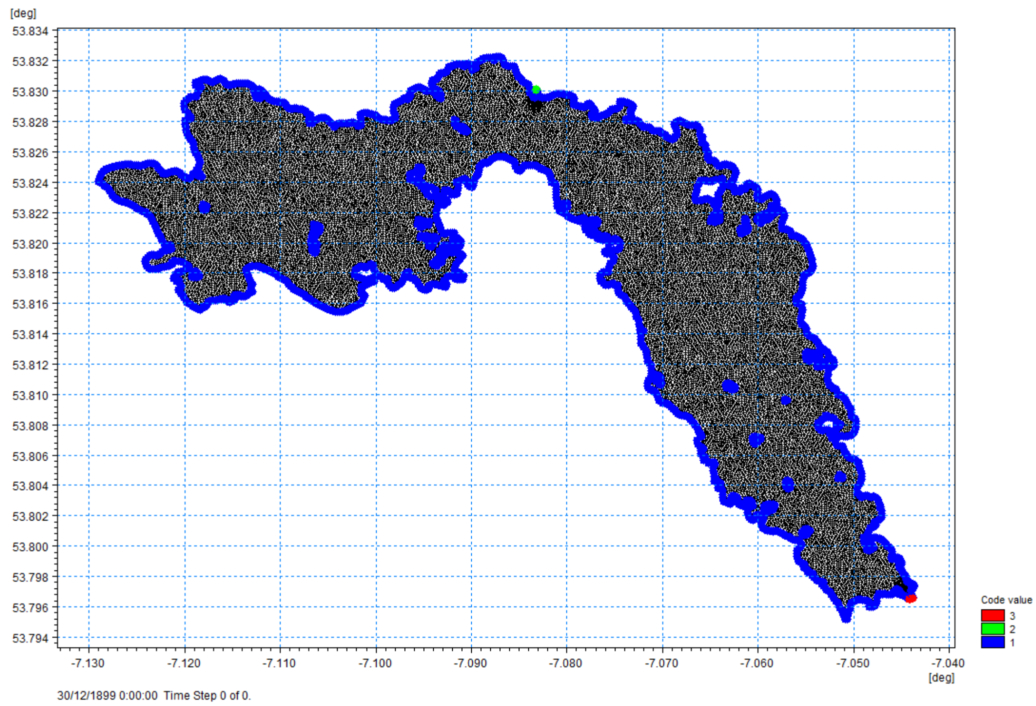


Figure 4-7. Model mesh.

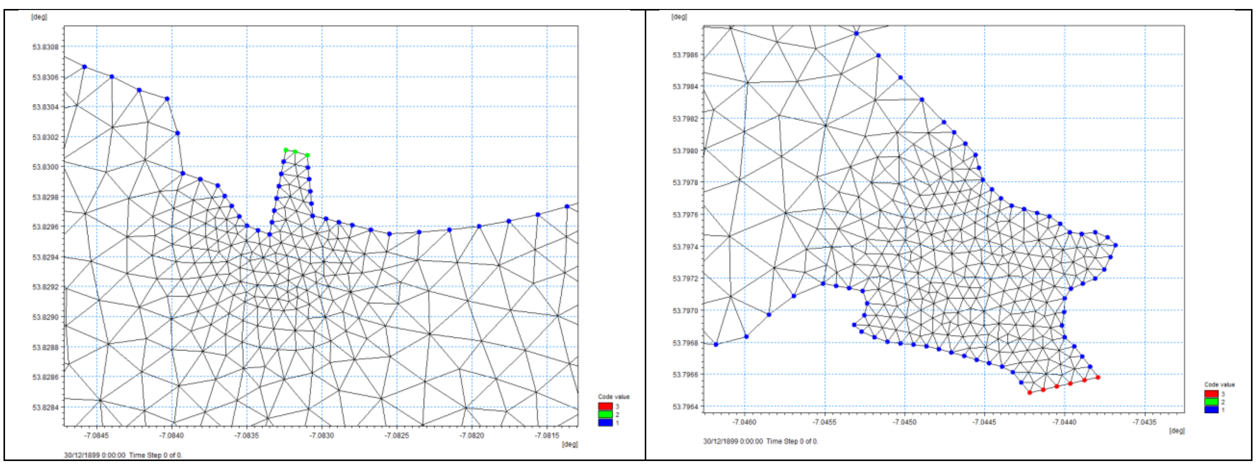


Figure 4-8. Mesh refinement around Kells-Blackwater inflowing (left) and Kells-Blackwater discharging (right).

Hydrodynamic Module – Boundary Conditions

The main boundary data applied to force the hydrodynamic model were river flows and meteorological conditions.

The main rivers flowing into Lough Ramor are:

- River Kells-Blackwater
- River Nadreegeel
- River Lislea

Other smaller rivers also flow into the lake (10 in total), but the above three rivers are by far the largest. As seen in Figure 4-9, the three main rivers flowing into the lake are along its north side. One smaller river, referred to here to as River W, flows into the lake from the west side. The Kells-Blackwater drains approximately 50% of the lake catchment. The Kells-Blackwater river drains the lake at its south eastern point (Figure 4-9).

Figure 4-9. Lough Ramor main rivers and OPW water level monitoring stations (1 – Virginia Hatchery; 2 – Stramatt Bridge; 3 – Virginia Golf Course).

The OPW maintains two hydrometric gauging stations on the main rivers: one on the inflowing River Kells-Blackwater (station no. 07033) and one on the discharging River Kells-Blackwater (station no. 07004); these are shown on Figure 4-9 as points 1 and 2, respectively. Station 07033, located at Virginia Hatchery, provides water level and flow data; the Kells-Blackwater drains a catchment area of 124.81 km^2 to this point. Station 07004, Stramatt, also provides water level and flow data.

Very little information is available for the other flows into the lake. From the EPA Maps website (https://gis.epa.ie/EPAMaps), information was obtained regarding annual mean flows into the lake for the Kells-Blackwater, Nadreegeel, Lislea and W; this is presented in Table 4-3. Flow data were not available for any of the other smaller streams, likely due to their small size.

Table 4-3. River mean annual flows into Lough Ramor.

River	Flow (m^3/s)	% KB Flow*
Kells-Blackwater	2.657	100
Nadreegeel	1.029	39
Lislea	0.504	19
W	0.241	9

** % KB Flow – river flow as a percentage of flow in Kells-Blackwater.*

The total annual mean inflow from these four largest rivers is 4.431 m^3/s. From EPA Maps, the mean annual flow out of the lake through the River Kells-Blackwater is given as 5.309 m^3/s. The four largest rivers therefore account for approximately 83% of the inflow to Lough Ramor.

A rating curve exists for station 07033 on the Kells-Blackwater; none of the other three inflowing rivers are rated. It was decided that the other rivers would contribute flow in accordance with their annual mean flows. From Table 4-3 above, it is seen that there is a disparity between the total annual mean inflows from the four rivers and the annual mean outflow. Thus, based on some preliminary hydrodynamic model runs, revised inflows were calculated so that annual mean inflows and outflows balanced. The revised inflows are presented in Table 4-4.

Table 4-4. Revised river inflows.

River	Flow (m^3/s)	% KB Flow*
Kells-Blackwater	2.657	100
Nadreegeel	1.533	58
Lislea	0.751	28
W	0.359	14

** % KB Flow – river flow as a percentage of flow in Kells-Blackwater*

During model simulations of historical events, flow data for the River Kells-Blackwater was obtained from the gauging station. The flows in the other three rivers were obtained by applying the % KB Flow from Table 4-4 for each river to the flows in the River Kells-Blackwater. These data were used during model assessment.

The closest Met Éireann meteorological station to Lough Ramor is the Mullingar Automated Weather Station (AWS), station number 875, situated to the west of Mullingar, Co. Westmeath. The station records hourly values of, inter alia, wind speeds and directions and air temperature. These data were used to apply meteorological boundary conditions to the model; it was assumed that meteorological conditions were constant over the lake surface at any particular time.

Hydrodynamic Module – Assessment

A hydrodynamic model was developed using the above bathymetric, river flows and meteorological data. In order to compare model performance with historical data, a model scenario was run to simulate lake dynamics; comparisons were made between simulated lake water surface levels and recorded levels.

An EPA water level recorder is located in Lough Ramor just west of the WWTP discharge point, between the Kells-Blackwater and Nadreegeel rivers. This recorder at Virginia Golf Course, station 07081, is shown as point 3 in Figure 4-9.

During model assessment, a winter–spring period between January and April 2023 was simulated. Water levels were also compared for the 2022 calendar year, which was used for assessment of the water quality module. Boundary lake inflows were synthesised in accordance with the methodology outlined, using OPW data at station 07033 for inflows and lake outflows were based on OPW data at station 07004. Wind speeds and directions along with air temperatures were specified based on Met Éireann data at station 875. Model simulated water surface levels at the location of station 07081 were compared against OPW recorded data at the station.

The hydrodynamic model developed, as detailed above, was assessed for its ability to simulate lake water surface elevation dynamics by comparing model results against data for a winter-spring period during 2023 and for the full calendar year 2022.

Data were available for the OPW maintained gauges at: Virginia Hatchery (07033), both flow and elevation; Stramatt Bridge (07004), both flow and elevation; and Virginia Golf Course in-lake (07081) elevation only. The gauge at Virginia Hatchery on the inflowing River Kells-Blackwater was used to estimate the flows into Lough Ramor from the rivers Kells-Blackwater, Nadreegeel, Lislea and W based on the analysis outlined in the Mixing Zone Assessment Methodology section above and summarised in Table 4-4.

A period from 01/01/2023 until 23/04/2023 was used to assess model efficacy; this is a wet period and leads to water level changes in the lake in the order of 1 m. A comparison between model results and data is presented in Figure 4-10.

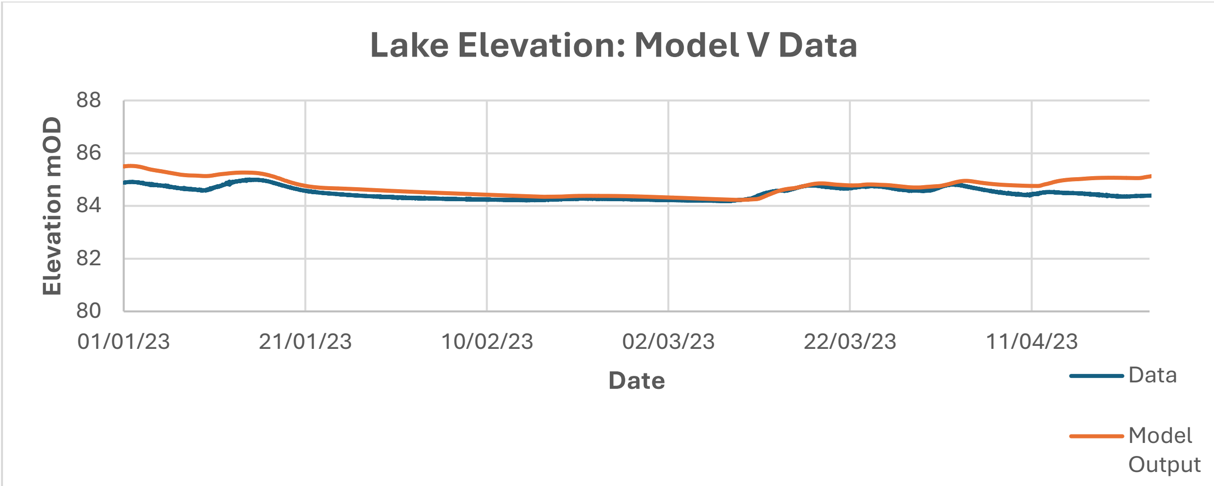


Figure 4-10. Water surface elevation - Model Output V Data.

There is good agreement between model results and data until early April when the values diverge. Over a relatively short period of time, we would expect that there is a water balance within the lake between inflows and outflows with net zero inflows to the lake; also, if inflows are larger than outflows, lake level should rise. However, when we consider the net inflows (i.e. inflows – outflows) to the lake from January to May in Figure 4-11 we see that from early April there is a significant net inflow persisting over a relatively large time period; this indicates that one of the gauges was not functioning properly and the rating curves contain inaccuracies. If these flows actually happened, the lake would have risen and been reflected in the data; however, the data show the water level decreasing for net positive inflows. The model results reflect this net inflow with higher lake elevation values.

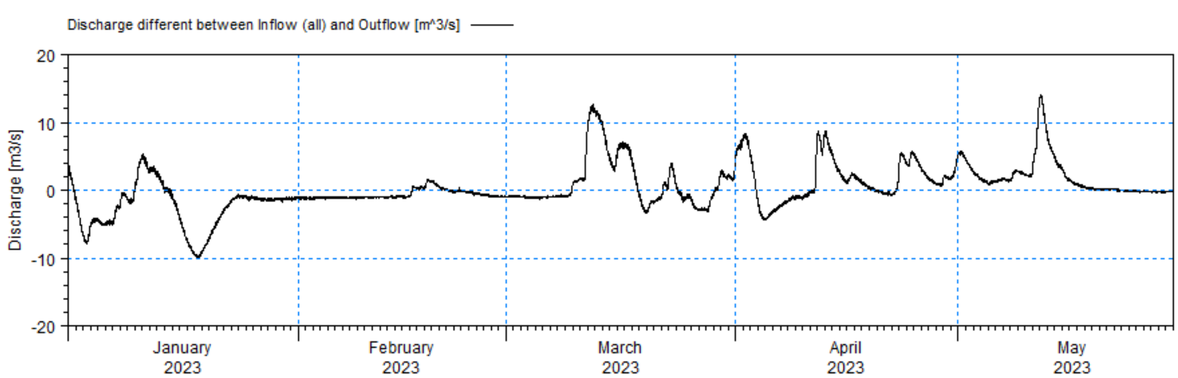


Figure 4-11. Net inflows to Lough Ramor.

The above discrepancies between measured and modelled water levels are likely to be due to water level records and associated rating curves. The OPW Hydro-Data site states that at the Virgina Hatchery station the rating curve is good to 0.75m but lacks measurements at high flows. The site states that for the Stramatt station the turbulence from the 9 arch bridge 20 m upstream and out of bank flow can make flow measurements difficult; further, due to uncertainties flow data are not published.

Given uncertainties in the bathymetric data, water level and flow datasets, it is considered that the comparison between model results and data is quite good and acceptable for this Tier 3 assessment study.

Figure 4-12 shows a typical flow field and associated water circulation patterns throughout Lough Ramor. This is the first time the hydrodynamics of the lake have been modelled in detail. Inflowing water from the River Kells-Blackwater forms a jet-like structure and, due to its momentum, it strikes the bank on the southern lake shore. Weak gyres are formed either side of the jet. The jet and gyres tend to form a hydrodynamic barrier separating western lake waters from eastern lake water. Waters from this jet then mix with lake waters and flow in a south eastern direction towards the lake outlet at Stramatt Bridge. Thus, most of the pollutants discharged into the lake are mixed and then advected to the outlet. By and large, the water current magnitudes are quite low. Figure 4-13 shows a contour-vector map of maximum lake current magnitudes; values are typically less than 0.05 m/s.

To further understand pollutant transport within the lake, a solute-advection model of the lake was developed to simulate the transport of waters discharging into the lake. Results are presented in Figure 4-14, showing four snapshots (A-D) over a 15-day period of transport based on the currents generated in the hydrodynamics module. The red colour represents original lake waters, the other colours represent varying degrees of concentrations of the inflowing waters. A number of processes become clear:

- Discharges from the rivers Kells-Blackwater and Lislea are transported south eastwards towards Stramatt Bridge through relatively strong axial flow along the lake. There is reasonable mixing across the lake also.

- Transport processes are quite different between the eastern and western sides of the lake due to the formation of a significant circulation barrier generated where the River Kells-Blackwater flows into the lake. As a result, better flushing is experienced in the eastern side of the lake.

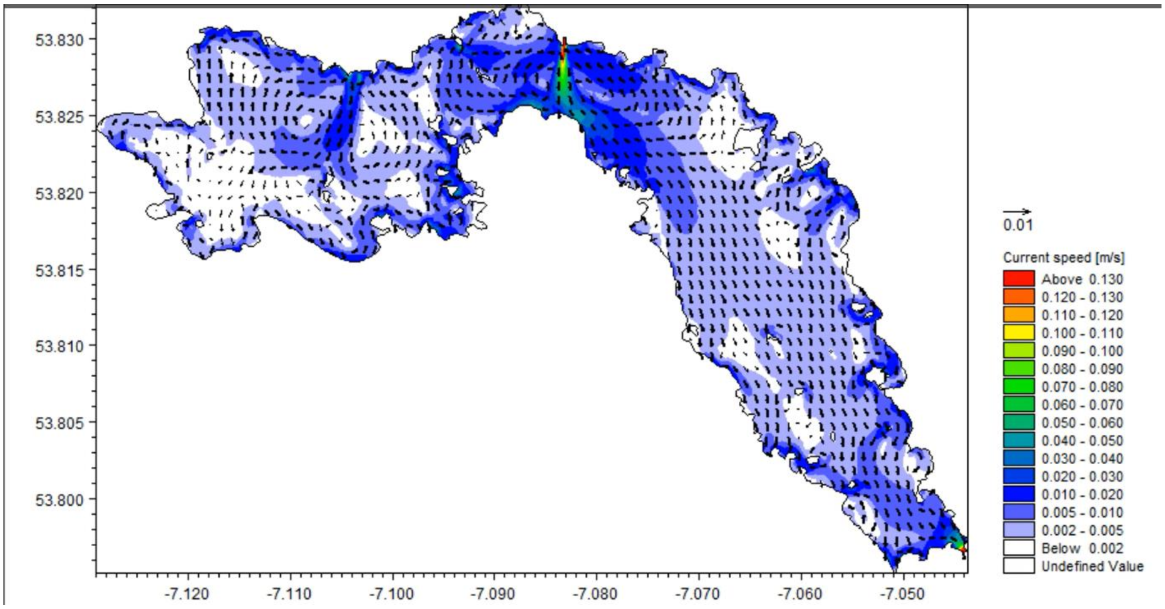


Figure 4-12. Typical flow field in Lough Ramor.

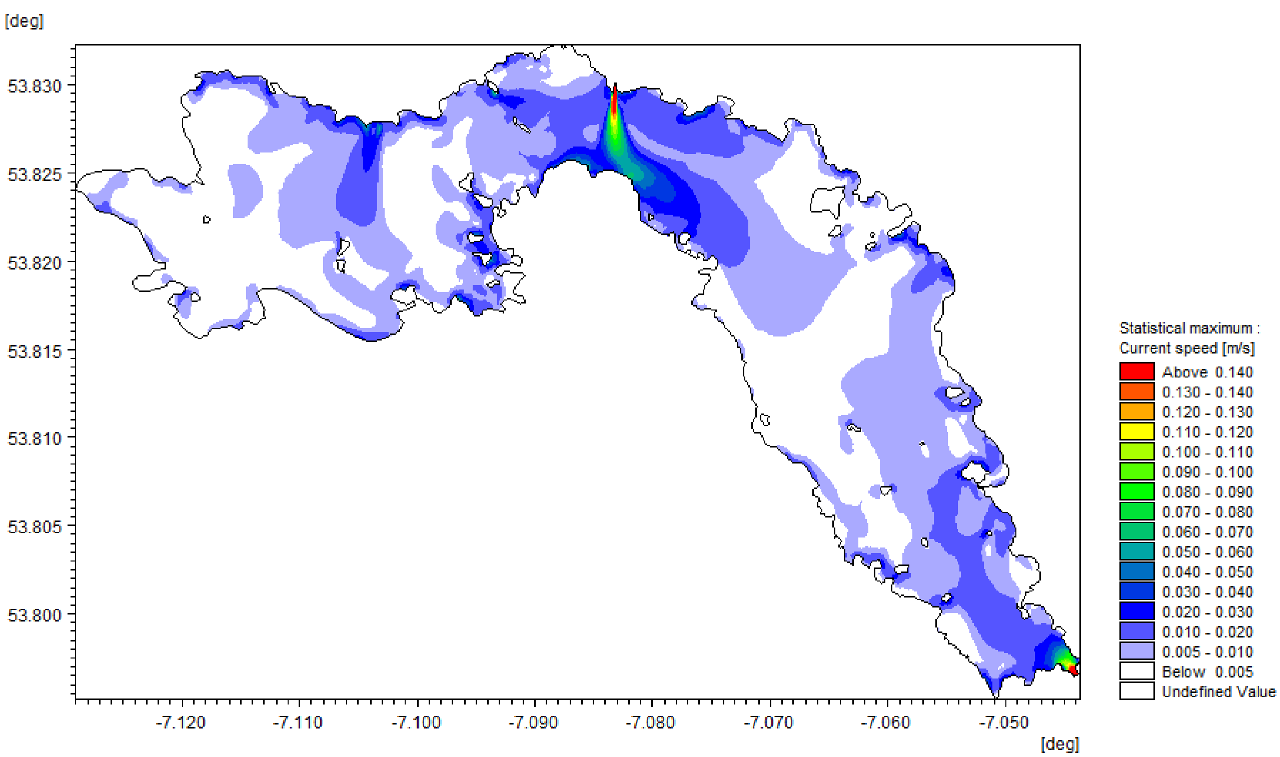


Figure 4-13. Maximum current magnitudes.

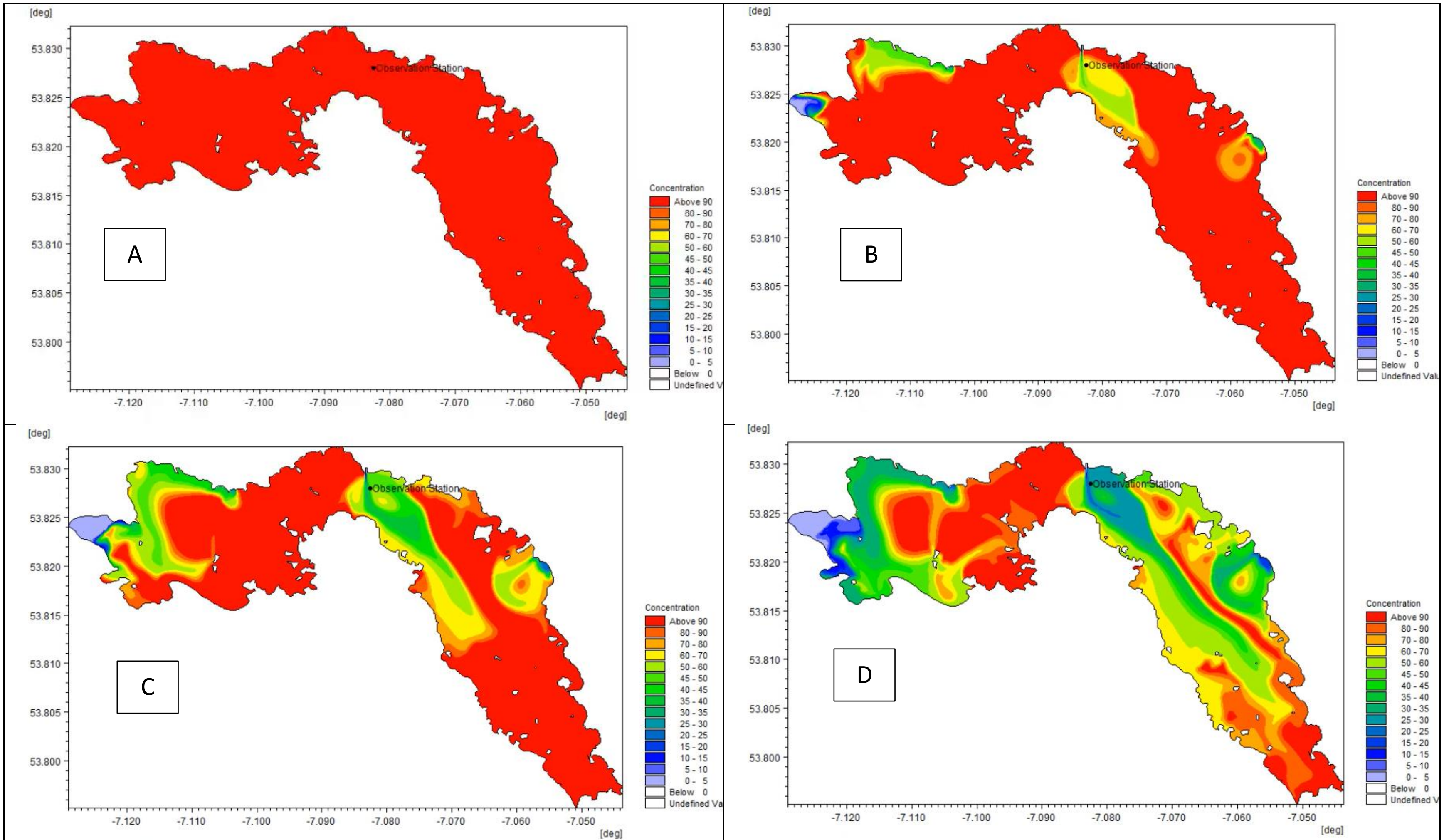


Figure 4-14. Typical transport patterns A – initially; B – after 44 h; C – after 154 h: D – after 360 h.

Water level comparisons between model results and data for the year 2022 are presented in Figure 4-15, along with lake inflows and outflows. After the initial start-up period, there is very good agreement between model results and data for about 8 months of the year. However, levels diverge around mid-October. This is again mostly likely due to errors in the water level recordings and rating curves at stations 07033 and 07004.

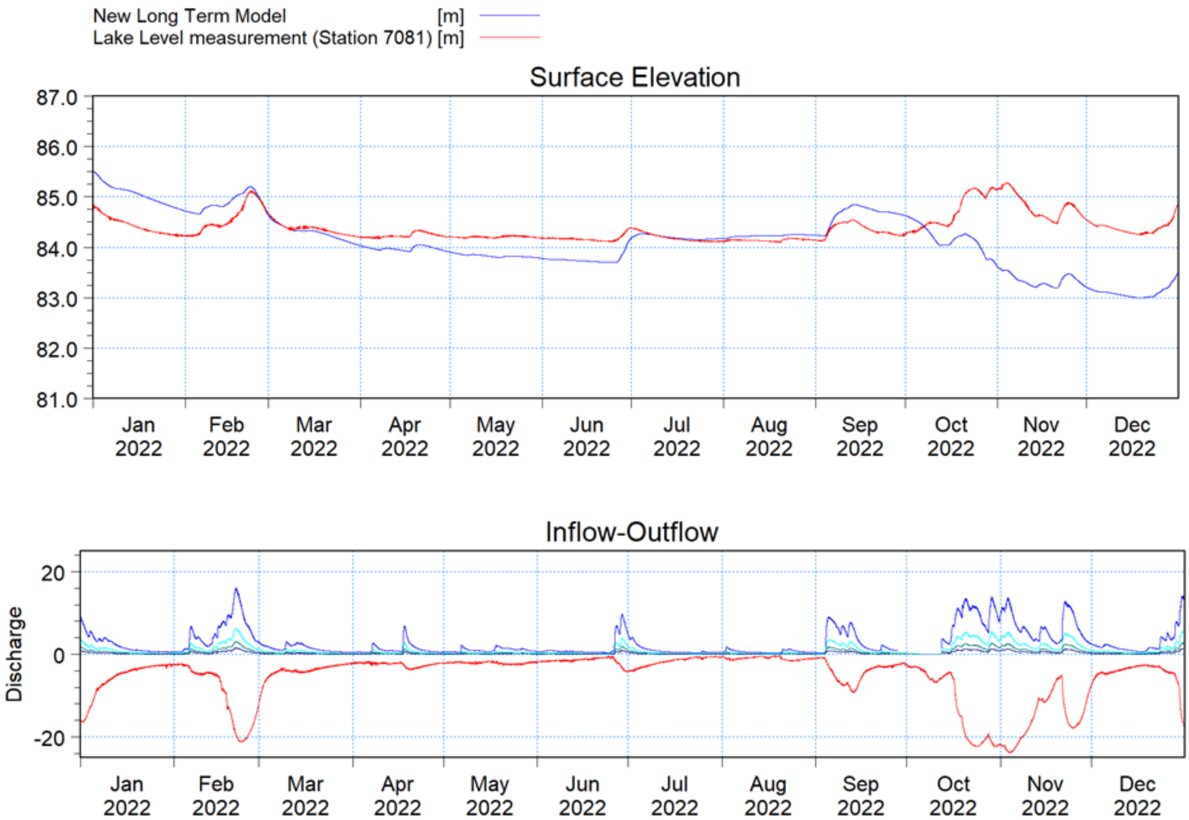


Figure 4-15. Water surface elevations and lake inflows and outflows.

Water Quality Module – Set-up and Boundary Conditions

A water quality model was developed based on an appropriate nutrient cycle for Lough Ramor. Five water quality constituents were included in the model:

1. Organic N
2. Ammonia
3. Nitrate (Total Oxidised N)
4. Organic P
5. Inorganic P (MRP or orthophosphate)

Water temperature was also modelled but this was included in the hydrodynamic module.

Monitoring data showed that nitrite levels in Lough Ramor and the inflowing rivers were at least two orders of magnitude lower than nitrate levels; thus, nitrite was omitted from the model.

The water quality governing equations include:

- ammonification of organic N (conversion of organic N to ammonia)
- nitrification of ammonia (conversion of ammonia to nitrate)
- mineralisation of organic P (conversion of organic P into orthophosphate)
- temperature dependence of all chemical transformations

Historically, high levels of phytoplankton were recorded in Lough Ramor due to the high nutrient loads from the rivers. However, in recent years, Lough Ramor has become host to invasive zebra mussels. Zebra mussels are filter feeders; this results in the generation of very low levels of phytoplankton throughout the lake as seen by the reduction in measured chlorophyll in the lake in recent years (Figure 3-32 and Figure 4-16). Recorded levels since 2019 have been very low – the average recorded level from 2019 to 2022 was 4 mg/l. As it was not possible to accurately include the predation of phytoplankton by zebra mussels in the model, the phytoplankton cycle, and its associated effects on the nutrient cycle, were not included in the water quality model. 2022 was therefore chosen as the time period for historical simulation and model assessment since the monitored chlorophyll levels were at their lowest (mean recorded value was 2 mg/l).

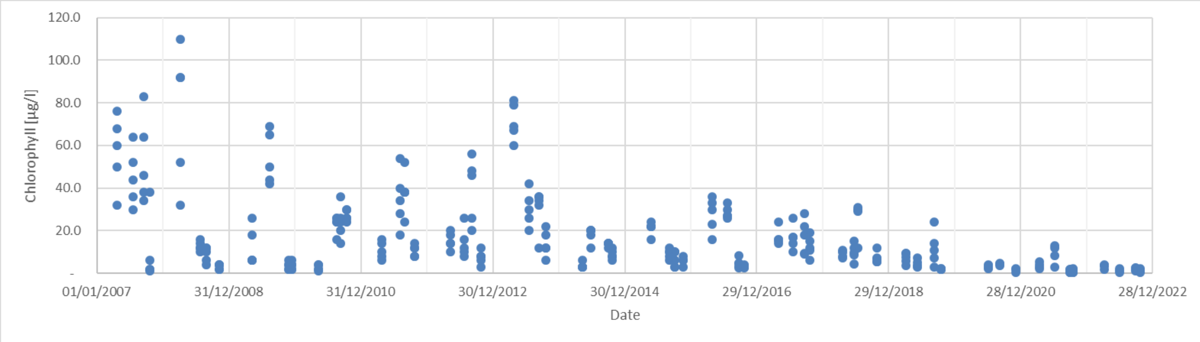


Figure 4-16. Measured chlorophyll levels in Lough Ramor, 2007–2022.

The main sources of nutrients to the lake are from:

- Inflowing rivers (Kells-Blackwater, Nadreegeel, Lislea and River W)
- Virginia Town WTTP
- Glanbia plant effluent

River water chemistry fluxes were specified to the model based on river discharge and inflow chemistry. River discharges were specified as per the section on hydrodynamic boundary conditions. Inflow chemistry data were available at two monitoring stations:

- RS07B010800 on the River Kells Blackwater
- RS07N010500 on the Nadreegeel River.

Table 4-5 shows the availability of the monitoring data required to develop the 2022 inflowing chemistry flux datasets. The data were incomplete with some parameters not measured. The temporal resolution was limited to single monthly measurements; these were assumed representative of the whole month and were specified to the model as monthly constants.

Table 4-5. Riverine water chemistry data available for 2020–2022.

Parameter	Kells Blackwater	Nadreegeel
Temp	✓	✓
Total N	X	X
Org N	X	X
Ammonia	✓	✓
Nitrate	✓	✓
TON	✓	✓
Total P	✓	X
Org P	X	X
MRP	✓	✓

For the Kells-Blackwater, data were available for all months of 2022 and were therefore used directly. Appropriate values for missing parameters were calculated as follows:

- Org P = Total P – MRP
- Org N: Using historical data when both Total N and TON were available, an average annual TON/TN ratio was calculated. This was applied to 2022 monthly TON data to compute 2022 monthly TN. 2022 monthly Org N were then calculated as TN-DIN.

For the Nadreegeel, data were available for 5 months of 2022. By averaging monthly data for the years 2020–2022 the number of months was increased to 7 and the remaining gaps were filled by linear interpolation of the preceding and following months. For missing parameters, appropriate values were calculated as follows:

- Org N: the average annual TON/TN ratio calculated for the Kells-Blackwater was applied to the 2022 monthly TON data to compute 2022 monthly TN. 2022 monthly Org N were then calculated as TN-DIN.
- Org P: an average annual MRP/TP ratio was calculated using 2022 data for the Kells-Blackwater. This was then applied to 2022 MRP data for the Nadreegeel to give 2022 monthly TP values. 2022 monthly Org P values were then calculated as: TP-MRP.

In the absence of any monitoring data for the Lislea and River W, the data for the Nadreegeel were used. The inflowing water chemistry boundary data for the Kells-Blackwater and the Nadreegeel are presented in Table 4-6 and Table 4-7, respectively.

Table 4-6. Inflowing water chemistry for River Kells-Blackwater.

Month	Temp °C	Org P mg/l	MRP mg/l	Org N mg/l	Ammonia mg/l	Nitrate mg/l
Jan	6.1	0.028	0.034	1.722	0.060	1.800
Feb	9.0	0.018	0.040	1.435	0.021	1.500
Mar	6.6	0.016	0.027	1.817	0.024	1.900
Apr	9.6	0.030	0.011	0.679	0.010	0.710
May	11.8	0.042	0.021	0.957	0.020	1.000
Jun	14.1	0.079	0.081	0.583	0.057	0.610
Jul	16.8	0.000	0.100	0.660	0.040	0.690
Aug	15.0	0.028	0.056	0.335	0.010	0.350
Sep	11.4	0.031	0.053	0.096	0.010	0.100
Oct	11.1	0.081	0.089	0.918	0.032	0.960
Nov	9.1	0.065	0.075	0.670	0.024	0.700
Dec	7.9	0.026	0.051	0.813	0.058	0.850

Table 4-7. Inflowing water chemistry for River Nadreegeel.

Month	Temp °C	Org P mg/l	MRP mg/l	Org N mg/l	Ammonia mg/l	Nitrate mg/l
Jan	8.8	0.037	0.041	1.152	0.048	1.200
Feb	8.0	0.030	0.033	1.008	0.048	1.050
Mar	7.2	0.023	0.025	0.864	0.048	0.900
Apr	9.1	0.022	0.024	0.722	0.049	0.753
May	11.1	0.034	0.037	0.581	0.050	0.605
Jun	13.8	0.024	0.026	0.355	0.094	0.370
Jul	14.7	0.021	0.023	0.494	0.078	0.515
Aug	15.6	0.018	0.020	0.634	0.063	0.660
Sep	13.8	0.026	0.029	0.653	0.043	0.680
Oct	11.9	0.035	0.038	0.653	0.043	0.680
Nov	10.1	0.043	0.048	0.672	0.023	0.700
Dec	5.0	0.029	0.032	0.840	0.065	0.875

The current “Organic Capacity (PE) - Collected Load (peak week)” cited in the 2020 Annual Environmental Report (AER) for the Virginia WWTP plant is 3,542 PE at a current average hydraulic loading of 989 m^3/day. It is proposed to increase the plant to 6,000 PE giving a future pro rata hydraulic loading of 1,675.3 m^3/day; wastewater water chemistry concentrations are presented in Table 4-8 – these are based on emission limit values (ELVs).

Table 4-8. Concentrations of chemistry constituents in WWTP effluent.

Parameter	Concentration [mg/l]
Organic N	1.25
Ammonia	1.00
Nitrate	4.00
Organic P	0.10
MRP	0.20

The Glanbia plant discharges effluent to the lake via two adjacent outfalls in the east of the lake (see Figure 4-17), specified here as EF6 and EF7. Flow rates and wastewater chemistry were obtained from the 2014 AER and are presented in Table 4-9. These values are used in subsequent model simulations and analyses. Note, 2014 AER data were used as more recent reports do not show data, they just show compliance with the licence.

Table 4-9. Flow rates and effluent chemistry concentrations for Glanbia discharges.

EF7				
Month	**Flow rate m³/day**	**Total N mg/l N**	**Ammonia mg/l N**	**Total P mg/l P**
Jan	947	4.8	0.55	0.85
Feb	986	7.38	0.58	0.76
Mar	892	7.73	0.53	0.75
Apr	831	6.33	0.53	0.88
May	924	4.3	0.55	0.74
Jun	914	1.78	0.37	0.65
Jul	886	1.67	0.29	0.53
Aug	970	1.75	0.36	0.44
Sep	931	2.06	0.45	0.35
Oct	1,019	2.18	0.55	0.52
Nov	1,020	2.32	0.62	0.48
Dec	797	1.78	0.73	0.64
EF6				
Month	**Flow rate m³/day**		**Ammonia mg/l N**	**Total P mg/l P**
Jan	519		0.58	0.18
Feb	647		0.46	0.2
Mar	799		0.45	0.21
Apr	952		0.51	0.18
May	2,591		0.47	0.14
Jun	3,407		0.27	0.15
Jul	3,212		0.41	0.15
Aug	1,671		0.55	0.13
Sep	526		0.61	0.22
Oct	672		0.59	0.23
Nov	788		0.7	0.18
Dec	749		0.8	0.14

Water Quality Module – Assessment

Water chemistry monitoring of Lough Ramor has been conducted annually since 2007. Samples are collected four times per year (usually in April, July, September and October although these can vary) at up to five stations. From 2018, additional sampling data are available for other months but only for a small number of constituents and only at a single station. Table 4-10 shows the 10 monitoring stations in the lake and Figure 4-17 shows their locations. There are five preferred primary sites and five corresponding surrogate sites used when primary sites are inaccessible. Parameters of relevance to this study for which data were available are:

- Temperature

- Total Oxidised N
- Ammonia
- Nitrate
- Total P
- Inorganic P (MRP or orthophosphate)

Table 4-10. List of monitoring stations in Lough Ramor.

Station Name	Station Code	Easting	Northing
Site 1, hymo station for reporting	LS070015906000010	258522	286417
Ramor Station 2	LS070015906000020	259500	286700
Ramor Station 3	LS070015906000030	260800	286700
Ramor station 5	LS070015906000050	261298	286610
Ramor Station 6	LS070015906000060	262000	285000
LIT_0020, surrogate site for 0010_0P	LS070015906000080	260472	287026
M_3, surrogate site for 0050_OP	LS070015906000200	262252	285692
Surrogate 2 for Ramor Station 2	LS070015906000250	260303	286546
Surrogate 3 for Ramor Station 3	LS070015906000260	262300	285926
Surrogate 4 for Ramor Station 6	LS070015906000270	262750	283379

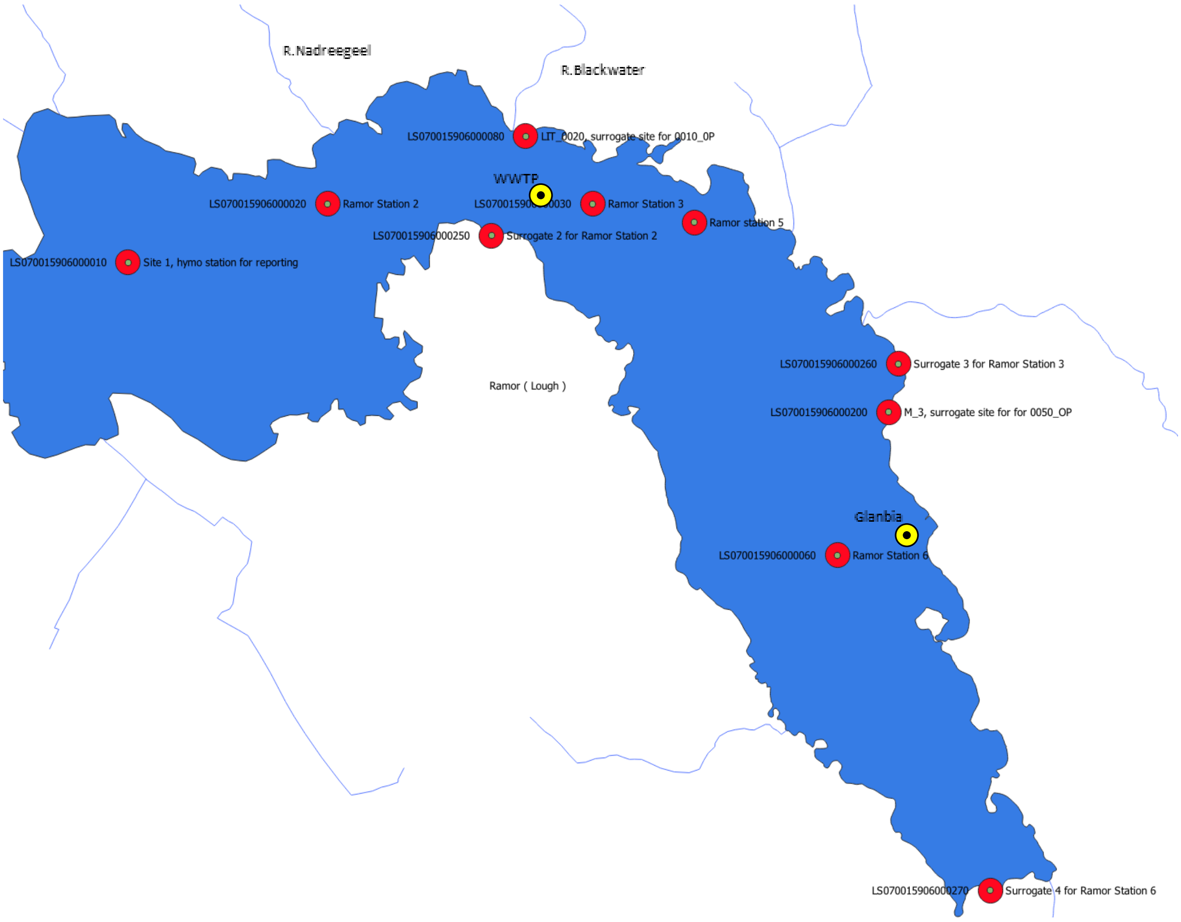


Figure 4-17. Map showing water chemistry monitoring stations (red) and outfalls (yellow).

Table 4-11 shows availability of measured in-lake water chemistry data for 2022. A complete set of monthly in-lake chemistry data was developed (Table 4-12) using the 2022 monitoring data as follows:

- For months where just single station measurements were available, these were taken as the monthly representative values for the lake.
- For months where multiple station measurements were available, the spatial averages were taken as the monthly representative values for the lake.
- For constituents where gaps of just one month existed (temperature, ammonia, total P), missing monthly values were calculated by linear interpolation of the preceding and following months' values.
- For constituents where gaps of more than one month existed:
    - Nitrate: Nitrate/Ammonia ratios were calculated using existing monthly data and an average ratio computed. Missing nitrate values were then computed using this average ratio and the corresponding ammonia concentrations.
    - TON: assumed equal to nitrate.

- MRP: MRP/TP ratios were calculated using existing monthly data and an average ratio computed. Missing MRP values were then computed using this average ratio and the corresponding TP concentrations.

Neither organic N nor organic P were monitored in the lake. Monthly in-lake values for these constituents were calculated as follows:

- Org N: The TON/TN ratio developed for Kells-Blackwater was applied to monthly in-lake TON data to compute monthly TN. Monthly Org N then calculated as TN-DIN.
- Org P: Calculated as TP-MRP.

Table 4-11. Monthly availability of measured in-lake chemistry constituent data showing the number of stations at which measurements were taken.

Month	Temp	TON	Ammonia	Nitrate	TP	MRP
Jan	1	---	1	---	1	---
Feb	---	---	---	---	---	---
Mar	1	---	1	---	1	---
Apr	4	4	4	4	4	4
May	---	---	---	---	---	---
Jun	1	4	4	4	4	4
Jul	1	---	1	---	1	---
Aug	3	---	3	---	3	---
Sep	4	4	4	4	4	4
Oct	4	4	4	4	4	4
Nov	1	---	1	---	1	---
Dec	---	---	---	---	---	---

Table 4-12. Representative monthly in-lake water chemistry values.

Month	Temp °C	Org N mg/l	Ammonia mg/l	Nitrate mg/l	Org P mg/l	MRP mg/l
Jan	6.7	0.929	0.055	0.917	0.025	0.026
Feb	9.2	0.676	0.040	0.667	0.037	0.038
Mar	11.7	0.422	0.025	0.417	0.049	0.051
Apr	9.6	1.531	0.018	1.582	0.022	0.015
May	14.5	0.400	0.047	0.372	0.023	0.024
Jun	19.4	1.183	0.070	1.167	0.029	0.029
Jul	3.1	0.503	0.025	0.501	0.049	0.051
Aug	3.5	0.975	0.052	0.967	0.049	0.051
Sep	11.5	1.196	0.071	1.179	0.034	0.044
Oct	11.1	1.183	0.070	1.167	0.056	0.074
Nov	5.2	1.098	0.065	1.083	0.049	0.051
Dec	6.0	1.014	0.060	1.000	0.037	0.038

For assessment of water quality performance, the model was run for the calendar year 2022 using current freshwater, WWTP and Glanbia loadings as specified above. Model outputs were compared with 2022 monthly in-lake water chemistry data (Table 4-12). A sensitivity study was conducted to determine the most suitable transformation rate values. The values presented in Table 4-13 gave the best agreement with measured data and were subsequently used in all scenario modelling.

Table 4-13. Constituent transformation rates used in model.

Transformation	Rate Used (/day)		Recommended Range* (/day)
Organic N → Ammonia	0.005		0.005 – 0.06
Ammonia → Nitrate	0.09		0.09 – 0.5
Organic P → MRP	0.01		0.001 – 0.22

** Zhang W, Rao YR (2011) Application of a eutrophication model for assessing water quality in Lake Winnipeg, J Great Lakes Res, doi:10.1016/j.jglr.2011.01.003.*

Figure 4-18 and Figure 4-19 compare modelled monthly-averaged concentrations of ammonia and total phosphorus at Stations 2, 3 and 5 with the lake-averaged monthly measured values from Table 4-12. Root Mean Square Error (RMSE) values for modelled versus measured data are presented in Table 4-13 and show that the RMSE for ammonia was approximately 50% of the measured monthly mean at the three observation stations while the RMSE for total phosphorus was between 20 and 30% of the monthly measured mean. Figure 4-20 presents a statistical summary of the monthly modelled and measured concentrations using box plots. For ammonia, all three stations show similar means and ranges to the measured data. For total phosphorus, the means and ranges of Stations 3 and 5 are very similar to the measured data while the mean and range of values at Station 2 are lower than those of the measured data. Considering the limited nature of the input and monitoring data (discussed in the previous section), this level of model performance was deemed satisfactory and the model was deemed fit-for-purpose for use in a Tier 3 mixing zone assessment.

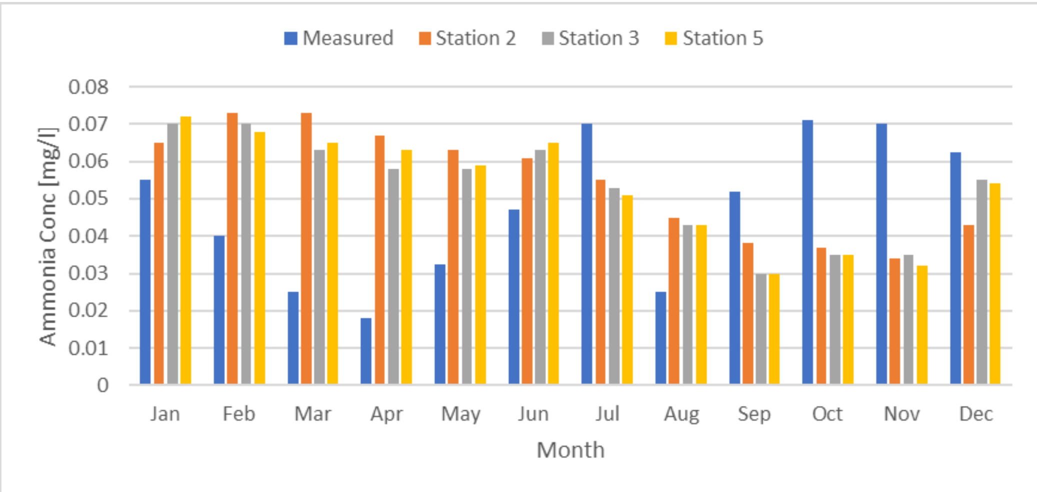


Figure 4-18. Comparison of measured and modelled monthly ammonia concentrations.

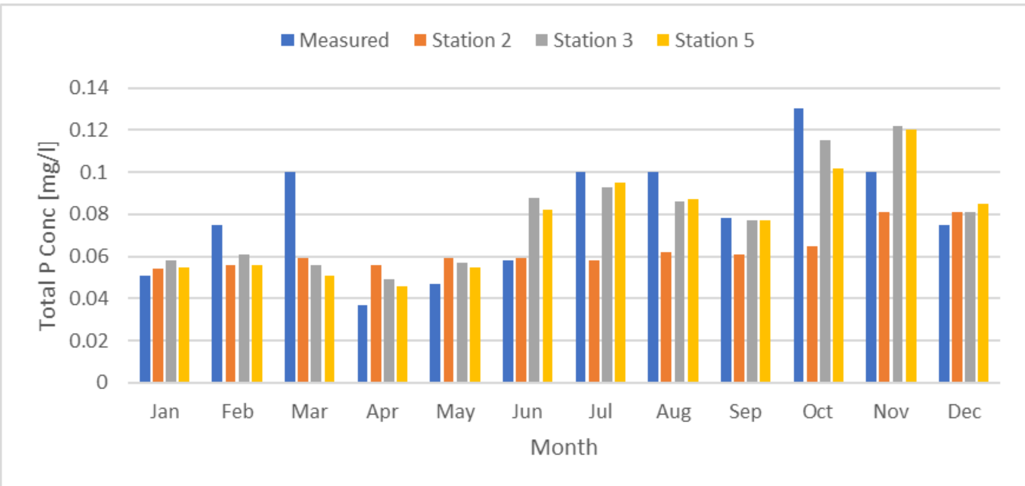


Figure 4-19. Comparison of measured and modelled monthly total phosphorus concentrations.

Table 4-14. RMSE in modelled versus measured monthly ammonia and total P concentrations.

Ammonia RMSE	**Station 1**	**Station 2**	**Station 3**
RMSE (mg/l)	0.026	0.024	0.025
RMSE (% of mean)	53	48	50
Total P RMSE			
RMSE (mg/l)	0.024	0.015	0.016
RMSE (% of mean)	30	19	20

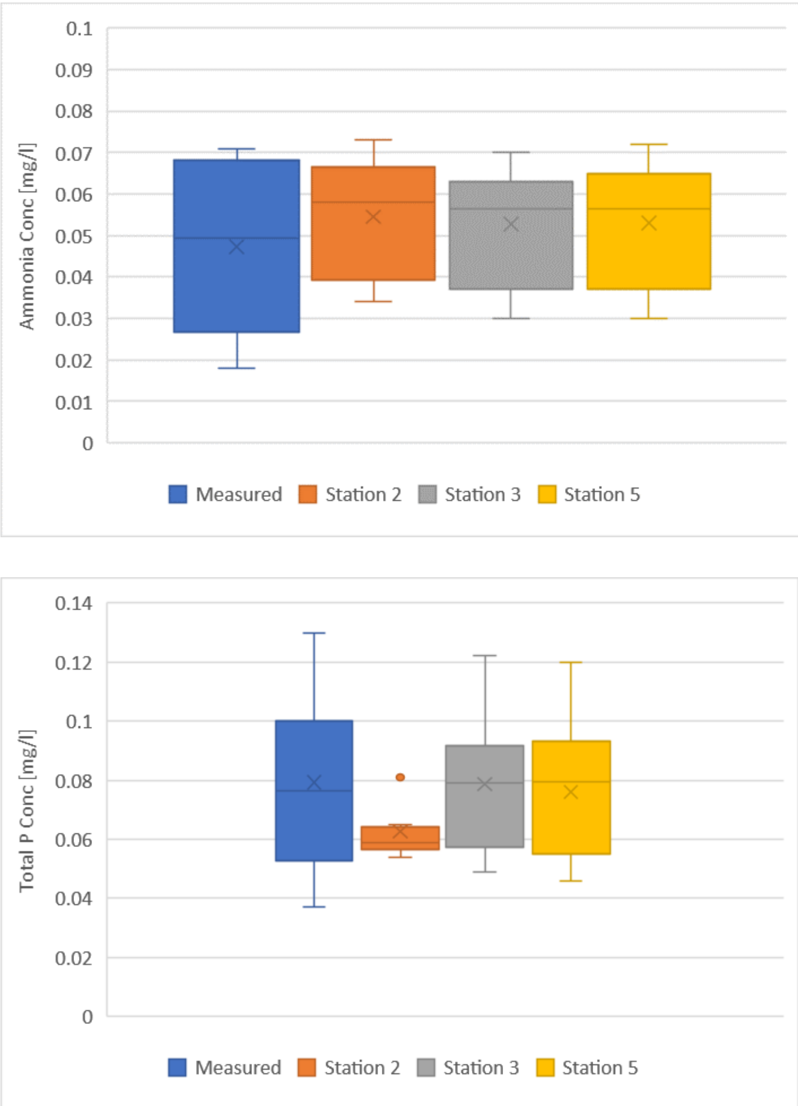


Figure 4-20. Box plot summary of measured and modelled monthly concentrations of ammonia and total phosphorus.

Assumptions and Limitations

During the development of the hydrodynamic and water quality models the following assumptions were made and limitations prevailed:

- **Bathymetry**: Lake bathymetry was based on a pre-existing contoured map of the lake previously used by Compass Informatics Ltd. during an EPA project.
- **Flow boundary conditions**: Flows were derived from rating curves of the inflowing Kells-Blackwater at Virginia Hatchery (07033) and the outflowing Keels-Blackwater at Stramatt Bridge (07004). The rating curves for these stations are approximate and are limited by lack of data at high flows at Virginia Hatchery and measurement difficulties at Stramatt Bridge. Flow boundary conditions for the other river inflows were estimated based on ratios of annual mean flows.
- **Hydrodynamic Results:** Model results were compared against water level records at Virginia (07081); water level records at this station have undergone very little checking since April 2021, especially at high water levels.
- **Initial lake water chemistry:** Measurements of in-lake water chemistry are limited in space and time (see Table 4-11). Measurements are only recorded on four dates throughout the year and at a maximum of four locations in the lake. The model required initial concentrations for the five modelled water quality parameters for 1st January 2022. January measurements were only recorded at a single station and only available for three parameters. Where available, the single station measurement was specified as the initial concentration throughout the lake and for those parameters where measurements were unavailable, appropriate values were interpolated using data from adjacent months. Given the potential variability of water quality conditions in space and time, the specified initial conditions may not therefore be an accurate representation of the actual lake chemistry on 1st January 2022.
- **Pollutant loads:** Specification of pollutant loads required specification of flow rates and water chemistry for all of the primary pollutant sources in the lake. It is rare that daily (or higher resolution) data are available for pollutant sources, thus monthly data are commonly used. Monthly data were used for the Lough Ramor model. This assumes that the load from a pollutant source is the same for each day of a particular month, but this is rarely the case in reality. For the rivers, monitoring data were only recorded on one date in each month. These were assumed to be representative of the monthly value but this may not be the case. For the River Nadreegeel, data were only available for 7 months, thus other months were estimated using interpolation. For the River Lislea and River W, no data were available, so they were attributed the same chemistry as the Nadreegeel. Organic nitrogen and organic phosphorus data are not measured; these were instead calculated using estimated TON/TN and MRP/TP ratios. For Virginia WWTP, a constant daily flow of 989 m^3/day was assumed. Effluent chemistry was assumed constant and equal to the ELVs for respective parameters. In reality, both the effluent flow and chemistry may vary daily. For

the Glanbia milk processing plant, monthly flow rates and effluent chemistry were specified based on a 2014 AER. Although the report is 10 years old and 2022 monthly flows and effluent chemistry may be different, more recent reports could not be used as they do not contain the required data.

- **Lake water chemistry for performance assessment:** representative monthly values of in-lake water chemistry were calculated from the same EPA monitoring data that the initial conditions were developed from. For months where monitoring data were available, they were only available on a single date and at a maximum of four stations. All station data available on a particular date were averaged spatially and assumed to be the lake monthly value. As lake conditions will vary daily and spatially throughout the lake, the single monthly values may not be accurate representative averages of the true conditions.
- **Transformation rates:** the model required specification of chemical transformation rates for conversion of organic nitrogen to ammonia, ammonia to nitrate and organic phosphorus to orthophosphate. These values are difficult to determine from measured data and are most commonly sourced from literature. Suitable ranges of values were obtained from relevant literature and optimum values were determined by running a series of simulations with different values and comparing model results against the measured data. While this is the typical approach used in water quality modelling, it does not guarantee that the determined optimum values are the true values.
- No new surveys were undertaken or new data collected during this project.

The above assumptions and limitations are commensurate with a Tier 3 mixing zone assessment.

5. MIXING ZONE ASSESSMENT SIMULATIONS AND RESULTS

Introduction

Mixing zone assessments were carried out for mean and low (Q95) river flow conditions under four different discharge scenarios resulting in the following seven water quality simulations:

1. Existing WWTP discharge scenarios
   1.1. Mean flow
   1.2. Low flow
2. Future WWTP discharge scenarios – existing initial/river conditions
   2.1. Mean flow
   2.2. Low flow
3. Future WWTP discharge scenarios – notionally clean initial/river conditions
   3.1 Mean flow
   3.2 Low flow
4. Full flow-to-treatment (FFT) scenario (Mean flow, future discharge and notionally clean initial/river conditions)

The primary aim of the study was to identify the presence and extent of any mixing zone(s) resulting from the proposed plant upgrade to 6,000 PE. A mixing zone is defined as an area of water adjacent to an effluent discharge where Good Status EQS water criteria are exceeded. The parameters of interest in this study were ammonia and total phosphorus. The applicable EQS values for ammonia are 0.065 mg/l N for the mean and 0.140 mg/l N for the 95%ile. For total phosphorus, only a mean value of 0.025 mg/l P is specified. The steady-state ammonia and phosphorus results obtained from the above model scenarios were used to produce water quality status compliance maps. These were in turn used to assess for mixing zones by identifying any breaches of good status resulting from the WWTP effluent plume.

Model Input Data

For the most part, measured data were used to develop the initial and boundary conditions for the above simulations. For the hydrodynamic module, the initial lake water level was computed as the mean of 16 years of measured data from Virginia (lake) station (no. 07081). Mean wind speed and direction were computed from 20 years of data from Mullingar weather station. Flow data were only available for the inflowing Kells-Blackwater, therefore, mean and low (95 percentile) flows for the four primary inflowing rivers/streams were obtained from the EPA Catchments website (https://gis.epa.ie/EPAMaps/Water) which provides mean and percentile flows calculated using the EPA's River Estimate Hydrotool. To assess the accuracy of these data, mean and 50-percentile flows for the inflowing Kells-Blackwater river were calculated from 44 years of measured data for the Virginia Hatchery monitoring station (no. 07033) and compared with the EPA figures. The relative difference was 0.3% for the mean flow and 4.8% for the 50-percentile flow. To ensure that steady-state hydrodynamic conditions were achieved, the mean and 95 percentile flows for the outflowing Kells-Blackwater were taken as the sum of the four inflowing rivers, plus Virginia WWTP and Glanbia discharges.

For the water quality module, initial lake water chemistry and inflowing river chemistry were calculated from EPA monitoring data. Monitoring data from 2019–2023 were used for the reasons discussed in the section: Water Quality Module – Set-up and Boundary Conditions regarding zebra mussels and their effects on lake phytoplankton levels. For initial lake water chemistry, the monitoring data were averaged spatially and temporally to give a single starting value for each water quality parameter. For river chemistry, monitoring data were available for the Kells-Blackwater and the Nadreegeel rivers. As discussed in above reference boundary conditions section, these data were incomplete so mean monthly concentrations for all parameters of interested were first computed using the approach outlined in the boundary conditions section. Mean monthly nutrient loads (in kilogrammes) were then calculated as the product of mean monthly inflow concentrations and mean monthly river inflows (calculated from measured flow data for the same period). The monthly loads were then summed to give mean annual loads and divided by the mean and 95-percentile flows to give the mean inflowing river chemistry values.

For the WWTP discharge, existing mean and maximum flows and water chemistry were calculated from monitoring data from the plant for the 3-year period 2021–2023. Future flows and water chemistry were provided by the design team. The full-flow-to-treatment scenario uses future WWTP discharge conditions. The plant is initially run at future mean discharge. It is then linearly increased up to the future maximum discharge over 2 h, kept at future max for 24 h, and then linearly reduced back down to mean discharge over 2 h.

Full details of the initial and boundary conditions specified for the mixing zone simulations are presented in Table B-1 in Appendix B. The sources of the data used to calculate the initial and boundary conditions are presented in Tables B-2 and B-3 for the hydrodynamics and water quality, respectively.

Model Results

The following sections present the results of the mixing zone analysis simulations. Hydrodynamic simulation results are presented first to show that steady-state hydrodynamic conditions were reached. These are followed by water quality simulation results from the mean flow, low flow and FFT scenarios, which include concentration timeseries and spatial maps of water quality status based on compliance with EQS values. The water quality status maps were the tool used to identify the presence of WWTP mixing zones.

Model simulations were typically run for 180 days. This length of simulation was necessary to allow steady-state water quality conditions to develop. Steady-state conditions were judged to have been reached when concentrations reached constant or near-constant values. In some cases (e.g. low flow conditions), steady-state conditions were not reached within the 180 days. For these cases, the model was re-run for another 180 days using the finishing concentrations from the first simulation as the initial conditions for the second simulation.

Hydrodynamic and water quality timeseries were output by the model at the 10 EPA monitoring stations shown in Figure 5-1. For brevity, results are only presented at stations of interest, primarily Ramor Stations 2, 3, 5 and 6 (highlighted in Figure 5-1). While the water quality model included organic and inorganic forms of nitrogen and phosphorus, for brevity results are only presented for the two parameters of interest – ammonia and total phosphorus.

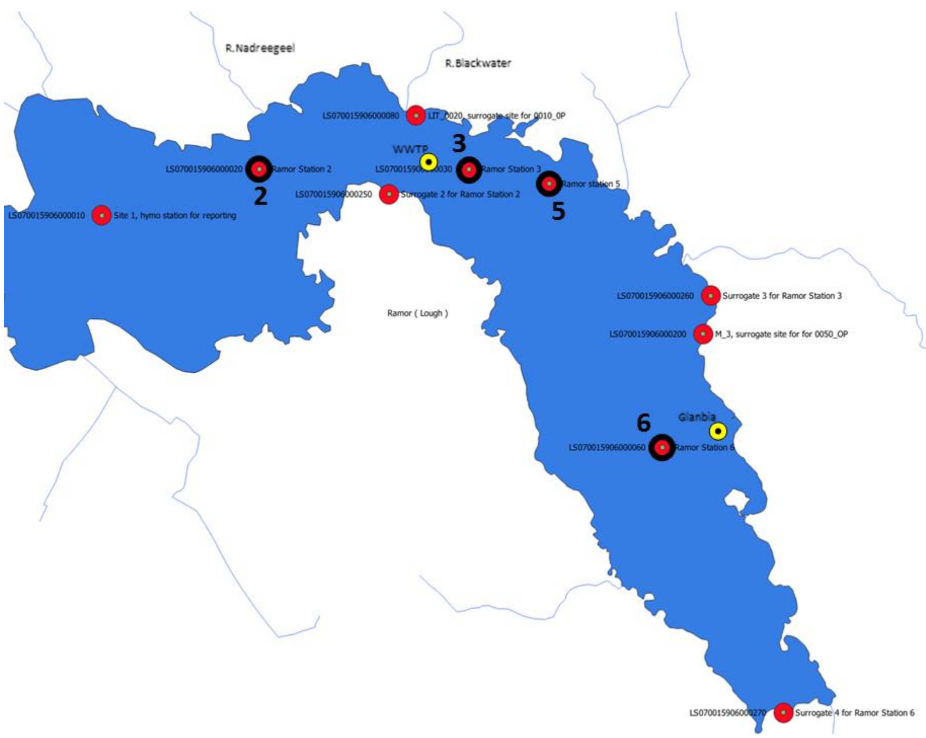


Figure 5-1. Map showing water chemistry monitoring stations (red) and outfalls (yellow).

Hydrodynamic Modelling Results

Hydrodynamic model outputs are presented in Appendix B for:

1. Mean river flow conditions
2. Low (Q95) river flow conditions

Figures C-1 – C-3 present hydrodynamic timeseries results at Station 2 to the west of the WWTP outfall, Station 3 to the east of the outfall and Station 6 in the southeast of the lake. Results are shown for water surface elevations, current speeds and current directions. Initially, the water in the lake is assumed stationary and so the model takes a number of days to spin-up and reach steady-state conditions (i.e. where water levels, and current speeds and directions remain constant with time). The plots show that the model reaches steady state at all locations after about 5 days.

Water Quality Results – Mean Flow Scenarios

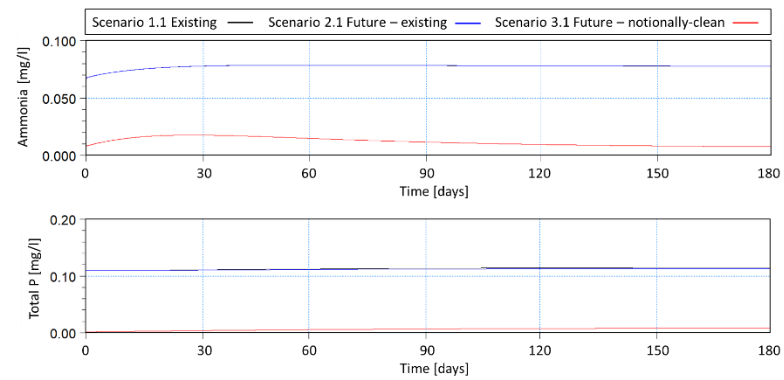
The mean flow scenarios included the following:

- Scenario 1.1: Existing
- Scenario 2.1: Future – existing
- Scenario 3.1: Future – notionally clean

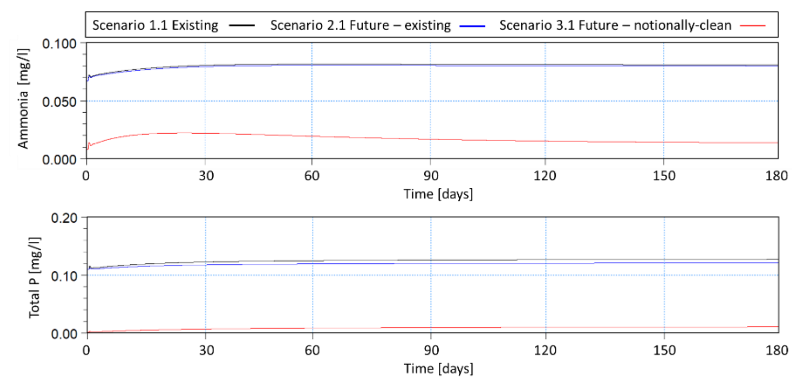
Timeseries of ammonia and total phosphorus from the three scenarios are compared in Figure 5-5 at Stations 2, 3, 5 and 6.

The graphs in Figure 5-5 show that there is very little difference between the results from Scenarios 1.1 and 2.1. Both of these scenarios use existing background water chemistry and existing river nutrient loads. The only difference between them is the WWTP discharge rate and chemistry with 1.1 using existing rates and chemistry and 2.1 using the future design flow and chemistry. For most of the graphs, the 1.1 and 2.1 concentrations are identical and the lines overlie each other. Where there are small differences, the future scenario concentrations are slightly lower due to the improved chemistry of the future plant effluent. The similarity of the model results for these two scenarios leads to the conclusions that (1) upgrading the plant to 6,000 PE has negligible impact on lake chemistry under existing lake and river conditions, and (2) river nutrient loads are currently the primary determinant of lake water chemistry. These findings are confirmed by the results of Scenario 3.1 which show that when notionally clean initial lake chemistry and river nutrient loads are used, ammonia and phosphorus levels in the lake are significantly reduced despite the higher WWTP discharge.

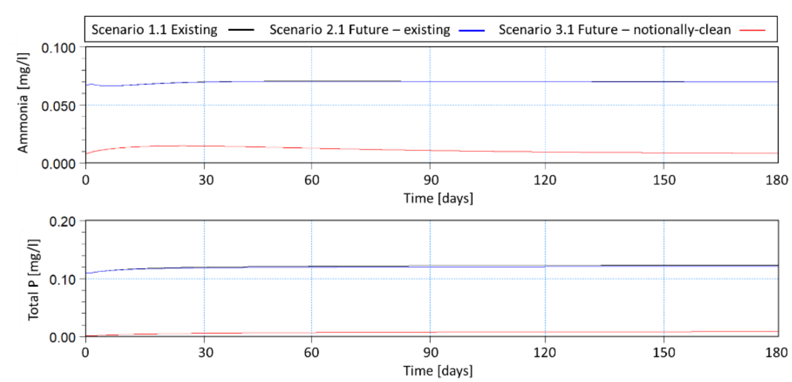
Station 2



Station 3



Station 5



Station 6

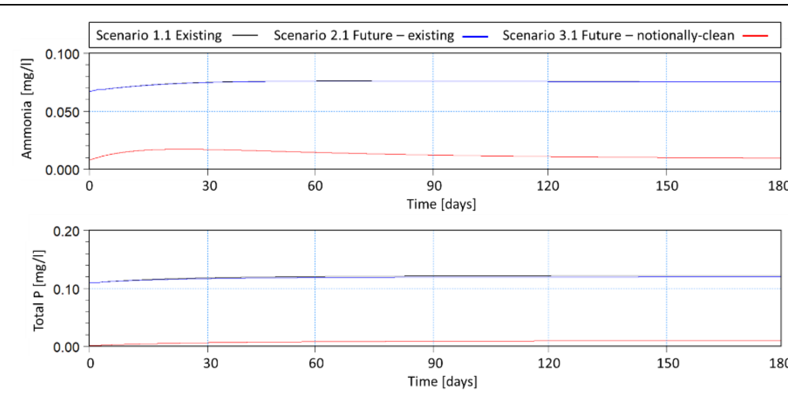


Figure 5-5. Comparison of ammonia and total phosphorus concentration timeseries between the three mean flow scenarios at Stations 2, 3, 5 and 6.

Water quality status maps were produced by comparing final steady-state nutrient concentrations with EQS values for High*,* Good*,* Moderate*,* Poor and Bad status. The EU intercalibration exercises defined High/Good and Good/Moderate boundaries for biological quality elements but the European Environment Agency produced thresholds for supporting nutrient conditions. Figures 5-6 and 5-7 present the water quality status maps for ammonia and total phosphorus for the three mean flow scenarios. The concentration snapshots used to create the maps are also shown for information.

Looking at the status maps for ammonia, it is seen that modelling the existing discharge conditions (Scenario 1.1) resulted in moderate status across most of the lake. Modelling the future plant discharge under existing lake and river conditions (Scenario 2.1) did not result in any change in status; however, when the future plant discharge was modelled under notionally clean lake and river conditions (Scenario 3.1), high water quality status was achieved across the whole lake. This provides further evidence that river nutrient loads are currently the primary factor influencing lake water quality.

Looking at the maps for total phosphorus, it is seen that regardless of the WWTP discharge specifications, using the existing lake and river conditions (Scenarios 1.1 and 2.1), resulted in bad status throughout the lake. This is in line with the most recent water quality assessments for the lake which found it failed on total phosphorus levels (see: Phosphorus and Ammonia Concentrations). However, when the future plant discharge is modelled under notionally clean lake and river conditions, phosphorus levels are significantly reduced, and the status improves to High or Good.

Looking at both sets of maps from a mixing zone assessment perspective, it is notable that while the WWTP plume is visible in the concentration snapshots, it is not visible in the water quality status maps and does not result in any near-field changes in water quality status. The model results therefore indicate that there is no mixing zone for ammonia or total phosphorus under mean flow conditions.

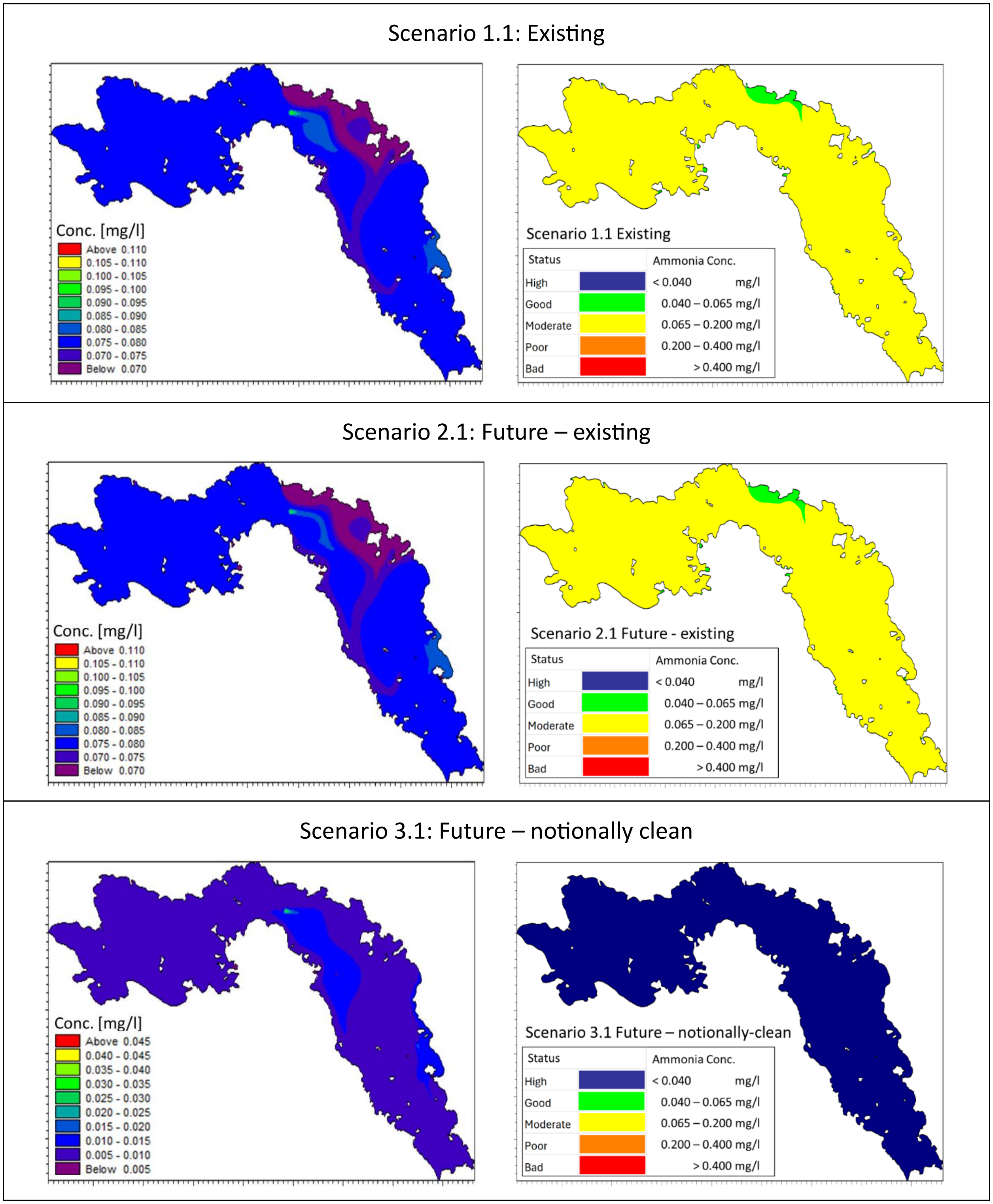


Figure 5-6. Ammonia status maps and corresponding concentration snapshots for mean flow scenarios.

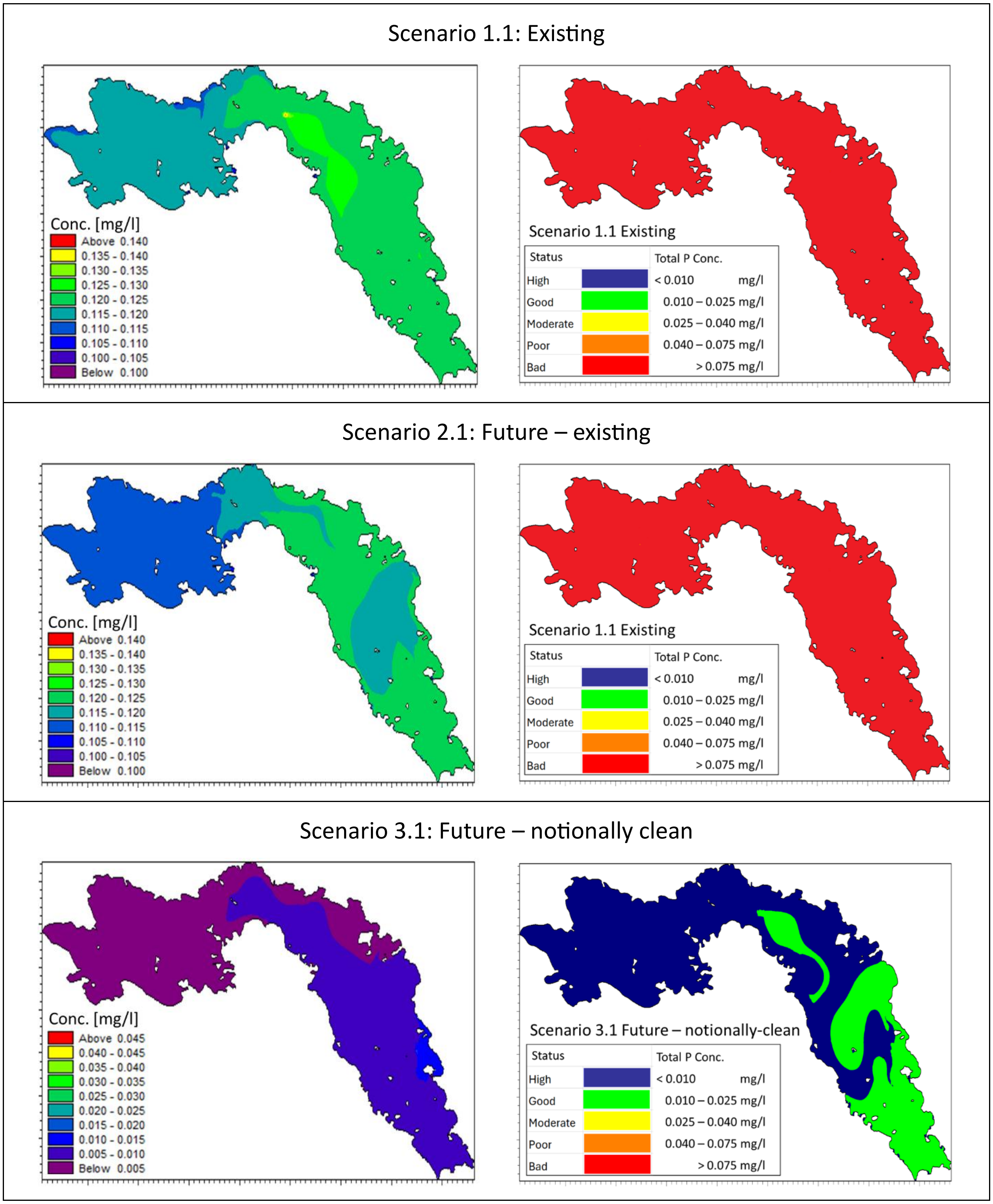


Figure 5-7. Total phosphorus status maps and corresponding concentration snapshots for mean flow scenarios.

Water Quality Results – Low Flow Scenarios

The low flow scenarios included the following:

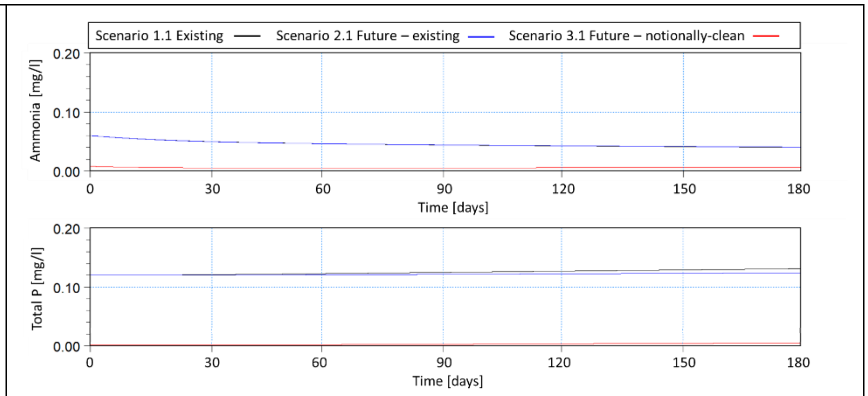
- Scenario 1.2: Existing
- Scenario 2.2: Future – existing
- Scenario 3.2: Future – notionally clean

Timeseries of ammonia and total phosphorus from the three scenarios are compared in Figure 5-8 at Stations 2, 3, 5 and 6. The results follow similar trends to those from the mean flow scenarios:

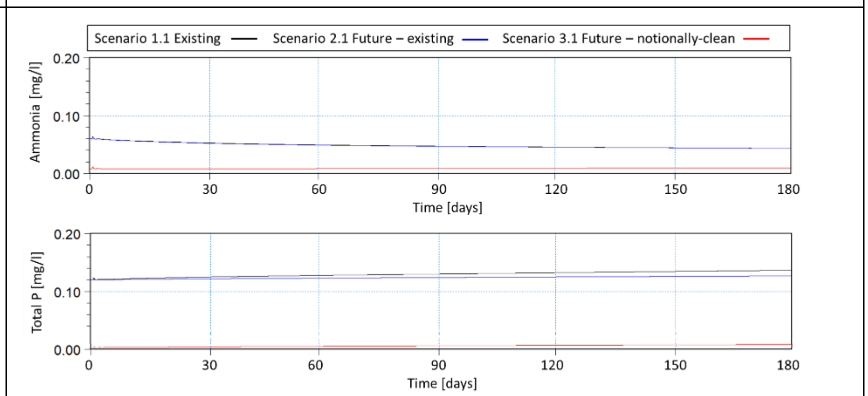
- There is very little difference between the concentrations predicted for Scenarios 1.2 and 2.2 which use existing lake and river nutrient conditions.
- Where there are small differences between 1.2 and 2.2, concentrations for the future plant discharge scenario (2.2) are lower due to the improved effluent chemistry.
- Future notionally clean concentrations (3.2) are significantly lower than those obtained using existing lake and river nutrient conditions, again indicating that the rivers are currently the primary influence on lake water quality.

Figures 5-9 and 5-10 present the water quality status maps for ammonia and total phosphorus for the three low flow scenarios (Note: the 95%ile EQS criteria were used here for ammonia water quality status). The concentration snapshots used to create the maps are also shown for information. For ammonia, high status is achieved throughout the lake for all three scenarios and there is no discernible mixing zone. For total phosphorus, the water quality is of Poor status throughout the lake under existing lake and river loading conditions (Scenarios 1.2 and 2.1) but improves to High/Good status under notionally clean lake and river loading conditions (Scenario 3.1). From a mixing zone perspective, although the near-field impact of the WWTP is observable in the concentration plots, it does not result in any near-field changes in water quality status. The model results therefore indicate that there is no mixing zone for ammonia or total phosphorus under low flow conditions.

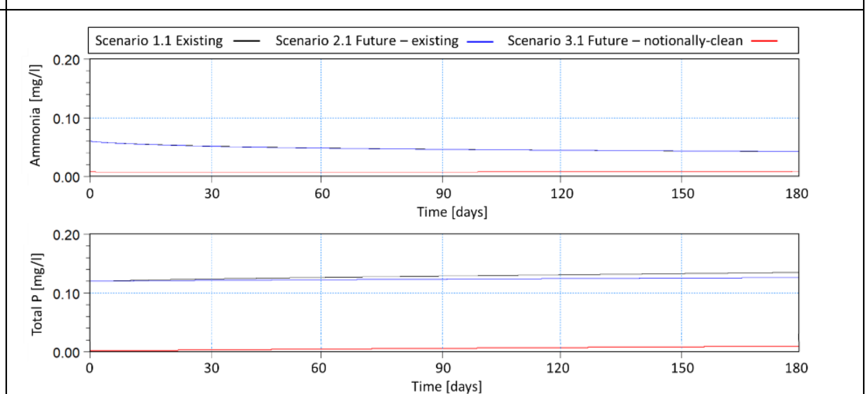
Station 2



Station 3



Station 5



Station 6

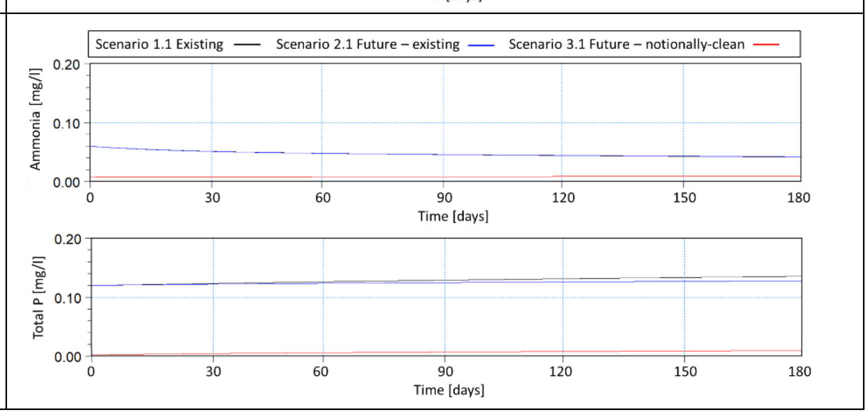


Figure 5-8. Comparison of ammonia and total phosphorus concentration timeseries between the three low flow scenarios at Stations 2, 3, 5 and 6.

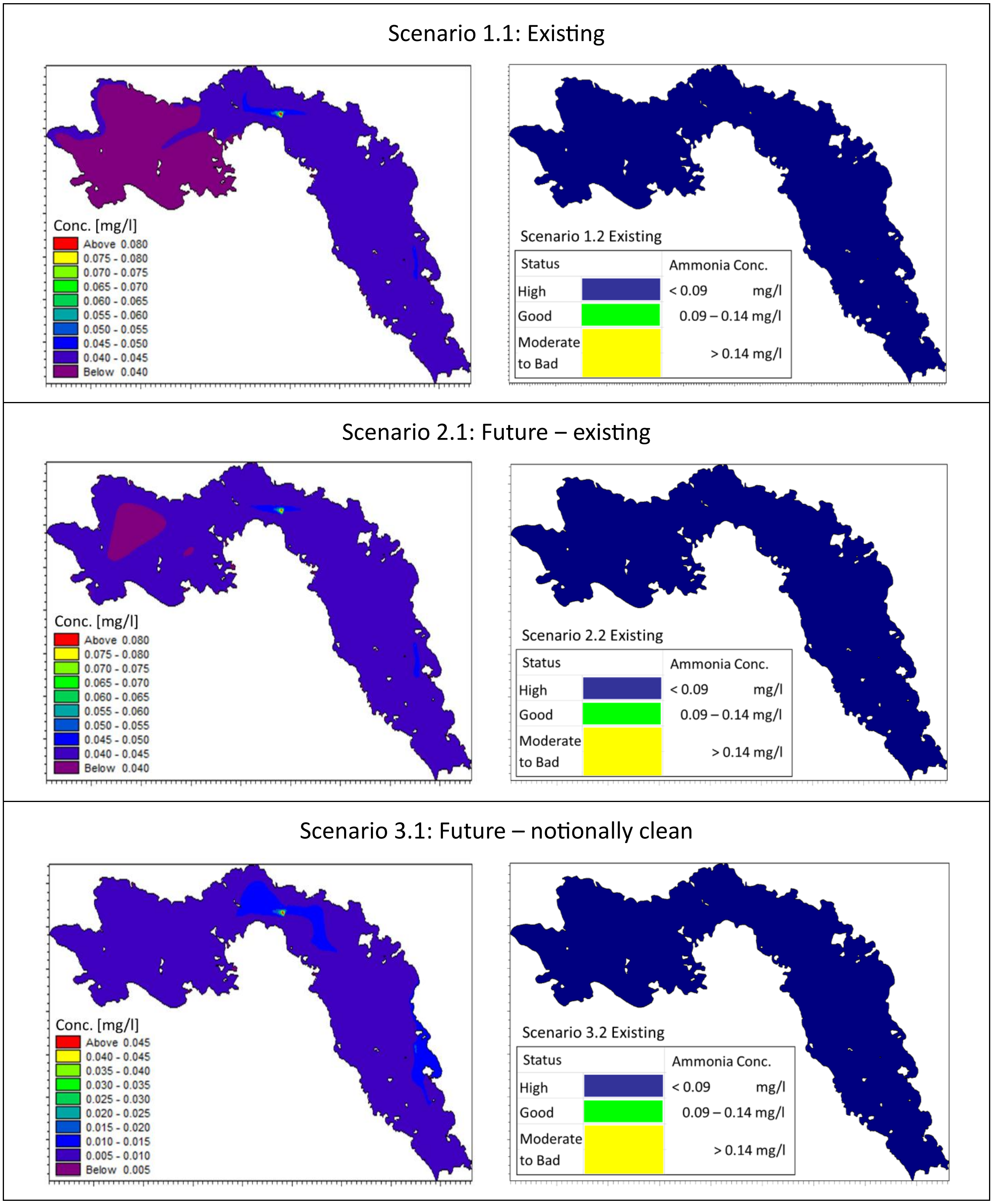
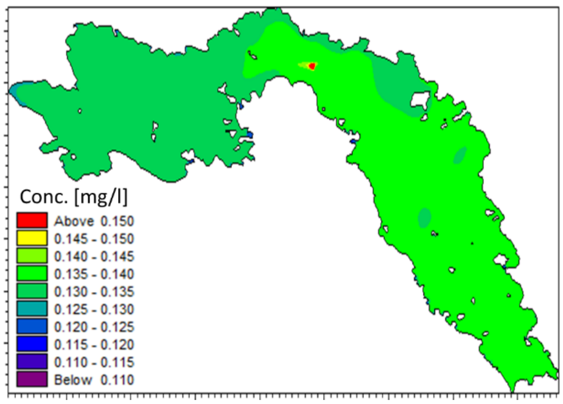
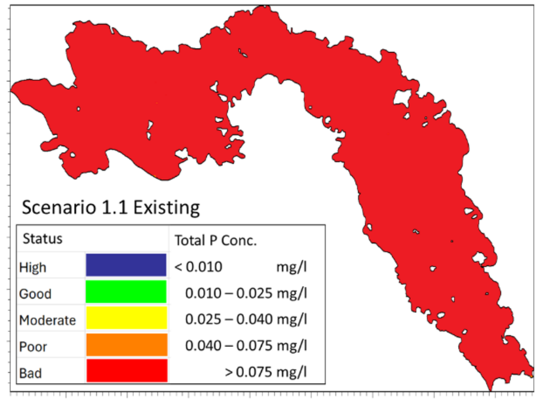


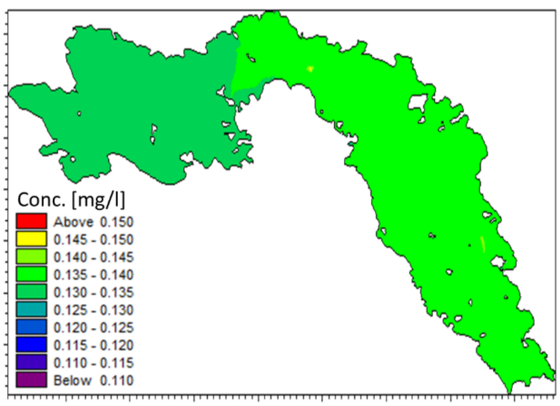
Figure 5-9. Ammonia status maps and corresponding concentration snapshots for low flow scenarios.

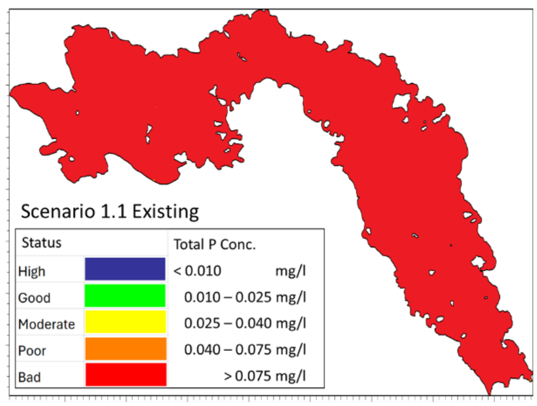
Scenario 1.1: Existing



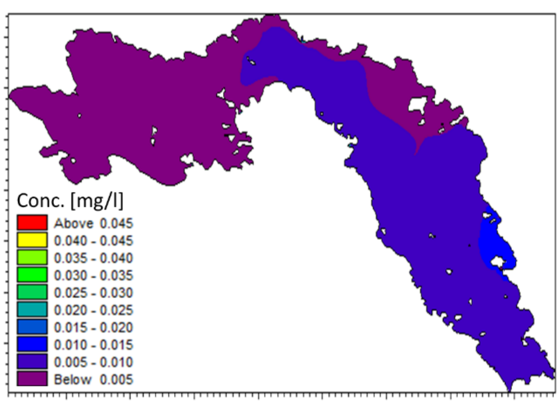


Scenario 2.1: Future – existing





Scenario 3.1: Future – notionally clean



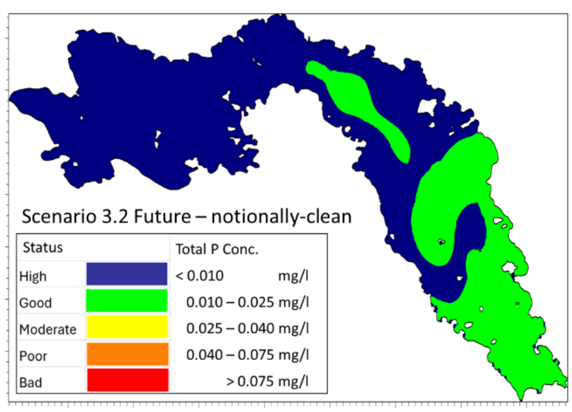


Figure 5-10. Total phosphorus status maps and corresponding concentration snapshots for low flow scenarios.

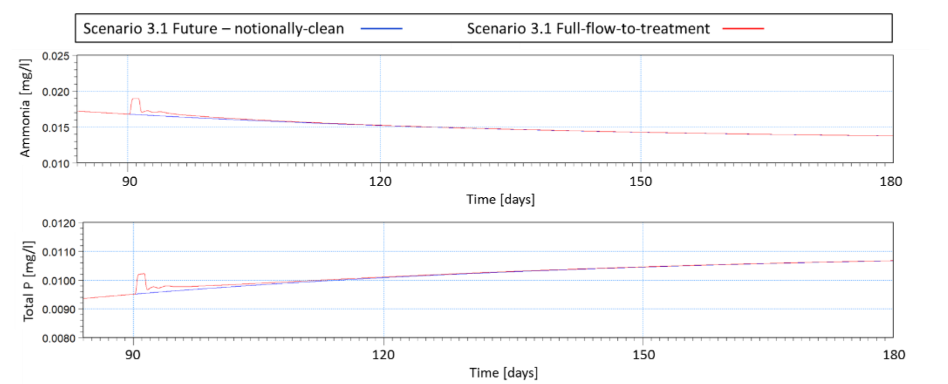
Water Quality Results – Full flow-to-treatment (FFT) Scenario

The full FFT scenario is used to demonstrate the impact of the future plant discharge on water quality when running at maximum discharge. As the effect of the treatment plant on water quality was shown to be negligible when existing lake and river nutrient conditions were used in the model, the full FFT scenario was simulated using notionally clean lake and river conditions. The results of the FFT scenario (No. 4) are therefore directly comparable with the Future – notionally clean Mean Flow Scenario (No. 3.1).

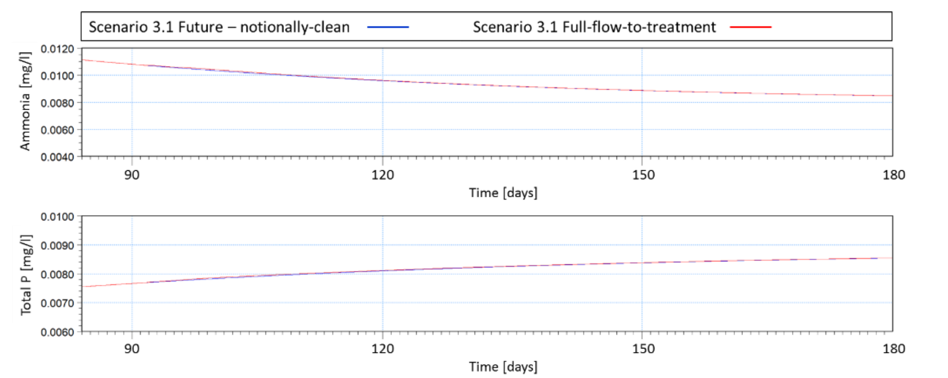
The plant was initially run at mean discharge, then ramped up to maximum discharge over a 2-h period, maintained at maximum discharge for 24 h and then reduced back to mean flow over a second 2-h period. From Figure 5.5, we see that steady-state conditions are reached by about Day 90; thus, full flow was set to occur over the 24 h of Day 91. To determine the impact of the 24 h of full flow, the results of Scenario 4 were compared with those from Scenario 3.1.

Figure 5-11 shows comparisons of ammonia and total phosphorus concentrations at Stations 3, 5 and 6 to the east of the WWTP outfall from Day 83 to Day 180. These stations were selected as they lie along the lake's main flushing pathway. The effect of the increase to full flow can clearly be seen at Station 3 closest to the outfall. There is a small but sharp increase in nutrient levels on Day 91 followed by a gradual reduction as conditions return to normal once the flow reverts back to its mean rate. The increase to full flow has very little noticeable impact at Stations 5 and 6 further away from the outfall. Differences in the concentration timeseries were calculated and are shown in Figure 5-12. The peak differences recorded at Station 3 were 0.0024 mg/l for ammonia and 0.0007 mg/l for total phosphorus; these are well below the limits of detection of 0.02 mg/l for ammonia and 0.01 mg/l for total phosphorus and are therefore negligible. Peak differences at Stations 5 and 6 were an order of magnitude smaller. At all three stations, differences gradually reduce to zero after their peaks.

Station 3



Station 5



Station 6

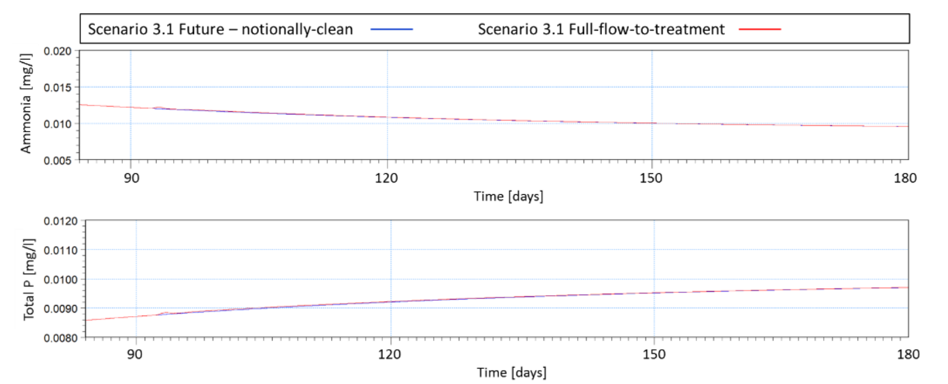


Figure 5-11. Comparison of ammonia and total phosphorus concentration timeseries between FFT Scenario 4 and Scenario 3.1.

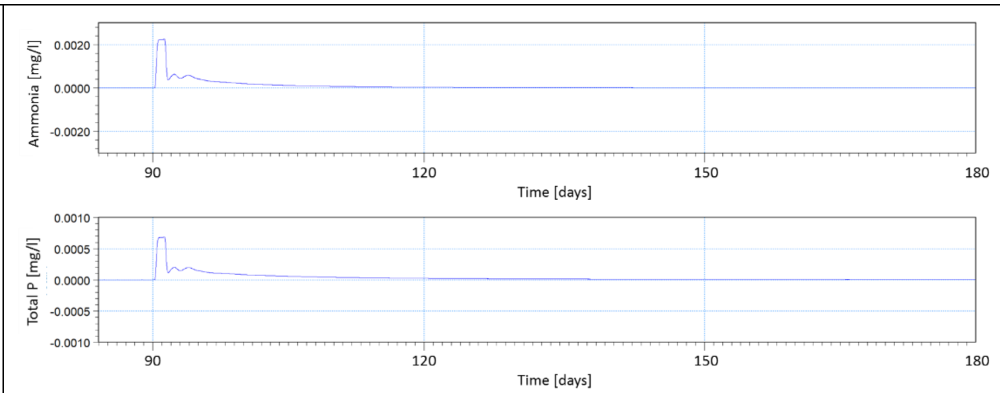
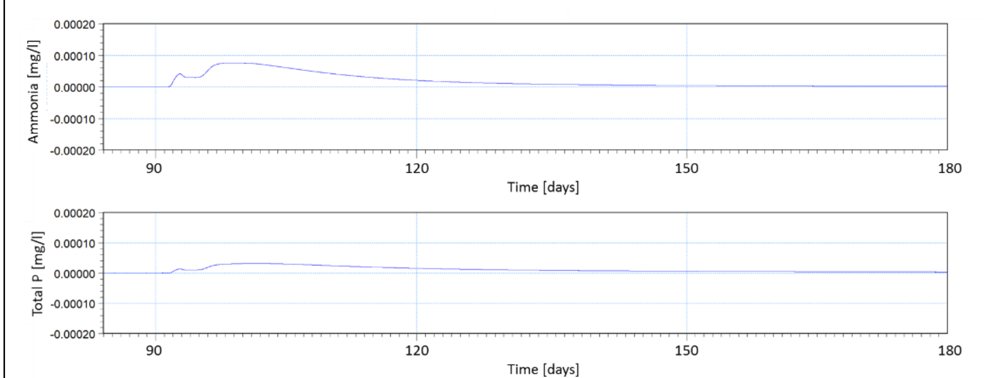
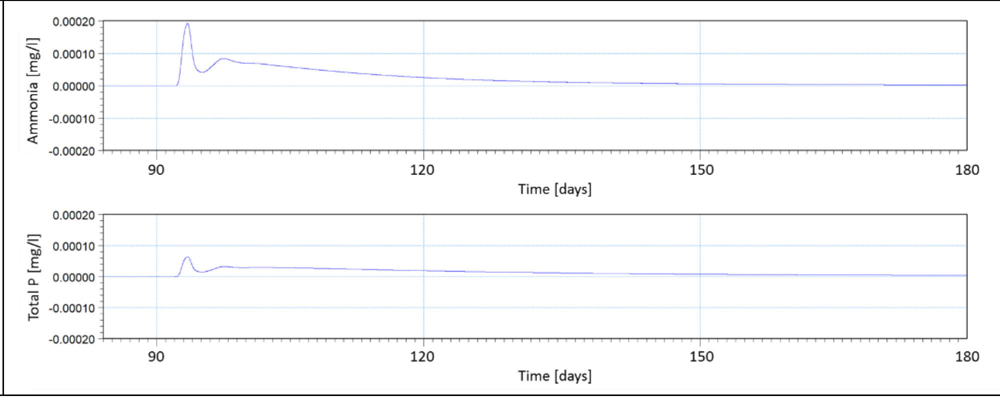
Station 3	
Station 5	
Station 6	

Figure 5-12. Differences in ammonia and total phosphorus concentration timeseries between FFT Scenario 4 and Scenario 3.1.

The time required for water quality conditions in the FFT scenario to return to normal after the maximum discharge can be determined from the snapshots in Figure 5-13 and 5-14. These show the differences in nutrient concentrations caused by the 24 h increase to maximum flow calculated 1 day before peak flow (D –1), the day of peak flow (D 0) and 1, 3, 5, 7, 10 and 15 days after peak flow. For ammonia, 1 day after peak flow the largest differences are of the order of 0.025 mg/l, slightly above the limit of detection (0.02 mg/l). After 3 days, differences fall below the limit of detection (0.02 mg/l) and are therefore considered negligible. For total phosphorus, just 1 day after peak flow the largest differences are of the order of 0.001 mg/l and thus are already below the limit of detection (0.01 mg/l).

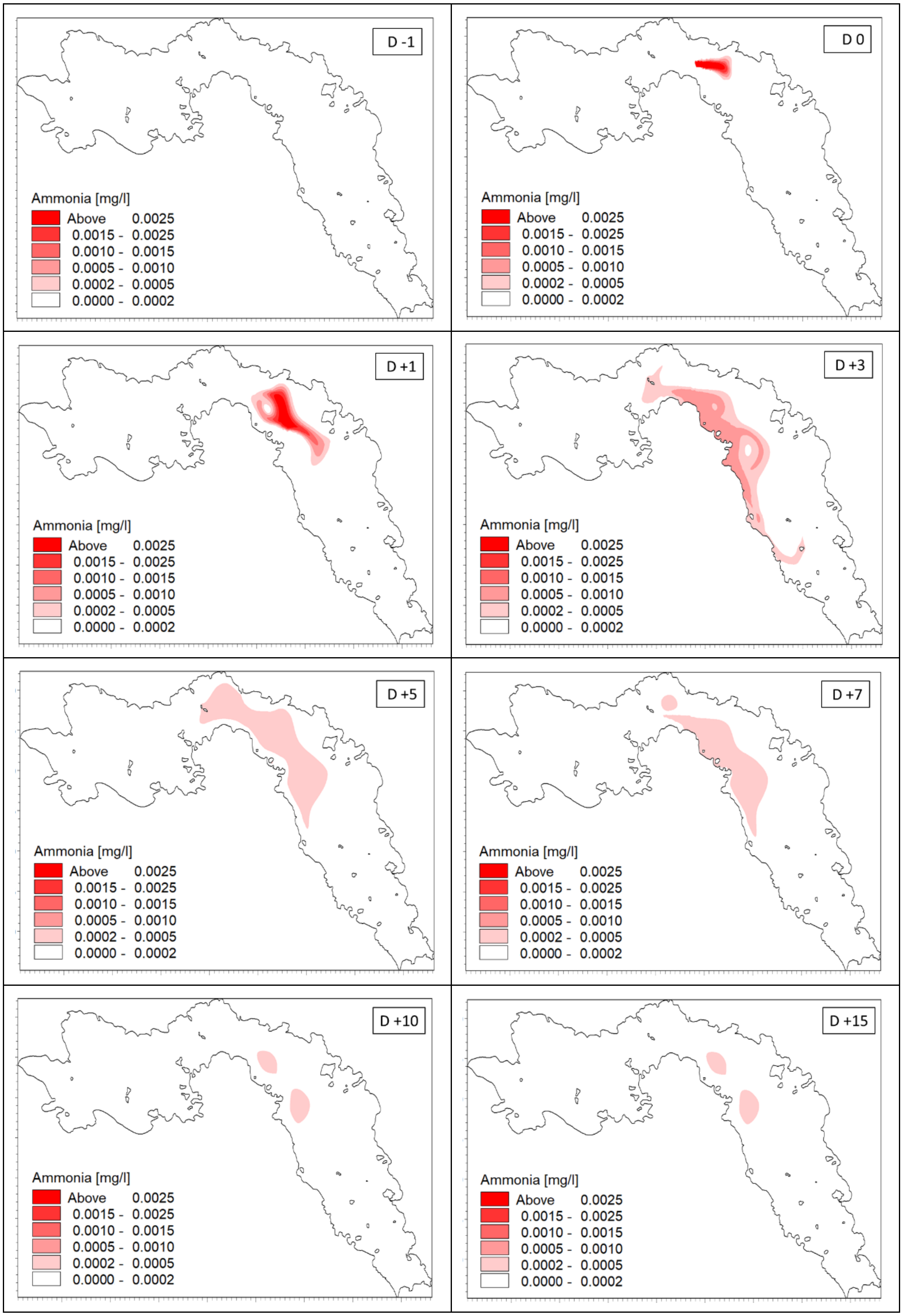


Figure 5-13. Ammonia concentration difference plots for FFT scenario at various days (D) relative to time of maximum discharge.

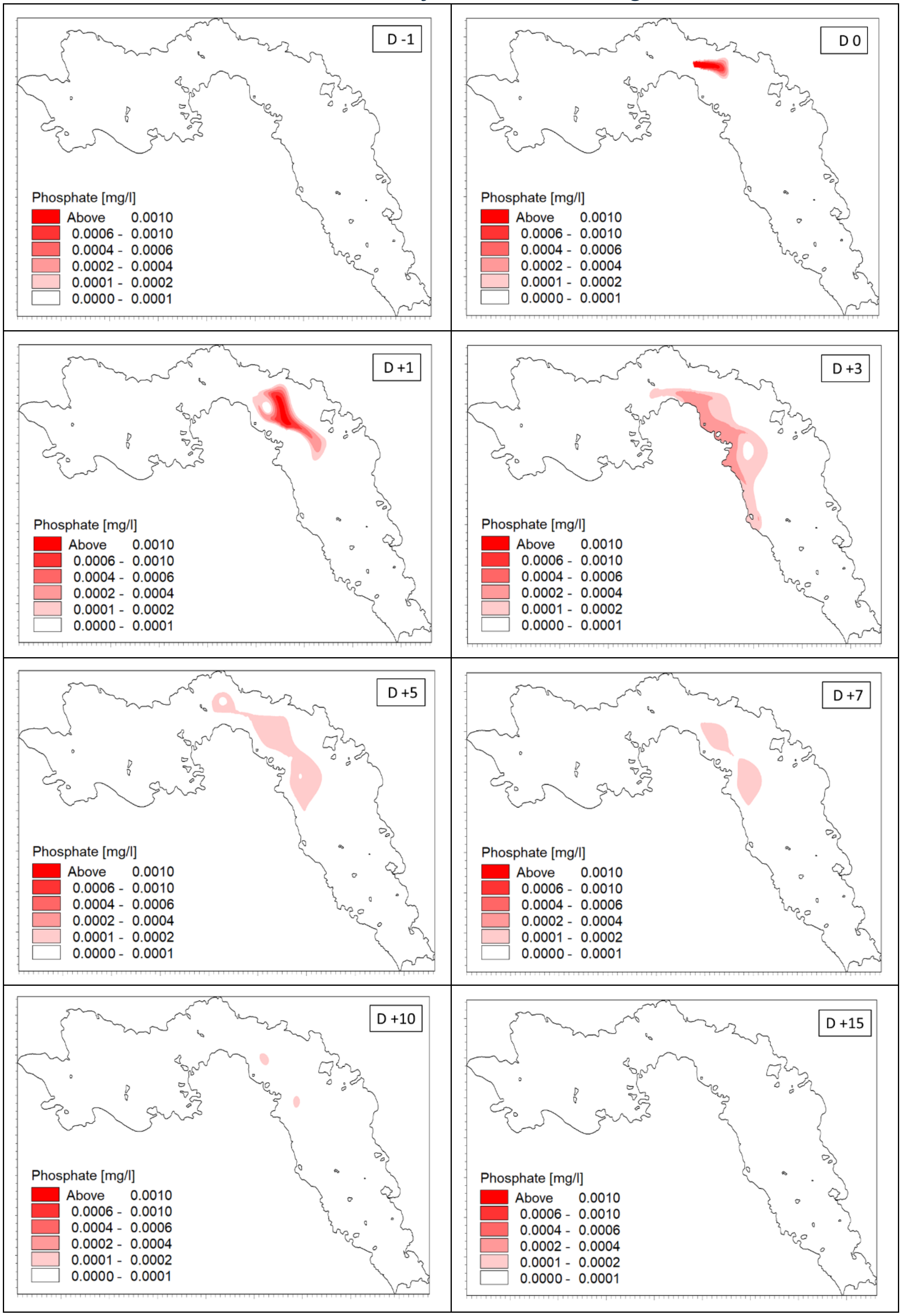


Figure 5-14. Ammonia concentration difference plots for FFT scenario at various days (D) relative to time of maximum discharge.

6. Overall Summary and Conclusions

Summary

Virginia WWTP in Co. Cavan currently treats wastewater from a PE of 3,800; it is proposed to upgrade the plant to treat a PE of 6,000. The WWTP discharges treated effluent into Lough Ramor. A 2-dimensional model of Lough Ramor was developed and applied to perform a Tier 3 mixing zone assessment for the future upgraded discharge. The industry standard model MIKE21 was used. The model simulates lake hydrodynamics and five nutrients, namely, organic nitrogen, ammonia and nitrate nitrogen, organic phosphorus and inorganic phosphorus. Model suitability was assessed by simulating hydrodynamic and water quality conditions in the lake for the year 2018 and comparing the results with measured data. The model was deemed suitable for use for mixing zone assessment.

The mixing zone assessment involved the simulation of three flow conditions: (1) mean river flows for comparison of nutrient concentrations with mean EQS criteria, (2) low (Q95) river flows for comparison of nutrient concentrations with 95%ile EQS criteria, and (3) full flow-to-treatment, where the discharge is increased from mean flow rate to max flow rate for a 24-h period, which is used to assess the impact of the plant when running at maximum flow. Seven water quality scenarios were simulated in total:

- (1) and (2) mean and low river flows with the current WWTP discharge and existing lake and river chemistry
- (3) and (4) mean and low river flows with the future upgraded WWTP discharge and existing lake and river water chemistry
- (5) and (6) mean and low river flows with the future upgraded WWTP discharge and notionally clean lake and river water chemistry
- (7) mean river flows with full FFT for the future upgraded WWTP and notionally clean lake and river water chemistry

All model simulations were run for 180 days so that steady-state conditions were achieved. 2D spatial concentration maps for ammonia and total phosphorus were compared with EQS criteria and the resulting water quality status maps were used to identify the presence and extents of any mixing zones that were formed.

Conclusions

The following are the main conclusions from the mixing zone assessment study based on the model results:

- The rivers are currently the primary factor influencing lake chemistry; the WWTP has a negligible impact.
- If river nutrient loads remain as they are, the upgraded plant will have a negligible effect on water quality in the lake. The model results show that ammonia and total phosphorus concentrations will either remain the same or slightly improve due to the improved chemistry of the plant's future effluent.
- Based on the water quality status maps, a WWTP mixing zones was not identified for any of the modelled mean or low-flow scenarios.
- Based on the full flow-to-treatment scenario results, it can be concluded that increasing the plant to maximum discharge has a relatively small impact on nutrient levels. Compared with the mean flow scenario, ammonia and total phosphorus concentrations in the FFT scenario temporarily increase in the vicinity of the outfall but very quickly return to the same levels as the mean flow scenario – this occurs within 3 days for ammonia and within 1 day for total phosphorus.
- The modelling results demonstrate that the proposed discharge and associated ELVs are compatible with the achievement of WFD objectives of receiving waters.

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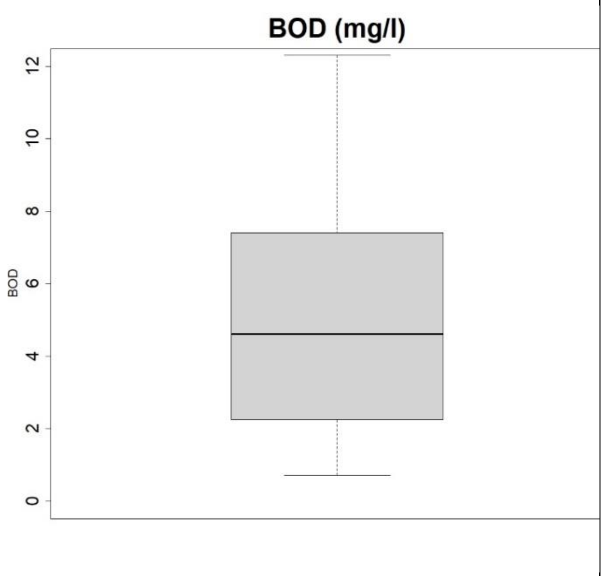
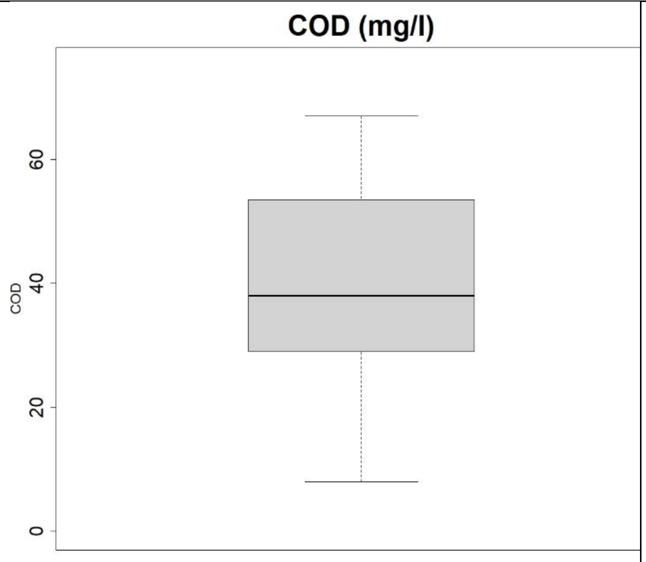
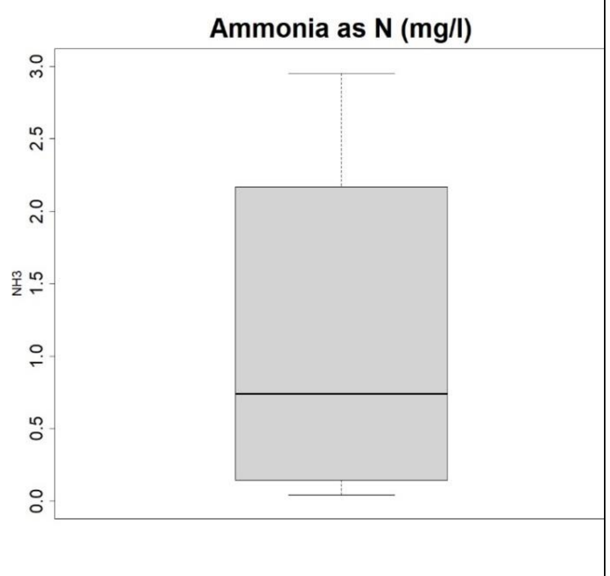
Appendix A: Virgina WWTP effluent discharge ranges from January 2021 to November 2023



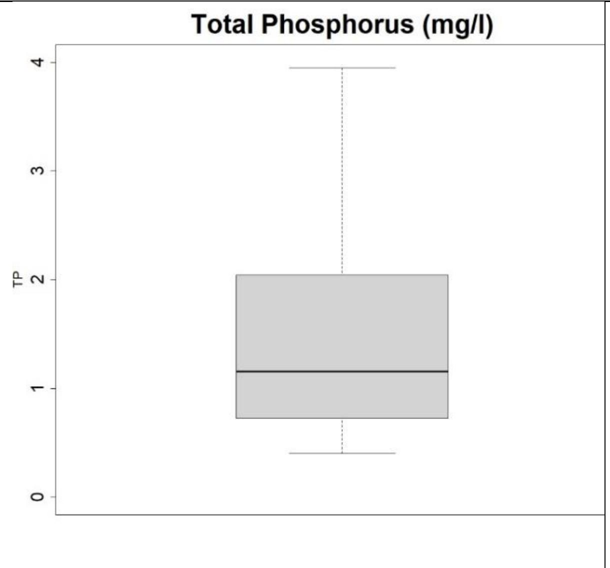
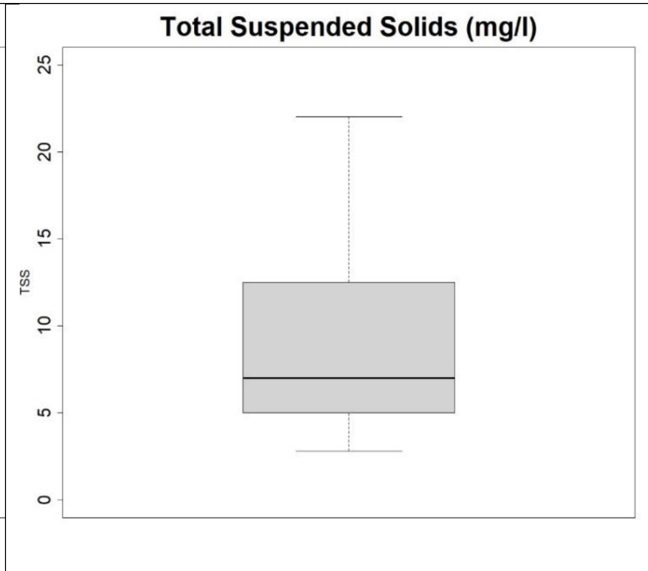
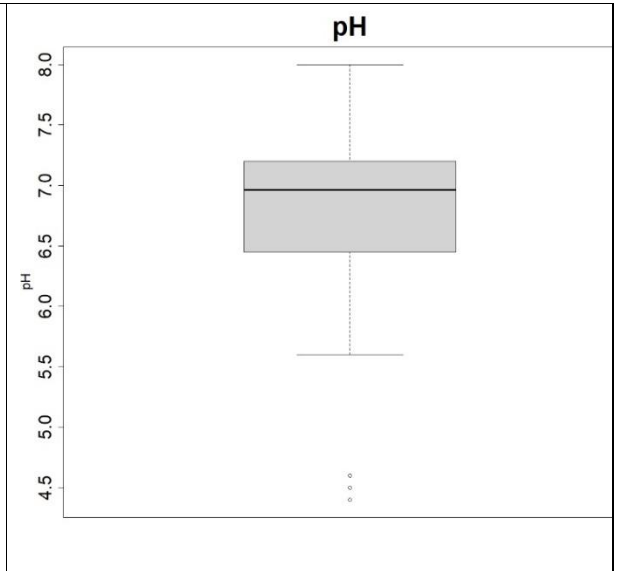
BOD ranges for Jan 2021 to Nov 2023



COD ranges for Jan 2021 to Nov 2023



Ammonia ranges for Jan 2021 to Nov 2023

		
TP ranges for Jan 2021 to Nov 2023	TSS ranges for Jan 2021 to Nov 2023	pH ranges for Jan 2021 to Nov 2023

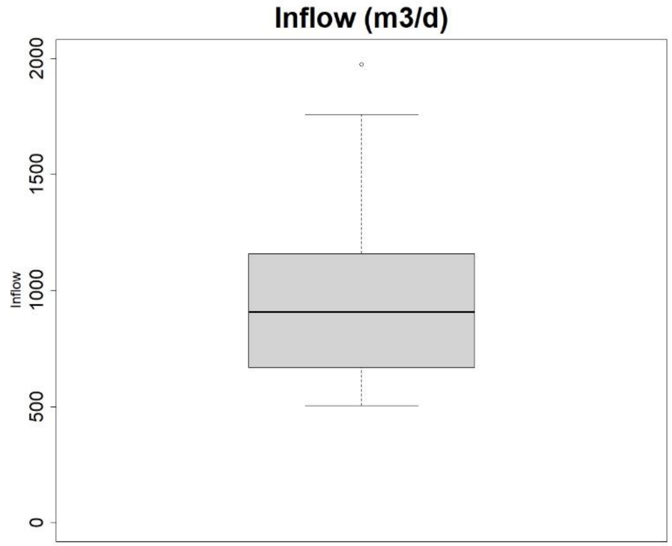
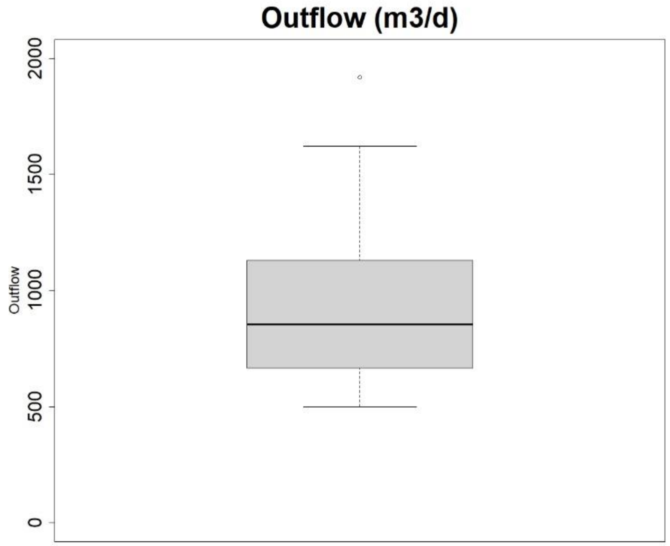
	
Inflowing volume ranges for Jan 2021 to Nov 2023	Outflowing volume ranges for Jan 2021 to Nov 2023

Table A-1: Statistical ranges for discharge parameters (Jan 2021 to Nov 2023).

	BOD (mg/l)	COD (mg/l)	TP (mg/l)	TSS (mg/l)	NH_3 (mg/l N)	pH	Inflow (m^3/day)	Outflow (m^3/day)
Minimum	0.71	8.0	0.400	2.83	0.040	4.4	504	498
1st Quartile	2.38	30.0	0.733	5.00	0.145	6.5	670	666
Median	4.60	38.0	1.155	7.00	0.740	7.0	908	854
Mean	7.14	46.3	1.623	10.97	2.179	6.7	1,093	931
3rd Quartile	7.20	52.8	1.963	12.25	2.165	7.2	1,159	1,129
Maximum	29.80	132.0	7.500	49.00	22.290	8.0	2,782	1,919

Appendix B – Mixing Zone Model Input Data and Sources

Table B-1. Model input data for mixing zone assessment simulations.

	1. Existing		2. Future – Existing conditions		3. Future – Notionally clean		4. Full-flow-to-treatment
Variable	**1.1 Mean Flow**	**1.2 Low Flow (Q95)**	**2.1 Mean Flow**	**2.2 Low Flow (Q95)**	**3.1 Mean Flow**	**3.2 Low Flow (Q95)**	
Initial Conditions							
Initial water depth	84.38 m OD Poolbeg	84.38 m OD Poolbeg	84.38 m OD Poolbeg	84.38 m OD Poolbeg	84.38 m OD Poolbeg	84.38 m OD Poolbeg	84.38 m OD Poolbeg
Lake Water Temp	11.7°	11.7°	11.7°	11.7°	11.7°	11.7°	11.7°
Air Temp	9.2°	9.2°	9.2°	9.2°	9.2°	9.2°	9.2°
Initial lake chemistry							
- Org N	1.096 mg/l	1.096 mg/l	1.096 mg/l	1.096 mg/l	0.0397 mg/l	0.0397 mg/l	0.0397 mg/l
- Ammonia	0.067 mg/l	0.067 mg/l	0.067 mg/l	0.067 mg/l	0.008 mg/l	0.008 mg/l	0.008 mg/l
- Nitrate	1.079 mg/l	1.079 mg/l	1.079 mg/l	1.079 mg/l	0.071 mg/l	0.071 mg/l	0.071 mg/l
- Org P	0.040 mg/l	0.040 mg/l	0.040 mg/l	0.040 mg/l	0.0004 mg/l	0.0004 mg/l	0.0004 mg/l
- MRP	0.039 mg/l	0.039 mg/l	0.039 mg/l	0.039 mg/l	0.0008 mg/l	0.0008 mg/l	0.0008 mg/l
Boundary Conditions							
Wind							
- Mean speed	6.2 m/s	6.2 m/s	6.2 m/s	6.2 m/s	6.2 m/s	6.2 m/s	6.2 m/s
- Mean direction	206° (SSW)	206° (SSW)	206° (SSW)	206° (SSW)	206° (SSW)	206° (SSW)	206° (SSW)
River Inflows							
- Blackwater	2.657 m^3/s	0.160 m^3/s	2.657 m^3/s	0.160 m^3/s	2.657 m^3/s	0.160 m^3/s	2.657 m^3/s
- Nadreegeel	1.029 m^3/s	0.057 m^3/s	1.029 m^3/s	0.057 m^3/s	1.029 m^3/s	0.057 m^3/s	1.029 m^3/s
- Lislea	0.241 m^3/s	0.078 m^3/s	0.241 m^3/s	0.078 m^3/s	0.241 m^3/s	0.078 m^3/s	0.241 m^3/s
- River W	0.504 m^3/s	0.015 m^3/s	0.504 m^3/s	0.015 m^3/s	0.504 m^3/s	0.015 m^3/s	0.504 m^3/s
River Chemistry							
Blackwater					All Rivers	All Rivers	All Rivers
- Org N	1.343 mg/l	1.343 mg/l	1.343 mg/l	1.343 mg/l	0.0754 mg/l	0.0754 mg/l	0.0754 mg/l
- Ammonia	0.043 mg/l	0.043 mg/l	0.043 mg/l	0.043 mg/l	0.0080 mg/l	0.0080 mg/l	0.0080 mg/l
- Nitrate	1.404 mg/l	1.404 mg/l	1.404 mg/l	1.404 mg/l	0.1429 mg/l	0.1429 mg/l	0.1429 mg/l
- Org P	0.056 mg/l	0.056 mg/l	0.056 mg/l	0.056 mg/l	0.0025 mg/l	0.0025 mg/l	0.0025 mg/l
- MRP	0.070 mg/l	0.070 mg/l	0.070 mg/l	0.070 mg/l	0.0050 mg/l	0.0050 mg/l	0.0050 mg/l

Table B-1. Cont'd

River Chemistry All Others - Org N - Ammonia - Nitrate - Org P - MRP	 1.228 mg/l 0.077 mg/l 1.280 mg/l 0.051 mg/l 0.056 mg/l	 1.228 mg/l 0.077 mg/l 1.280 mg/l 0.051 mg/l 0.056 mg/l	 1.228 mg/l 0.077 mg/l 1.280 mg/l 0.051 mg/l 0.056 mg/l	 1.228 mg/l 0.077 mg/l 1.280 mg/l 0.051 mg/l 0.056 mg/l			
WWTP Inflow	931 m^3/d (0.0108 m^3/s)	931 m^3/d (0.0108 m^3/s)	1687.5 m^3/day (0.0195 m^3/s)	1687.5 m^3/day (0.0195 m^3/s)	1687.5 m^3/day (0.0195 m^3/s)	1687.5 m^3/day (0.0195 m^3/s)	*See note below on FFT.
WWTP Chemistry - Org N - Ammonia - Nitrate - Org P - MRP	 2.73 mg/l 2.18 mg/l 10.00 mg/l 0.62 mg/l 1.00 mg/l	 2.73 mg/l 2.18 mg/l 10.00 mg/l 0.62 mg/l 1.00 mg/l	 2.5 mg/l 1.0 mg/l 8.0 mg/l 0.1 mg/l 0.2 mg/l	 2.5 mg/l 1.0 mg/l 8.0 mg/l 0.1 mg/l 0.2 mg/l	 2.5 mg/l 1.0 mg/l 8.0 mg/l 0.1 mg/l 0.2 mg/l	 2.5 mg/l 1.0 mg/l 8.0 mg/l 0.1 mg/l 0.2 mg/l	 2.5 mg/l 1.0 mg/l 8.0 mg/l 0.1 mg/l 0.2 mg/l
Glanbia Inflow - EF6 - EF7	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/day (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)	 1,378 m^3/d (0.0159 m^3/s) 923 m^3/day (0.0107 m^3/s)
Glanbia Chemistry EF6 - Org N - Ammonia - Nitrate - Org P - MRP EF7 - Org N - Ammonia - Nitrate - Org P - MRP	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l	 0.000 mg/l 0.467 mg/l 0.000 mg/l 0.161 mg/l 0.000 mg/l 3.124 mg/l 0.508 mg/l 0.000 mg/l 0.627 mg/l 0.000 mg/l
River Outflow (rivers + outfalls)	4.4684 m^3/s	0.3474 m^3/s	4.4771 m^3/s	0.3561 m^3/s	4.4771 m^3/s	0.3561 m^3/s	Changes due to varying WWTP inflow.

**For FFT scenario, WWTP discharge initially at future mean discharge (1,687.5 m^3/day). It is then linearly increased up to future max (3,450 m^3/day) over 2 h, kept at future max for 24 h, and then linearly reduced back down to future mean over 2 h.*

Table B-2. Sources of input data for hydrodynamic model.

Data	Values	Source
Initial water depth	84.38 m OD Poolbeg	OPW Virginia (lake) station (07081): using all daily data available for full years from 01/01/2008 to 31/12/2023
Mean River Inflows - Blackwater (Virginia) - Nadreegeel - Lislea - River W	 2.657 m^3/s 1.029 m^3/s 0.241 m^3/s 0.504 m^3/s	EPA's River Estimate Hydrotool https://gis.epa.ie/EPAMaps/Water
Mean River Outflow - Blackwater (Stramatt)	 4.431 m^3/s	EPA's River Estimate Hydrotool https://gis.epa.ie/EPAMaps/Water
Q95 River Inflows - Blackwater (Virginia) - Nadreegeel - Lislea - River W	 0.160 m^3/s 0.057 m^3/s 0.078 m^3/s 0.015 m^3/s	EPA's River Estimate Hydrotool https://gis.epa.ie/EPAMaps/Water
Q95 Mean River Outflow - Blackwater (Stramatt)	 0.302 m^3/s	EPA's River Estimate Hydrotool https://gis.epa.ie/EPAMaps/Water
Current WWTP Outflow - Mean - Max	 931 m^3/day 1,919 m^3/day	Measured plant outflow data: Jan 2021 – Dec 2023
Future WWTP Outflow - Mean - Max	 1687.5 m^3/day 3,450 m^3/day	Mean: 1.25xDWF for 6,000 PE with DWF calculated as 175 l/PE/day + 50 l/PE/day infiltration Max – provided by WWTP design team.
Glanbia Mean Outflow - EF6 - EF7	 1,378 m^3/day 926 m^3/day	Calculated from average monthly discharges in 2014 AER. 2014 used as relevant data not included in more recent AERs
Wind - Mean speed - Mean direction	 6.2 m/s 206°	Met Éireann daily wind data for Mullingar station. Calculated for Jan 2004 – Dec 2023

Mean Lake Water Temp	11.7°	Virginia (lake) station (07081): daily data from 02/2016 – 04/2024
Mean Air Temp	9.2°	Met Éireann long-term monthly data analysis for Mullingar station: https://www.met.ie/climate/available-data/monthly-data

Table B-3. Sources of input data for water quality model (mg/l N or P).

Water Chemistry	Org N	Ammonia	Nitrate	Org P	MRP	Source
Initial Lake						
- Existing	1.096	0.067	1.079	0.0400	0.0390	EPA data: 2019–2023
- Notionally clean	0.397	0.008	0.071	0.0004	0.0008	L. Ramor Calculated from EQS values
Existing Rivers						
- Blackwater	1.343	0.043	1.404	0.056	0.070	EPA data 2019–2023
- Nadreegeel	1.228	0.077	1.280	0.051	0.056	EPA data 2019–2023
- Lislea	1.228	0.077	1.280	0.051	0.056	Nadreegeel data assigned
- River W	1.228	0.077	1.280	0.051	0.056	Nadreegeel data assigned
Notionally Clean Rivers						
- All	0.0754	0.0080	0.1429	0.0025	0.0050	Calculated from EQS values
WWTP						Existing: From measured data (2021–2023) and design team recommendations
- Existing	2.73	2.18	10.00	0.62	1.00	
- Future	2.5	1.00	8.00	0.10	0.20	Future: From design team
Glanbia						From 2014 AER. 2014 used as relevant data not included in more recent AERs
- EF7	3.124	0.508	0.000	0.627	0.000	
- EF6	0.000	0.467	0.000	0.161	0.000	

Appendix C – Mixing Zone Model Hydrodynamic Model Results

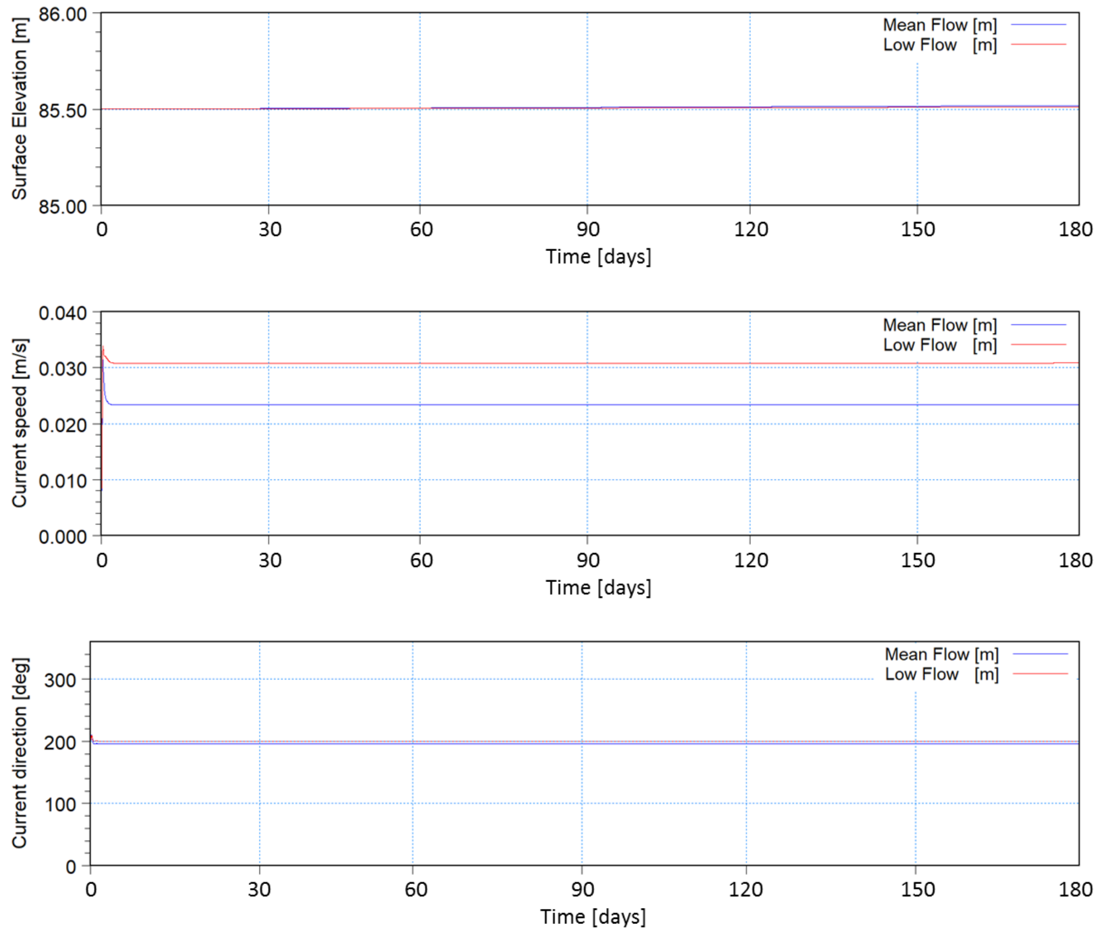


Figure C-1. Hydrodynamic model results at Station 2 for mean and low river flows.

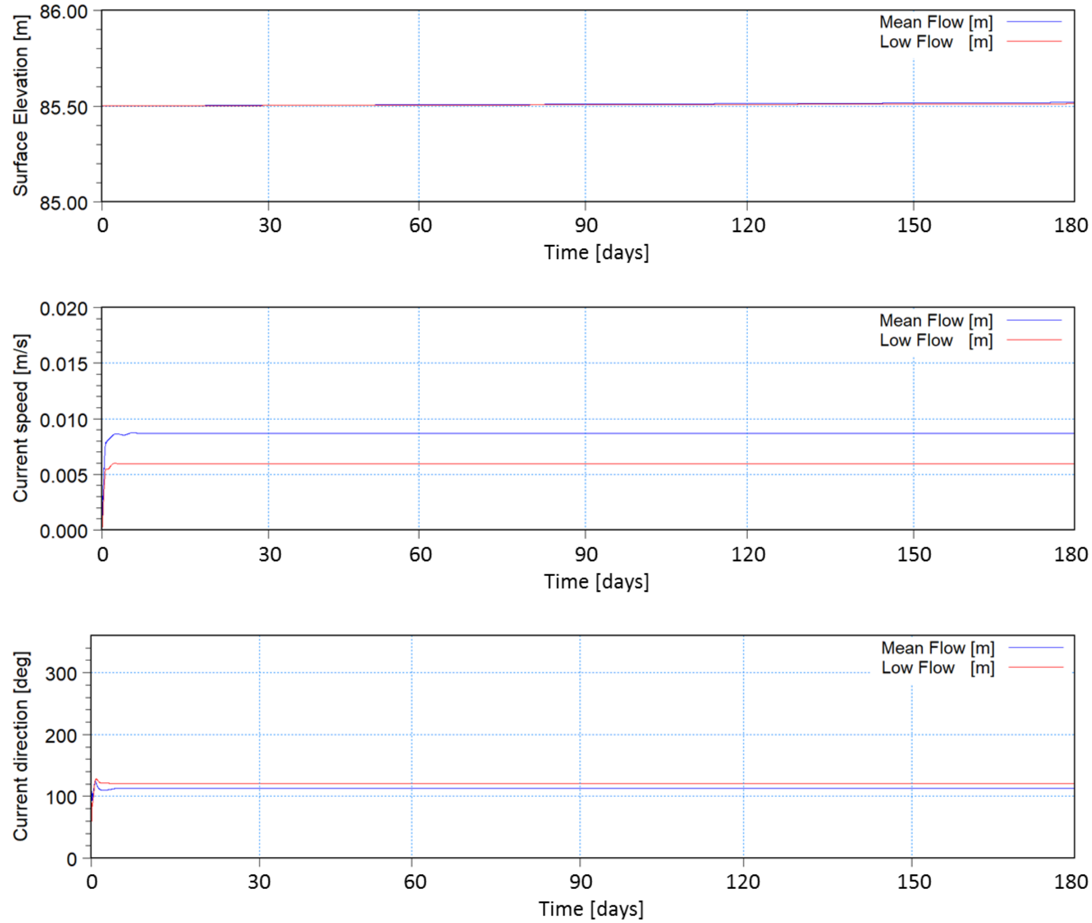


Figure C-2. Hydrodynamic model results at Station 3 for mean and low river flows.

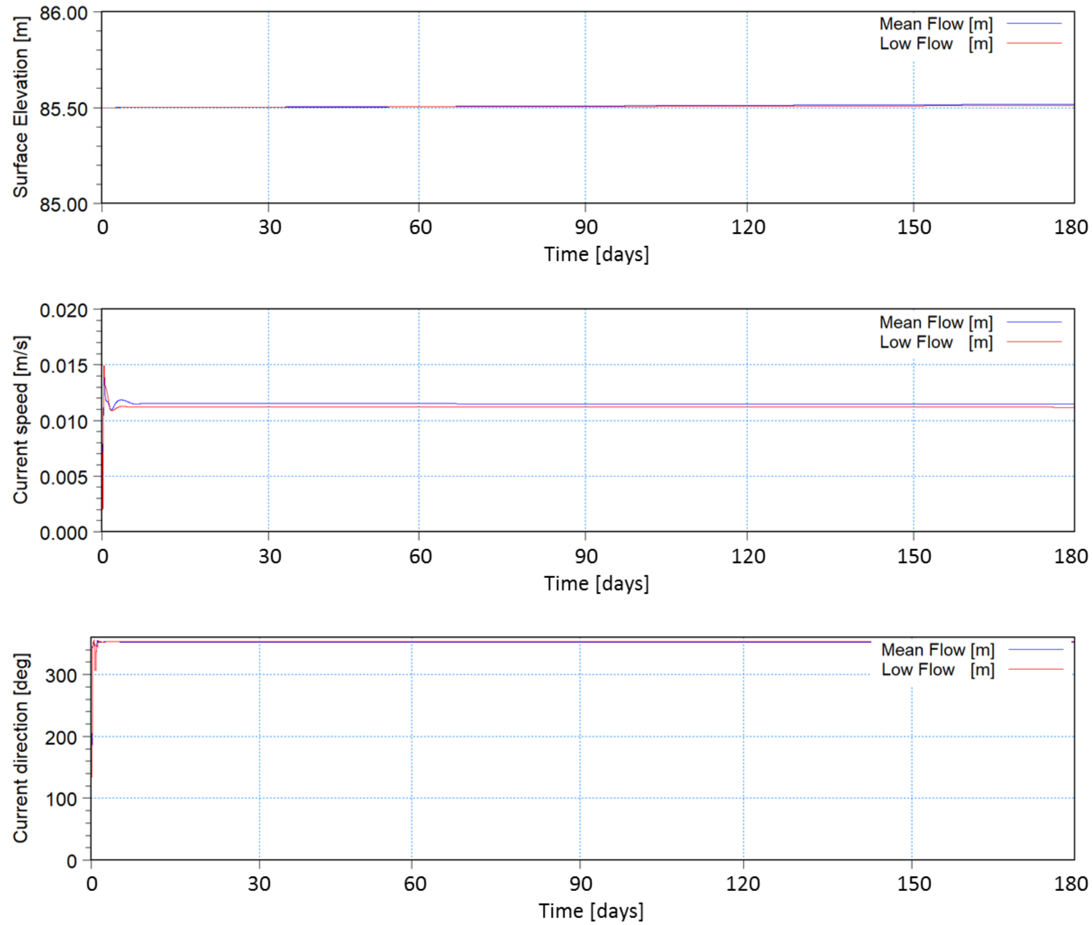


Figure C-3. Hydrodynamic model results at Station 6 for mean and low river flows.

ATTACHMENT D.2.4:

PRIORITY SUBSTANCE ASSESSMENT REPORT
NOVEMBER 2024

Priority Substances Assessment

Agglomeration Name:	Virginia
Licence Register No.	D0255 Licence Review

Table of Contents

1 Introduction

This report has been prepared for the **Virginia agglomeration,** in County Cavan, to inform a Waste Water Discharge Licence (WWDL) Review Application for D0255-01.

This desk top study has been undertaken to determine the necessity, if any, for further analysis of the primary discharge (SW001) based on the *Guidance on the Screening for Priority Substances for Waste Water Discharge Licences,* issued by the EPA.

Relevant inputs to the Virginia Waste Water Treatment Plant (WwTP) and estimates for the emissions from the primary discharge point (SW001) have been taken into account in the preparation of this report.

Wastewater effluent sampling at Virginia was undertaken on 14th September 2021 as part of Uisce Éireann's (UÉ) Dangerous Substances Effluent Monitoring Programme. The results of this monitoring, where applicable, were used to inform this assessment.

2 Desktop Study

2.1 Assessment of Analysis Required

A. Review of all industrial inputs into WWTP

A review of available online mapping and all EPA licensed facilities was undertaken to determine the non-domestic discharge types which will being received at the Virginia WwTP. In addition, all planning applications within the agglomeration, since 2019, were reviewed to determine the associated non-domestic discharges being sent to the Virginia WwTP. The UÉ Technical Assessment Manual Sectoral Profile Data was reviewed to determine the potentially dangerous substances which could be released to sewer from industrial inputs.

As per the EPA, IPC and IE database, there are no industrial premises with an IPC licences within the Virginia agglomeration collection network.

There is 1. No trade effluent licence under Section 16 of the Water Pollution Act 1977 (amended 1990) within the Virginia agglomeration (Licence Number: SS-S001-11) with a licenced p.e. of 71 which accounts for approximately 1.2% of the proposed design capacity (6,000 p.e.) of the upgraded Virginia WwTP.

It is considered that the Priority Substances which are possibly being emitted to sewer have been well represented in this partial characterisation of the wastewater (**Table 2.1**).

Upon review of the types of businesses, amenities, and educational facilities in Virginia, **Table 2.1** provides an indicative list of non-domestic discharge types to the WwTP and details potential dangerous/priority substance.

Table 2.1 – List of Non-Domestic Discharge Types to WwTP and Details of Potential Dangerous/Priority Substance

Type of Industry within the Agglomeration	Potential Source of Dangerous / Priority Substances (Yes / No)	Dangerous / Priority Substances Monitoring Undertaken (Yes / No)	List of Potential Dangerous Substances Based on Industry Type (Source: *Technical Assessment Manual - Sectoral Profile Data*)
Garages and Filling Stations	Yes	Unknown	Benzene Di (2-ethylhexyl) phthalate (DEHP) Lead and its compounds Naphthalene Nickel and its compounds Cadmium and its compounds Mercury and its compounds Chromium (III) Copper Toluene Xylenes (Total) Zinc
Construction	Yes	Unknown	Lead and its compounds Nickel and its compounds Mercury and its compounds Arsenic Chromium (III) Copper Zinc
Schools and Universities	Yes	Unknown	Dichloromethane Lead and its compounds Nickel and its compounds Trichloromethane
Launderettes and Dry Cleaners	Yes	Unknown	Di (2-ethylhexyl) phthalate (DEHP)
Hairdressers	Yes	Unknown	Nickel and its compounds Cadmium and its compounds
Dentists	Yes	Unknown	Octylphenols Mercury and its compounds
Petroleum Products	Yes	Unknown	Benzene Fluoranthene Lead and its compounds Naphthalene Nickel and its compounds Octylphenols Anthracene Cadmium and its compounds C10-13-Chloralkanes Mercury and its compounds Nonylphenols Polyaromatic Hydrocarbon (PAH)

B. Discharge monitoring

Primary discharge monitoring for the possible presence of Specific Pollutants, Priority and Priority Hazardous Substances as outlined in Table 10, 11 and 12 of European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended, is available for this agglomeration.

As mentioned above, wastewater effluent sampling at Virginia was undertaken on the 14th September 2021 as part of UE's Dangerous Substances Effluent Monitoring Programme. The results of this monitoring were used to inform this assessment.

C. Downstream monitoring location's participation in relevant monitoring programme

There is no priority substances monitoring data for the downstream ambient monitoring location, Lough Ramor.

D. Participation in PRTR reporting

Estimated data from the PRTR reporting tool was required for this desktop assessment as measured data was unavailable for all parameters in **Appendix 1**.

2.2 Review Outcome of Desktop Study

Following the desktop study, all parameters in **Appendix 1** have been assessed to establish any potential impact on the receiving waters. Priority substance measured concentrations in the primary discharge were not available for all parameters, as such estimated concentrations were assessed. This desktop study is considered to provide partial characterisation of the wastewater.

3 Assessment of Significance and Recommendations

An assessment of the potential for impacts on receiving waters from priority substances in the primary discharge (SW001) has been carried out. The assessment considers the primary discharge relevant to Environmental Quality Standards (EQS) for priority substances in surface waters, as set out in the European Communities Environmental Objectives (Surface Waters) Regulations 2009, as amended.

Based on the estimated and measured data, no parameters were identified as potentially being higher than the required EQS.

Does the assessment use the Desk Top Study Method or Screening Analysis to determine if the discharge contains the parameters in Appendix 1 of the EPA guidance	Desk Top Study and Screening Analysis
Does the assessment include a review of licensed / authorised inputs to the works?	Yes
Does the assessment include a review of other (unauthorised) inputs to the works?	Yes

Does the assessment use the Desk Top Study Method or Screening Analysis to determine if the discharge contains the parameters in Appendix 1 of the EPA guidance	Desk Top Study and Screening Analysis
Does the report include an assessment of the significance of the results where a listed material is present in the discharge? (e.g., impact on the relevant EQS standard for the receiving water)	Yes
Does the assessment identify that priority substances may be impacting the receiving water?	No
Does the Improvement Programme for the agglomeration include the elimination / reduction of all priority substances identified as having an impact on receiving water quality?	Not applicable

4 Conclusion

An assessment of the potential for impacts on receiving waters from priority substances in the primary discharge has been carried out to inform this WWDL review application. The assessment considered the Primary Discharge relevant to the surface waters Environmental Quality Standards (EQS) for priority substances (as per the Surface Waters Regulations), as listed in the EPA Guidance on the Screening for Priority Substances for Waste Water Discharge Licences (2011) and those which are listed in the PRTR tool. It should be noted that not all substances that are listed in the Surface Waters Regulations are included in the PRTR tool.

After dilution it can be concluded that none of the substances listed in the Specific Pollutants, Priority and Priority Hazardous Substances, are likely to be present in the effluent discharge to Lough Ramor, at concentrations above the standards in S.I No. 77 of 2019.

Based on the results of this desk top study, it can be determined that **no for further analysis** of the discharge, based on the *Guidance on the Screening for Priority Substances for Waste Water Discharge Licences*, issued by the EPA, is required.

Appendix 1 – Screening of Parameters for Priority Substances

AA: Annual Average

MAC: Maximum Allowable Concentration

EQS: Environmental Quality Standards

Dilution factor in receiving water: 15.5 dilution estimated in the vicinity of the discharge point (based on an Average Daily Effluent Flow (1.25 DWF) of 1,687.5m^3/day and 95%ile flow 0.302 m^3/s in the Blackwater (Kells)_070 (Flow data from Station no. 07004 (Stramatt) (1986-2021))

No.	Compound	Group of compounds	AA-EQS Inland SW (µg/l)	AA-EQS Other SW (µg/l)	Estimated & Sampled Conc. (µg/l)[1]	Data Source	Sample Date (if applicable)	Effluent Concentration above AA concentration (Yes/No)	Effluent Concentration above AA concentration after dilution (Yes/No)
1	Benzene	VOCs	10	8	< 1.00	Sample	14/09/2021	No	No
2	Carbon tetrachloride	VOCs	12	12	< 1.00	Sample	14/09/2021	No	No
3	1,2-Dichloroethane	VOCs	10	10	< 1.00	Sample	14/09/2021	No	No
4	Dichloromethane	VOCs	20	20	< 1.00	Sample	14/09/2021	No	No
5	Tetrachloroethylene	VOCs	10	10	< 1.00	Sample	14/09/2021	No	No
6	Trichloroethylene	VOCs	10	10	< 1.00	Sample	14/09/2021	No	No
7	Trichlorobenzenes	VOCs	0.4	0.4	< 0.03	Sample	14/09/2021	No	No
8	Trichloromethane	VOCs	2.5	2.5	< 1.00	Sample	14/09/2021	No	No
9	Xylenes (all isomers)	VOCs	10	10	< 2	Sample	14/09/2021	No	No
10	Ethyl Benzene	VOCs	n/a	n/a	< 1.00	Sample	14/09/2021	N/A	N/A
11	Toluene	VOCs	10	10	< 1.00	Sample	14/09/2021	No	No
12	Naphthlene[1]	PAHs	2	2	< 0.010	Sample	14/09/2021	No	No
13	Fluoranthene[1]	PAHs	0.0063	0.0063	0.002	PRTR Estimated Workbook	N/A	No	No
14	Benzo[k]fluoranthene[2]	PAHs	MAC of 0.017	MAC of 0.017	0.002	PRTR Estimated Workbook	N/A	No	No

[1] The EQS for these substances shall take effect from 22 December 2015

[2] No indicative parameter is provided for this group of substances

No.	Compound	Group of compounds	AA-EQS Inland SW (µg/l)	AA-EQS Other SW (µg/l)	Estimated & Sampled Conc. (µg/l)[1]	Data Source	Sample Date (if applicable)	Effluent Concentration above AA concentration (Yes/No)	Effluent Concentration above AA concentration after dilution (Yes/No)
15	Benzo[ghi]perylene[2]	PAHs	MAC of 8.2 x 10^{-3}	MAC of 8.2 x 10^{-4}	0.002	PRTR Estimated Workbook	N/A	No	No
16	Indeno[1,2,3-c,d]pyrene[2]	PAHs			< 0.010	Sample	14/09/2021	N/A	N/A
17	Benzo[b]fluoranthene[2]	PAHs	MAC of 0.017	MAC of 0.017	< 0.010	Sample	14/09/2021	No	No
18	Benzo[a]pyrene	PAHs	1.7 x 10^{-4}	1.7 x 10^{-4}	0.002	PRTR Estimated Workbook	N/A	No	No
19	Di(2-ethylhexyl)phthalate (DEHP)	Plasticiser	1.3	1.3	0.917	Sample	14/09/2021	No	No
20	Isodrin[3]	Pesticides	∑=0.01	∑=0.005	0.000	PRTR Estimated Workbook	N/A	No	No
21	Dieldrin[3]	Pesticides			0.000	PRTR Estimated Workbook	N/A	No	No
22	Diuron	Pesticides	0.2	0.2	< 0.10	Sample	14/09/2021	No	No
23	Isoproturon	Pesticides	0.3	0.3	< 0.10	Sample	14/09/2021	No	No
24	Atrazine	Pesticides	0.6	0.6	< 0.020	Sample	14/09/2021	No	No
25	Simazine	Pesticides	1	1	< 0.022	Sample	14/09/2021	No	No
26	Glyphosate	Pesticides	60	-	0.37	Sample	14/09/2021	No	No
27	Mecoprop	Pesticides	n/a	n/a	< 0.04	Sample	14/09/2021	N/A	N/A
28	2,4-D	Pesticides	n/a	n/a	0.051	Sample	14/09/2021	N/A	N/A
29	MCPA	Pesticides	n/a	n/a	< 0.05	Sample	14/09/2021	N/A	N/A
30	Linuron	Pesticides	0.7	0.7	< 0.10	Sample	14/09/2021	No	No

[3] ∑ of Aldrin, Dieldrin, Endrin and Isodrin.

No.	Compound	Group of compounds	AA-EQS Inland SW (µg/l)	AA-EQS Other SW (µg/l)	Estimated & Sampled Conc. (µg/l)[1]	Data Source	Sample Date (if applicable)	Effluent Concentration above AA concentration (Yes/No)	Effluent Concentration above AA concentration after dilution (Yes/No)
31	Dichlobenil	Pesticides	n/a	n/a	< 0.004	Sample	14/09/2021	N/A	N/A
32	2,6-Dichlorobenzamide	Pesticides	n/a	n/a	< 0.050	Sample	14/09/2021	N/A	N/A
33	PCBs	PCBs	n/a	n/a	0.000	PRTR Electronic Toolset	N/A	N/A	N/A
34	Phenols (as Total C)	Phenols	8	8	0.910	PRTR Electronic Toolset	N/A	No	No
35	Lead	Metals	1.2	1.3	< 0.30	Sample	14/09/2021	No	No
36	Arsenic	Metals	25	20	0.54	Sample	14/09/2021	No	No
37	Copper	Metals	**5** or 30[2]	5	4.8	Sample	14/09/2021	No	No
38	Zinc	Metals	8 or **50** or 100[3]	32	49.364	Sample	14/09/2021	No	No
39	Cadmium	Metals	0.08 or 0.09 or **0.15** or 0.25[4]	0.2	< 0.02	Sample	14/09/2021	No	No
40	Mercury	Metals	MAC of 0.07	MAC of 0.07	< 0.010	Sample	14/09/2021	No	No
41	Chromium VI	Metals	3.4	0.6	< 0.20	Sample	14/09/2021	No	No
42	Selenium	Metals	n/a	n/a	< 1.2	Sample	14/09/2021	N/A	N/A
43	Antimony	Metals	n/a	n/a	< 1.3	Sample	14/09/2021	N/A	N/A
44	Molybdenum	Metals	n/a	n/a	< 2.50	Sample	14/09/2021	N/A	N/A
45	Tin	Metals	n/a	n/a	< 1.5	Sample	14/09/2021	N/A	N/A
46	Barium	Metals	n/a	n/a	3.8	Sample	14/09/2021	N/A	N/A
47	Boron	Metals	n/a	n/a	< 56	Sample	14/09/2021	N/A	N/A
48	Cobalt	Metals	n/a	n/a	0.39	Sample	14/09/2021	N/A	N/A
49	Vanadium	Metals	n/a	n/a	0.27	Sample	14/09/2021	N/A	N/A

No.	Compound	Group of compounds	AA-EQS Inland SW (µg/l)	AA-EQS Other SW (µg/l)	Estimated & Sampled Conc. (µg/l)[1]	Data Source	Sample Date (if applicable)	Effluent Concentration above AA concentration (Yes/No)	Effluent Concentration above AA concentration after dilution (Yes/No)
50	Nickel	Metals	4	8.6	3	Sample	14/09/2021	No	No
51	Fluoride	General	500	1,500	320	Sample	14/09/2021	No	No
52	Chloride	General	n/a	n/a	65000	Sample	14/09/2021	N/A	N/A
53	TOC	General	n/a	n/a	9219.77	PRTR Electronic Toolset	N/A	N/A	N/A
54	Cyanide	General	10	10	< 5	Sample	14/09/2021	No	No
	Conductivity	General	n/a	n/a	567	Sample	14/09/2021	N/A	N/A
	Hardness (mg/l $CaCO_3$)	General	n/a	n/a	83200	Sample	14/09/2021	N/A	N/A
	pH	General	n/a	n/a	6.95	Sample	14/09/2021	N/A	N/A

Note - Where the concentration in the result is less than the limit of detection (LOD), a value of LOD/2 was applied to assess if the concentration was above the AA concentration

Notes:

1. Where measured values are available these should be used instead of estimated values from PRTR tool.
2. In the case of Copper, the value 5 applies where the water hardness measured in mg/l $CaCO_3$ is less than or equal to 100; the value 30 applies where the water hardness exceeds 100 mg/l $CaCO_3$. Estimated $CaCO_3$ value > 100 where no sampling data available (based on PRTR tool)
3. In the case of Zinc, the standard shall be 8 µg/l for water hardness with annual average values less than or equal to 10 mg/l $CaCO_3$, 50 µg/l for water hardness greater than 10 mg/l $CaCO_3$ and less than or equal to 100 mg/l $CaCO_3$ and 100 µg/l elsewhere. Estimated $CaCO_3$ value > 100 where no sampling data available
4. For Cadmium and its compounds the EQS values vary dependent upon the hardness of the water as specified in five class categories (Class 1: <40 mg $CaCO_3$/l, Class 2: 40 to <50 mg $CaCO_3$/l, Class 3: 50 to <100 mg $CaCO_3$/l, Class 4: 100 to <200 mg $CaCO_3$/l and Class 5: >200 mg $CaCO_3$/l)