Chapter 16

Biodiversity:

Aquatic Ecology

Contents

Tables

Figures

Plates

Appendices

16 BIODIVERSITY: AQUATIC ECOLOGY

16.1 Introduction

This chapter of the Environmental Impact Assessment Report (EIAR) identifies, describes, and presents an assessment of the likely significant effects on aquatic ecology of the N2 Slane Bypass and Public Realm Enhancement Scheme (hereafter referred to as the 'Proposed Scheme'). Potential impacts are assessed for construction and operational/ maintenance phases of the Proposed Scheme. The Proposed Scheme is described in **Chapter 4 – Description of the Proposed Scheme** (which contains detailed descriptions of the drainage design for the scheme) and **Chapter 5 – Description of the Construction Phase** (which sets out the detailed construction methodology, including sediment and pollutant control measures for the construction phase). Other aspects related to biodiversity and aquatic ecology/the water environment are addressed in other specific chapters of the EIAR, namely:

- **Chapter 9 – Noise and Vibration:** Baselines descriptions and impact assessment related to noise and vibration effects. Hydroacoustic effects in relation to the Boyne bride construction are also considered;
- **Chapter 15 – Biodiversity: Terrestrial Ecology:** Baseline descriptions and impact assessment related to the terrestrial aspects of biodiversity. This chapter also deals with species that rely on the aquatic environment, namely otter and kingfisher;
- **Chapter 17 – Water:** Baseline descriptions and impact assessment relating to other aspects of the surface water environment such as Water Framework Directive considerations, hydrology and flood risk; and
- **Chapter 18 – Land, Soils, Geology and Hydrogeology:** Baseline descriptions and impact assessment relating to groundwater and hydrogeology.

There are also clear linkages between the Environmental Impact Assessment and Appropriate Assessment processes. This chapter should therefore be read in conjunction with the Stage 1 – Appropriate Assessment Screening and Stage 2 – Natura Impact Statement for the Proposed Scheme which have been prepared with reference to European sites; these are available under separate cover as part of the overall application for development consent to An Bord Pleanála (ABP).

These parallel but separate processes commonly overlap, but also differ in key respects. While the EIA and AA must clearly be distinguished in terms of their respective scope and conclusions, the processes have been carried out concurrently and draw on common data and information. The key findings of the AA are reflected in the relevant section(s) of this chapter of the EIAR.

16.2 Methodology

16.2.1 Legislation, Policy and Guidance

16.2.1.1 Legislation

The assessment of the likely significant impacts of the proposed scheme on aquatic ecological features has taken account of the following legislation, policy and guidance documents, where relevant:

EU Legislation

- EU Habitats Directive - Council Directive 92/43/EEC (1992), ensures the conservation of a wide range of rare, threatened or endemic animal and plant species and the conservation of characteristic habitat types; and
- EU Water Framework Directive (2000/60/EC) (WFD) for the protection and improvement of water quality in all waters so that good ecological status is achieved within specified timelines.

National Legislation

- The Wildlife Act 1976, as amended, is the principal national legislation providing for the strict protection of wildlife and the control of some activities that may adversely affect wildlife. It aims to provide for the protection and conservation of wild fauna and flora, to conserve a representative sample of important ecosystems and protect species from injury, disturbance, and damage to breeding and resting sites (EC, 2000). Such species, where relevant, are considered as sensitive ecological receptors in this chapter;
- Part XAB of the Planning and Development Acts, 2000 – 2022 (S.I. No. 30 of 2000) as amended and the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. No. 477 of 2011), as amended ('the Habitats Regulations'), transpose the EU Habitats Directive (see above) into Irish law. In Ireland, these sites are designated as European Sites and include Special areas of Conservation (SAC), established under the Habitats Directive and Special Protection Areas (SPA), established under the Birds Directive 2009/147/EC as well as candidate sites (cSAC and cSPA);
- European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272 of 2009), as amended, establishes the legally-binding water quality objectives for all surface waters and outlines environmental quality standards for pollutants;
- European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003), as amended, give legal effect in Ireland to the WFD; and
- European Communities (Quality of Salmonid Waters) Regulations (S.I. No. 293 of 1988) designate "*waters capable of supporting salmon (Salmo salar), trout (Salmo trutta), char (Salvelinus) and whitefish (Coregonus)*" as salmonid waters. They also set out the quality standards that must be achieved in these waters.

16.2.1.2 Policy

Consideration has been given to the following relevant policy documents in the preparation of this chapter:

- Meath County Development Plan 2021-2027;
- The 3rd National Biodiversity Action Plan 2017-2021 (DCHG, 2017) which is a framework for the conservation and protection of biodiversity in Ireland and the 4th draft National Biodiversity Action Plan (NBAP) which will set the national biodiversity agenda for the period 2023-2027; and
- The 2nd cycle River Basin Management Plan (RBMP) and the draft 3rd cycle RBMP which set out the measures necessary to protect and restore water quality in Ireland. The overall aim is to ensure that Ireland's natural waters are sustainably managed and that freshwater resources are protected so as to maintain and improve Ireland's water environment.

16.2.1.3 Guidance

The methodology and associated impact assessment were conducted with regard to the general guidance on undertaking EIA, as presented in **Section 1.3.3** of **Chapter 1 – Introduction**, and the following topic-specific guidance:

- CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Chartered Institute of Ecology and Environmental Management Version 1.2 - Updated April 2022;
- NRA (2009) Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes. National Roads Authority;
- NRA (2009) Guidelines for assessment of ecological impacts of national road schemes, Revision 2; and
- NRA (2003) Guidelines for assessment of ecological impacts of national road schemes, Revision 1.

16.2.2 Zone of Influence

With regards to aquatic surveys and impact assessment, the Zone of Influence (ZoI) was considered using expert judgement and taking into account existing watercourse morphology, size and flow types in terms of potential for downstream export of pollutants. In total, small tributaries were investigated at select locations for up to 4 km downstream of the Proposed Scheme (Thurstianstown, Mattock), while aquatic habitats of the main channel of the River Boyne were investigated in detail for the 1 km stretch downstream of Slane, with consideration through desk studies of habitats, species and water quality between Slane and the upper tidal limit at the Mattock confluence. For purposes of the site-specific surveys, the locations and distances are detailed in **Table 16-2**.

16.2.3 Sources of Information to inform the Assessment

16.2.3.1 Desk Study

A thorough desk-based search of available baseline information was undertaken. Verified online information, plus published and unpublished literature was utilised as set out in **Table 16-1**.

Table 16-1: Summary of Key Desktop Sources

Title	Author/Source	Year
Surface and ground water quality status, and river catchment boundaries	EPA (online)	2022
NPWS designated areas spatial data	National Parks and Wildlife Services	2022
OSI historical mapping	Geo Hive (online)	2022
Distribution records for protected aquatic species held online by the National Biodiversity Data Centre (NBDC)	NBDC	2022
Inland Fisheries Ireland Reports and Water Framework Directive fish survey data	Gargan et al. (2021, 2022); Kelly et al. (2010, 2013, 2014, 2015, 2017), Massa-Gallucci & Mariani (2011), McCollom et al (2019)	2010-2022
Status of EU Protected Habitats and Species in Ireland, Volume 1, 2, and 3	NPWS	2019a 2019b 2019c

16.2.3.2 Field Studies

The EPA delineated watercourses relevant to the aquatic assessment are listed in **Table 16-2**. These are set within three EPA River Water Bodies (RWB), namely the Boyne_160, Boyne_170 and Mattock_030. The names of the three watercourses referred to in this report and their relationship to the proposed scheme are:

- **River Boyne:** One (1) proposed crossing of River Boyne main channel and one (1) proposed crossing of the adjoining navigational canal as part of the Proposed Scheme; receiving surface water for drainage in the Boyne_160 and Boyne_170 RWBs.
- **Mattock (Mooretown) Stream:** One (1) proposed crossing as part of the Proposed Scheme; receiving surface water for drainage in the Mattock_030 RWB.
- **Thurstianstown Stream:** No proposed crossing of this watercourse. It receives a small proportion of surface water flow from the western side of the road via a field drain at the southern end of the Proposed Scheme within RWB Boyne_160.

Table 16-2: Watercourses and River Water Bodies of the Receiving Aquatic Environment

EIAR Watercourse Name	EPA RWB Name	EPA RWB Code	Direct Crossings	Drainage to Watercourse
Boyne	Boyne_170	IE_EA_07B042150	One clear span bridge over main channel with a clear span section over the adjoining navigational canal	✓
Mattock (Mooretown) Stream	Mattock_030	IE_EA_07M010300	Series of three culverts on the EPA delineated Mattock (Mooretown) branch plus one drain crossing upstream of the Slane stream (a tributary of the Mattock (Mooretown)	✓
Thurstianstown	Boyne_160	IE_EA_07B042100	*None*	✓ (distant)
Boyne	Boyne_160	IE_EA_07B042100	*None in this section of the Boyne.*	✓ (distant)

Table 16-3 shows a record of baseline field studies conducted between 2020 and 2022 to inform the impact assessment. Selected sites on the River Boyne, Mattock (Mooretown) Stream and Thurstianstown Stream were subject to walk-over survey and habitat assessment, including Q-value sampling. The aims of field studies were to: (1) identify key aquatic receptors, and (2) fully characterise baseline conditions of in-stream habitats. Focus was placed on fisheries and protected aquatic species value of habitats, with particular consideration of aquatic Annex II species of the Special Areas of Conservation (SAC) i.e. river lamprey and salmon. Assessment of ecological value was backed up by desk studies and published scientific literature.

Table 16-3: Aquatic Survey Record

Survey Date	Locations	Survey Types
19 March 2022	River Boyne – proposed crossing point plus walkover survey between Slane Bridge and 1km downstream of Slane Bridge.	In-stream, riparian and floodplain habitat description; in-stream plant communities.
	Mattock (Mooretown) Stream – proposed crossing points plus 200m downstream, including adjoining drains downstream of existing N2 crossing.	Q-value sample and analysis; in-stream and riparian habitat descriptions, in-stream plant communities.
	Thurstianstown Stream – survey reach downstream of proposed scheme (receives surface drainage on western side at southern end).	Q-value sample and analysis; in-stream and riparian habitat descriptions; in-stream plant communities.
10 August 2021	River Boyne – Slane Bridge	Q-value sample and analysis; in-stream habitat description.
	Mattock (Mooretown) Stream – proposed crossing point plus adjoining drains downstream of existing N2 crossing.	Q-value sample and analysis; in-stream and riparian habitat description.
12 August 2020	River Boyne – Slane Bridge	Q-value sample and analysis; in-stream habitat description.
	Mattock (Mooretown) Stream – just downstream of proposed crossing point.	Q-value sample and analysis; in-stream and riparian habitat description.

16.2.3.3 Biological Water Quality Assessment (Q-value)

In Ireland, biological water quality is assessed using the Q-value metric. The system is based on field sampling and observations, which evaluates habitat quality and macroinvertebrate diversity and abundance to interpret ecological status as set out in **Table 16-4**. The EPA operate a system of river monitoring which provides Q-value data for classification of status on a three-yearly cycle. This data is useful in characterising water and habitat quality for the purposes of Ecological Impact Assessment (EcIA) since water quality is a primary determinant of habitat quality for aquatic organisms. Under the Water Framework Directive (WFD) (2000/60/EC) all surface waters must be maintained or restored to, at least, Good Ecological Status (Q4). High status waters must not suffer deterioration.

Potentially affected watercourses were also sampled during field studies to determine Q-value and water quality implications, in accordance with EPA protocols. This involved taking a two-minute, travelling kick-sample in a fast flowing (riffle) area of the river using a long-handled sampling net (250 mm width, mesh size 0.25 mm). Stone washing was employed to ensure 'clinging' species, e.g. leeches and gastropods, were adequately collected. The relative abundance and sensitivity of aquatic organisms to pollution was then assessed at the bankside using the Q-rating system as published in Toner et al. (2005).

Table 16-4: Biological Water Quality and Status – Q-value System

Q-value	EQR*	Quality Status	Water Quality	Ecological Status
Q5	1.0	Unpolluted	Good	High
Q4-5	0.9	Unpolluted	Fair-to-Good	
Q4	0.8	Unpolluted	Fair	Good
Q3-4	0.7	Slightly Polluted	Doubtful-to-Fair	Moderate
Q3	0.6	Moderately Polluted	Doubtful	Poor
Q2-3	0.5	Moderately Polluted	Poor-to-Doubtful	
Q2	0.4	Seriously Polluted	Poor	Bad
Q1-2	0.3	Seriously Polluted	Bad-to-Poor	

** Ecological Quality Ratio*

16.2.3.4 Fisheries Habitat Assessment

Field-based fisheries habitat assessments involved visually assessing the principal bankside and in-channel habitats (e.g. substrates, flow type, aquatic vegetation) and the suitability of the latter as spawning and/or nursery sites for salmonids, lampreys and coarse fish species.

16.2.3.5 White-clawed Crayfish Habitat Assessment

Pre-existing information on crayfish distribution (*Austropotamobius pallipes*) throughout the Boyne and Blackwater River catchments was obtained through desk studies (NBDC mapping and other publications). Field-based crayfish assessments involved manual presence/absence survey at kick-sample sites using a hand net during macroinvertebrate sampling (Q-value). In-stream habitats were visually assessed during walkover surveys of watercourses covering 1km of the River Boyne downstream of Slane and at sites investigated on tributaries. This involved recording the principle in-channel and bank-side features, and their suitability as refuges for crayfish.

16.2.3.6 General Habitat Descriptions

Sites were assessed as to bankside and in-channel habitats. Site habitat characteristics recorded included substrate and flow types; depth and width; shading; surrounding land-use; and general morphological character. The latter were recorded based on criteria for river hydromorphology using the principles of the River Hydromorphology Assessment Technique (RHAT) (Northern Ireland Environment Agency (NIEA) and EPA, 2014).

16.2.4 Key Parameters for Assessment

The aquatic impact assessment relied on assessment of baseline and predicted parameters including, but not limited to:

- Biological water quality indicators (macroinvertebrate Q-value);
- Physicochemical conditions (primarily nutrients, oxygen, suspended solids, dissolved metals);
- Fisheries habitat quality evaluation using a combination of WFD fish data and physical habitat survey/assessment;
- Protected species habitat evaluation using a combination of NPWS, IFI and NBDC data along with site-specific physical habitat survey/assessment; and

- Evaluation of hydromorphological conditions supporting the biological quality elements with a focus on how it supports aquatic ecology. See also **Chapter 17 – Water** for other parameters related to hydrological conditions beyond this.

16.2.5 Assessment Criteria and Significance

16.2.5.1 Ecological Valuation of Watercourses

The criteria used for assessment of ecological value of watercourses are adapted from NRA (now Transport Infrastructure Ireland – TII) Guidelines (NRA, 2003 and 2009) involving careful consideration of fisheries value, water quality and consideration of contextual information for the resource at a geographic level. Ecological value was assigned to the receiving watercourses on the basis of rarity, conservation status and geographical distribution. The evaluation criteria used to classify sites is shown in **Table 16-5**. This is based on NRA guidelines that were originally published in 2003, with slight modifications from the second revision of that document in 2009 which set out criteria that classify aquatic habitat value within the study area. Only criteria with direct relevance to aquatic habitats and fisheries within the study area have been retained in this table. Site-specific survey data and EPA biological monitoring data fed into this overall assessment of aquatic ecological value. All assessments were made in the context of national trends, guidelines and regulations and EU WFD criteria, as appropriate.

Table 16-5: Ecological Evaluation Criteria – Watercourses

Relevant Criteria	Category
International Importance: • Sites designated (or qualifying for designation) as an SAC; • Salmonid water designated pursuant to the European Communities (Quality of Salmonid Waters); Regulations, 1988, (S.I. No. 293 of 1988); • Major salmonid (salmon, trout or char) lake fisheries.	A
National Importance: • Sites or waters designated or proposed as an Natural Heritage Area (NHA) or Statutory Nature Reserve or National Park; • Undesignated sites containing significant numbers of resident or regularly occurring populations of Annex II species under the EU Habitats Directive; • Resident or regularly occurring populations (assessed to be important at the national level) of species protected under the Wildlife Acts; and/or; species listed on a Red Data list; • Major trout fishery rivers; • Waterbodies with major amenity fisheries value; • Commercially important coarse fisheries.	B
County Importance: • Small water bodies with known salmonid populations or with good potential salmonid habitat; • Undesignated sites containing any resident or regularly occurring populations of Annex II species under the EU Habitats Directive; • Large water bodies with some coarse fisheries value; • Sites containing habitats and species that are rare or are undergoing a decline in quality or extent at a national level.	C
Local Importance (Higher Value): • Small water bodies with some coarse fisheries value or some potential salmonid habitat; • Any waterbody with unpolluted water (Q-value rating 4-5, Q5).	D
Local Importance (Lower value): • Water bodies with no current fisheries value and no significant potential fisheries value.	E

(Adapted from NRA, 2003 and 2009)

16.2.5.2 Impact Assessment

The impact assessment approach adopted is from the 2018 Chartered Institute of Ecology and Environmental Management Guidelines (CIEEM, 2018 and revisions of 2022) whereby Important Ecological Features (IEFs) are identified and both pre-mitigation and residual impacts are assessed using the source-pathway-receptor (S-P-R) framework as being either **Significant** or **Not Significant** on the basis of geographical importance. An IEF is defined as one that is greater than Category D (Local Importance – Higher Value) in terms of NRA (2003, 2009) (**Table 16-5**, above). All aquatic ecological features identified within the ZoI for the Proposed Scheme have been identified and assessed as to whether they are considered IEFs to be scoped into the impact assessment.

The impact assessment addresses construction and operational phases and considers the magnitude, extent, timing and duration of potential impacts as well as their likelihood of occurring (CIEEM, 2018), which are defined in qualitative terms as follows:

- **Positive or Negative (adverse)**. Positive and negative (adverse) impacts and effects were determined according to whether the change is in accordance with nature conservation objectives and policy:
  - Positive – a change that improves the quality of the environment (e.g. by increasing species diversity, extending habitat or improving water quality). This may also include halting or slowing an existing decline in the quality of the environment.
  - Negative (adverse) – a change which reduces the quality of the environment (e.g., destruction of habitat, removal of foraging habitat, habitat fragmentation, pollution).
- **Extent.** The extent is the spatial or geographical area over which the impact/effect may occur under a suitably representative range of conditions (e.g. noise transmission under water).
- **Magnitude.** Magnitude refers to size, amount, intensity and volume. It was quantified if possible and expressed in absolute or relative terms (e.g. the amount of habitat lost, percentage change to habitat area, percentage decline in a species population).
- **Duration.** Duration was defined in relation to ecological characteristics (such as the lifecycle of a species) as well as human timeframes. For example, five years, which might seem short-term in the human context or that of other long-lived species, would span at least five generations of some invertebrate species.
- **Frequency and Timing**. The number of times an activity occurs can influence the resulting effect. The timing of an activity or change may result in an impact if it coincides with critical life-stages or seasons (e.g. salmonid and/or lamprey spawning season).
- **Reversibility.** An irreversible effect is one from which recovery is not possible within a reasonable timescale or there is no reasonable chance of action being taken to reverse it. A reversible effect is one from which spontaneous recovery is possible or which may be counteracted by mitigation.

There may be any number of possible impacts on IEFs arising from a project/scheme. However, it is only necessary to describe in detail the impacts that are likely to be significant. Impacts that are either unlikely to occur, or if they did occur are unlikely to be significant, are scoped out. If in doubt, the precautionary principle is applied, and the potential impact is assessed.

When assessing the significance of an effect and for the purposes of this assessment, the significance of an effect is simply any effect that is sufficiently important to require assessment and reporting so that the decision maker is adequately informed of the environmental consequences of permitting a project. For the purposes of ecological impact assessment, a ‘significant effect’ is defined as an effect that either supports or undermines the biodiversity conservation for the IEF. These significant effects are qualified with reference to an appropriate geographical scale.

Mitigation is proposed along the S-P-R chain using avoidance, prevention, reduction and offsetting as per EPA Guidelines (2022). Levels of significance and likelihood of direct, indirect and cumulative impacts were guided by criteria set out in the EPA Guidelines (2022) but are divided into ***Significant*** or ***Not Significant*** as per the CIEEM Guidance (2018) in order to provide concise, definitive information to the competent authority.

Particular consideration was given to the prediction of how the proposed development may affect the integrity of the River Boyne and River Blackwater SAC and the conservation status of any Annex I habitats and Annex II species affected.

16.2.6 Data Limitations

This Chapter of the EIAR has been prepared based upon the best available information and in accordance with current best practice and relevant guidelines.

There were no technical difficulties or otherwise encountered in the preparation of this chapter of the EIAR.

16.3 Description of Existing Environment (Baseline Scenario)

16.3.1 Current Baseline Environment

16.3.1.1 Mainline Bypass

16.3.1.1.1 Overview

The River Boyne rises just west of Edenderry, Co. Kildare and flows east along the Kildare/Offaly border entering Co. Meath via Trim, Navan and Slane to discharge to the Irish Sea just east of Drogheda, Co. Louth. The Boyne is one of the largest river catchments in Ireland (2,694 km^2) draining predominantly agricultural land, with occasional urban centres. There is a strong limestone influence in the catchment, with waters at Slane being of high alkalinity and elevated conductivity. The lands either side of the River Boyne at Slane are underlain by limestone or sandstone/shale till with low-permeability soils.

The River Boyne is of international importance being designated as part of the River Boyne and River Blackwater SAC (Site Code: 002299) and River Boyne and River Blackwater SPA (Site Code: 004232).

The proposed new bridge crossing to the east of Slane passes over the River Boyne, but there is no direct in-stream footprint as the proposed bridging structure will span both the main channel and the (currently disused) Boyne Navigation canal. There will however be a construction and operational phase footprint within the SAC boundary related to construction of bridge piers either side of the Boyne channel. The Proposed Scheme also intersects with the Mattock (Mooretown) Stream, a small tributary of the Mattock River just north of Slane, plus a number of minor drains of low significance.

16.3.1.1.2 Field Study Results

Field study target notes are compiled in **Appendix 16.1**, along with selected, representative site photographs. Macroinvertebrate sampling results and consequent Q-value ratings are listed in **Appendix 16.2**. The following summarises the findings of baseline surveys and assigns an ecological quality category to each watercourse.

River Boyne

The study reach covered approx. 1,300 m downstream of the existing N2 Slane Bridge. The focus was on the proposed bypass crossing point on the Boyne located approx. 600 m downstream of the existing N2 bridge, plus the habitats / aquatic receptors of the approx. 500 m reach downstream of that point (**Appendix 16.1**, **Figure A16.1a**). In the vicinity of the crossing point the river is wide (approx. 40 m; >2 m depth) forming a swift glide with standing waves in the mid-channel. The right-hand side (RHS[1]) river margin has a sandy berm (3-4 m wide) supporting various emergent macrophytes including reed sweet grass (*Glyceria maxima*), reed canary grass (*Phalaris arundinacea*), brooklime (*Veronica beccabunga*), and Yellow iris (*Iris psuedocorus*). Occasional stands of common club-rush (*Schoenoplectus australis*) were recorded and branched burr-reed (*Sparganium erectum*) occurs in the summer. The RHS floodplain is low-lying and of low gradient, forming a wet-to-damp meadow with occasional waterlogged drainage runnels. The left-hand side (LHS) river margin is similar but with a steeper rise beyond the riverbank onto improved grassland.

Downstream of the proposed crossing point a mid-channel island splits the channel, then merges through gaps in an old, diagonally orientated, fish weir. These morphological features create nice flow diversity for salmonids including channels of fast water (nursery and foraging habitat) and slack pools, glides and backwaters (holding and resting habitat). Coarse fish species may be present, including roach and pike. Sandy sediment deposits at margins and in backwaters would support juvenile lamprey. The channel is the migration route for native anadromous species: mainly salmon, river and sea lamprey and European eel. The Slane area is a very important recreational salmon and trout fishery, leased out to Slane Bridge Anglers and Rossin and Slane Angling Clubs. IFI estimate approx. 300 salmon are caught and released downstream of Slane each year, many of them close to the proposed crossing reach. Q-value data (**Appendix 16.2**) rates

[1] RHS / LHS = Right / Left Hand Side, i.e., the right or left side of the river bank when facing downstream

the reach at Q4, 'good' status, though likely close to the Q3-4 'moderate' boundary judging by water chemistry data, reported in this section below. ***International Importance – Category A.***

Mattock (Mooretown) Stream

The study area covered an approx. 250 m reach of the stream encompassing the existing N2 culvert, and the downstream reach, including adjoining drains (**Appendix 16.1**, **Figure A16.1b**). This is a small stream in the upper headwaters of the Mattock River which has been heavily drained for agricultural purposes. The stream is bound by hedgerow with tillage land beyond. Though subject to occasional dredging, it appears to recover cobble/ gravel substrates in reaches of faster riffle/run type flows and for that reason, supports trout and likely brook lamprey. Fish numbers are probably lower than would be expected for the stream type owing to poor water quality and high sediment loads. Q-value data (**Appendix 16.2**) rates the stream at Q3 'poor' status. ***Local Importance (Higher Value) – Category D***. The adjoining drains are not permanent watercourses and are of low ecological significance. A drain, not delineated in EPA mapping, termed the "Slane Stream" is a small tributary of the Mattock (Mooretown) Stream. It is a minor collector drain of Local Importance (Lower value) and therefore not an IEF.

Thurstianstown Stream

The study area covered an approx. 500 m reach of the stream encompassing upstream and downstream of the local road crossing, plus adjoining drains (**Appendix 16.1**, **Figure A16.1c**). A low volume drain in the upper headwater of this stream is subject to receiving incidental over-the-edge drainage water from the western side of the Proposed Scheme at the southern tie-in. There is no direct drainage discharge to this stream during the operation phase as collected road drainage is directed to proposed attenuation Pond 1, which joins local field drains that flow towards Pond 2 to ultimately outfall to the Boyne Navigation Canal. The upper Thurstianstown drain is a straightened, deepened field boundary ditch with low ecological significance. It merges into the Thurstianstown 'main channel', which is heavily drained and channelised. It primarily forms a uniform glide over silty substrates and consequently has little or no fisheries significance, perhaps only supporting stickleback. Q-value data (**Appendix 16.2**) rates the stream at Q3, 'poor' status, with a very unbalanced faunal community indicative of disturbance. ***Local Importance (Lower Value) – Category E.*** This stream is not ranked as an IEF and hence not considered further in this assessment.

16.3.1.1.3 Fisheries Data Review

In terms of fisheries, the Boyne, as part of the River Boyne and River Blackwater SAC, is designated for Annex II species: river lamprey and salmon. The conservation objective for these species is "*… to maintain or restore the favourable conservation condition of the… Annex II species for which the SAC has been selected*" (NPWS 2021). The main channel of the River Boyne is also a designated salmonid river (S.I. No. 293 of 1988, Quality of Salmonid Waters Regulations). Along with its tributaries, the Boyne is considered one of Ireland's top game fisheries including spring salmon, grilse, sea trout and brown trout.

Whilst the River Boyne was previously one of the most salmon prolific rivers on the east coast, with approx. 10,000 salmon running the system in the 1980s, this has since dramatically declined. The theoretical Conservation Limit (CL)[2] set for the River Boyne by the Standing Scientific Committee on Salmon (SSCS) is currently 10,242 salmon per annum. In 2020 and 2021 the Boyne fish counters (located in Navan) showed deficits of -7,840 and -7,776 fish, respectively, meaning only 24% of the CL was achieved in both years (Gargan et al., 2021, 2022). The river therefore continues to be managed as catch & release-only for salmon. IFI staff estimate that approximately 300 salmon are caught and released downstream of Slane each year, many of them close to the proposed crossing in the townland of Crewbán (Kevin O'Brien IFI *pers. comm*). In summer when the water is low the best of the salmon fishing is located between Slane and Oldbridge. Good numbers of salmon are taken annually during the months of July, August and September on the fisheries downstream of Slane village. Sea trout are mainly concentrated near Oldbridge, but can be caught as far upstream as Slane, with a small run of large sea trout at the end of May and into June.[3] The best of the fishing is from the end of June to the end of September.

The SAC site synopsis (NPWS, 2014) highlights the importance of the Boyne in that it represents an eastern river which holds large three-sea-winter salmon (20-30 lb) which generally arrive in February. Smaller spring

---

[2] Scientifically derived sustainable stock level, i.e. the number of returning salmon that would be required to maintain the carrying capacity of the system based on its accessible area of fluvial habitat.

[3] Salmon and sea trout fishing on the River Boyne, Available at: https://fishinginireland.info/salmon/east/boyne/ (Accessed April 2022)

fish (10 lb) arrive in April/May; grilse come in July and a further run of fish occurs in late August (NPWS, 2014). The fishing season is 1 March to 30 September.

An extensive arterial drainage scheme was undertaken in the Boyne catchment by the OPW from 1969 to 1986 which affected virtually the entire catchment upstream of Navan. Removal of impassable weirs as part of that drainage scheme inadvertently increased potential salmonid production capacity within the system (O'Grady, 2006), although subsequent water quality pressures, such as peat extraction and lake eutrophication in the upper tributaries, had significant negative ecological impacts on the system (O'Grady, 1998, cited in O'Connor, 2006). The Boyne main channel between Drogheda and Navan (including Slane) was never drained but retains a number of weirs that may restrict fish movement to some extent. The Mattock River tributary meets the Boyne just downstream of the first weir at Oldbridge, and it is apparent that fish have unrestricted movement there (e.g. Massa-Gallucci and Mariani, 2011).

Spawning sites for Atlantic salmon (and brown trout) are confined principally to the tributaries as there are very limited gravel deposits in the main channel (O'Grady 1998). Genetic studies have indicated that brown trout populations in the Boyne main channel are entirely composed of recruits from tributary sub-catchments (Massa-Gallucci and Mariani, 2011). The Boyne main channel supports mainly adult brown trout and also acts as nursery for salmon parr, which can hold station in faster water.

Fisheries surveys have been undertaken by IFI on the Boyne and its tributaries on a number of occasions between 2009 and 2016 as part of the WFD Fisheries Monitoring programme (Kelly et al., 2010, 2013, 2014, 2015, 2017). Sites on the upper Boyne, Blackwater (Kells) and Athboy are, 'moderate' or 'poor' status for fish based on most recently available data. A summary of all available fisheries data is reported in **Appendix 16.2**. Brown trout were the most commonly occurring species throughout each of the surveys, along with stone loach, three-spined stickleback and minnow, plus occasional coarse fish (roach, gudgeon, perch) and a few lamprey and eel. Note that apart from brown trout, the bulk of the balance of the numbers tended to be made up by minnow, three-spined stickleback and stone loach, all of which are more typical of sluggish flows and can tolerant enriched conditions better than salmon and trout. At the few locations salmon were recorded, i.e. Athboy (2009, 2012, 2016) and Blackwater (Kells) (2009, 2013), densities were small and declined over time.

Fish surveys also formed part of a five-year study whereby IFI monitored an experimental Environmental River Enhancement Programme (EREP)[4] measure on the Stonyford River tributary of the Boyne (McCollum et al., 2019), with data (**Appendix 16.2**) showing brown trout to be most abundant species, followed by three-spined stickleback, roach and lesser numbers of juvenile lamprey. Salmon were recorded infrequently in low numbers.

IFI also conduct surveys under the Salmon Conservation Fund throughout the Boyne catchment to assess distribution and abundance of salmon fry to inform fisheries management. A total of 142 sites were electro-fished in 2020 with mean fry/5min values of 10.36 for trout and 14.94 for salmon (IFI, 2020). The data is illustrated in **Figure 16.1**. The highest number of salmon fry was 109 (128 fry/5min) in the Mattock River. A River Boyne site, 1.5 km upstream of Slane Bridge, recorded low numbers of trout (6.86/5min) and salmon fry (1.41/5 min). In general, the main channel and larger tributaries had fewer fry compared to the smaller, more headwater tributaries in the upper system. The overall picture of the Boyne catchment from Slane upstream is one of modest-to-poor salmon and trout production, with barriers (weirs), drainage and impaired water quality likely to be limiting factors.

[4] Environmental River Enhancement Programme – joint measures by IFI in conjunction with the OPW to restore salmonid productive capacity in drained rivers.

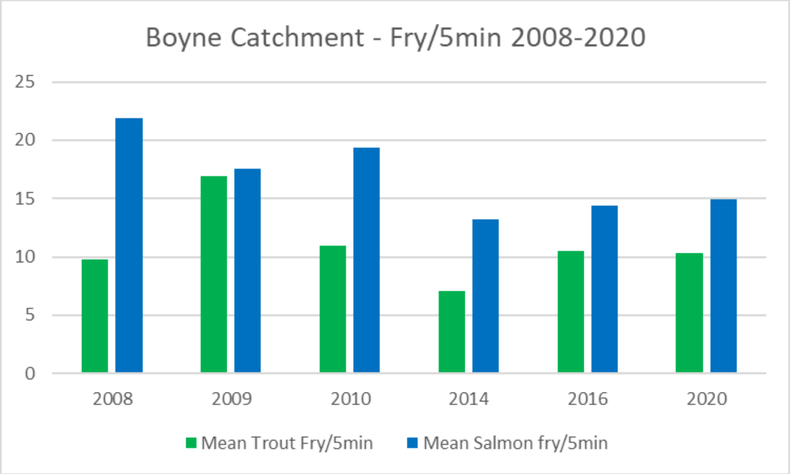


Figure 16.1: Boyne Catchment Salmonid Fry Densities 2008-2020

In addition to the Mattock River showing relatively high densities of both trout and salmon (IFI, 2020), genetic studies of Boyne catchment trout by Massa-Gallucci and Mariani (2011) suggest the trout population of the Mattock is a sea trout breeding unit, likely reproductively isolated from the rest of the Boyne stock. This aligns with the lack of obvious migration barriers (i.e. no weirs) between the estuary and the Mattock confluence near Oldbridge.

Juvenile lamprey (*ammocoete*) distribution was surveyed in the Boyne catchment in 2005 (O'Connor, 2006); electrofishing of suitable lamprey nursery habitat (silt deposits) was used, which found undifferentiated Lampetra spp. larvae present at varying densities throughout the catchment. The highest density was recorded on the Lower Boyne at the existing N2 Slane Bridge (79.00 m^{-2}), with a high density also found on the Mattock River at New Bridge (38.00 m^{-2}). The study concluded that, in the historically undrained reach of the Boyne between Drogheda and Navan, populations of both *Lampetra planeri* (brook lamprey) and *Lampetra fluviatilis* (river lamprey) were well above favourable conservation status and *Petromyzon marinus* (sea lamprey) may also be present. Threats to lamprey success were considered to be evident water quality problems and presence of large weirs.

16.3.1.1.4 Biological Water Quality

The WFD is enforced in Ireland under the European Union Environmental Objectives (Surface Waters) Regulations S.I. No. 272 of 2009, as amended. A target for Q4 and above is required for rivers sites to comply with good (Q4) or better (Q5) status required under the directive. **Table 16-6** shows most recent (2020) river monitoring results from relevant EPA river stations (RS) on the River Boyne and its Mattock tributary. Q-value status, as reported by the EPA, is determined by the biological quality element: macroinvertebrate fauna. The data shows impaired water quality in the vicinity of Navan, with a gradual improvement occurring over distance downstream. The River Boyne is currently reported at 'moderate' status (Q3-4) just upstream of Slane Bridge, but 'good' status (Q4) from Slane Bridge downstream to the estuary. The Mattock is also at 'good' status (Q4) just upstream of its confluence with the Boyne. The Mattock (Mooretown) Stream is not monitored as part of the EPA river monitoring programme.

Table 16-6: EPA Biological River Monitoring Data: Boyne Sub-catchment (2020)

EPA RS Code	EPA RWB Name	Station Name	Location in relation to Proposed Scheme	2020	Q-value Status
RS07M010300	Mattock_030	New Br u/s Boyne R confluence	~4.5km d/s proposed Mattock crossing	Q4	Good
RS07B042200	Boyne_180	Oldbridge (Obelisk Br)	~12.8km d/s proposed Boyne crossing	Q4	Good
RS07B042100	Boyne_160	Slane Br.	~0.6km u/s proposed Boyne crossing	Q4	Good
RS07B042010	Boyne_150	d/s Broadboyne Br (RHS)	~6.3km u/s proposed Boyne crossing	Q3-4	Moderate

EPA RS Code	EPA RWB Name	Station Name	Location in relation to Proposed Scheme	2020	Q-value Status
RS07B011800	Blackwater (Kells)_120	Slane Rd Br Navan	~13.6km u/s proposed Boyne crossing	Q3	Poor
RS07B041700	Boyne_120	Kilcarn Old Bridge	~14km u/s proposed Boyne crossing	Q3-4	Moderate

16.3.1.1.5 Physicochemical Water Quality

In addition to examination of EPA water chemistry data, discrete water sampling has been carried out at specific locations as part of baseline studies to inform this EIAR. Detailed results of all water chemistry parameters are presented in **Chapter 17 – Water**. The following is a brief summary of physicochemical conditions on the River Boyne and Mattock (Mooretown) Stream as relates to aquatic ecology and biological quality elements as part of ecological status classification.

<u>River Boyne</u>

Five sites on the River Boyne, located from upstream of Slane Bridge to downstream of the Mattock River confluence, have been monitored bi-monthly since August 2021 (see **Chapter 17**, **Figure 17.5**, Sites A, B, E1, E4 and E5). Results show the Boyne to be moderately nutrient enriched, with notably elevated mean and 95%ile values for orthophosphate and ammonia, and slightly elevated Total Organic Nitrogen (TON). The data confirms there are upstream sources of nutrient enrichment in the catchment, likely of agricultural and/or wastewater discharge origin.

Occasional spikes in Total Suspended Solids (TSS) were recorded in discrete grab samples. Maximum TSS concentration during the sampling period was 72 mg/l recorded on 13 December 2021, at Site B (just downstream of Slane). TSS values on that day were 56 mg/l and 40 mg/l at E1 and A, respectively. TSS means for Boyne main channel sites near Slane over the overall sampling period (n=16 samples) were 17 mg/l at Sites A and B, and 12 mg/l at Site E1. Mean TSS does not exceed the 25 mg/l (mean annual) criteria for this designated salmonid river. The values are on the high side of ideal for a salmonid river, but the sampling period covered the winter months when spates and hence sediment transport could reasonably be expected to be more common. Continuous turbidity data was recorded over this same monitoring period, but the data was considered unreliable, with results appearing to be confounded by turbulence and/or bio-fouling of sondes. The turbidity data demonstrated that there are major problems with continuous turbidity measurement on such a large, swift river; this is likely related to the difficulty of anchoring and maintaining the sonde.

A Biological Oxygen Demand (BOD) spike was recorded at Site B September to October 2021, but BOD was otherwise within criteria for ‘good’ status at all sites. Elevated BOD issue at Site B is likely to have been associated with die-back, degradation and wash-out (in the autumn months) of in-stream vegetation from the upstream, adjoining navigation canal. Excessive macroalgal growth was recorded at times on the Boyne main channel during summer baseline surveys, mainly *Cladophora* spp., a species that indicates enriched nutrient conditions. Overall, the higher frequency EIAR water sampling results tend to not support the classification of ‘good’ WFD status on the Boyne. Macroinvertebrate sampling in 2020 and 2021 indicated ‘good’ status (Q4), aligning with EPA assigned status. The in-stream conditions are considered, overall, to be borderline for salmon parr nursery (more impaired than ideal), but would be very productive for trout, which tend to thrive in slightly enriched conditions.

<u>Mattock (Mooretown) Stream</u>

Two sites have been monitored bi-monthly since August 2021; upstream (Site C) and downstream (Site D) of the existing N2 culvert. The stream is highly nutrient enriched, with elevated mean and 95%ile values for orthophosphate, ammonia and suspended solids, and high BOD on occasion. TON is not considered high for an eastern agricultural stream, suggesting that high levels of ammonia present are prevented from oxidization, possibly linked with excessive algal growth and consequent oxygen fluctuations. Nutrient concentrations at both sites are well in excess of those required to meet ‘good’ WFD ecological status under the Surface Water Regulations. This aligns with macroinvertebrate sampling that indicates biological water quality is ‘poor’ status.

Total Suspended Solids (TSS) concentrations were often excessive at both Site C and D. Maximum values were 457 mg/l (Site C) and 791 mg/l (Site D), with means (n=16 samples) of 88 mg/l and 100 mg/l, respectively. The results are likely linked to tillage related run-off. In addition, Site C (upstream) had consistently elevated concentrations of trace heavy metals, with mean values indicating exceedance of surface water environmental quality standards (EQS). The chemical signature at Site C suggests inorganic fertiliser application is the likely source of elevated metal concentrations. Presence of heavy metals in inorganic fertilisers, or as separate micronutrient applications, is well established in agricultural practice, with trace heavy metals commonly applied (as micronutrients) to Irish soils, including zinc, copper and cadmium (Teagasc, 2020), which are regularly elevated at Site C. The relatively low levels of these trace metals at Site D, just 200 m downstream suggests some form of removal within the stream, which could be the result of uptake by plants, i.e. known uptake of zinc by *Heliosciadium nodiflorum*[5] (Bruen et al., 2006), or adsorption onto sediment and substrates.

Water chemistry indicates a strong agricultural influence, with current drainage from the existing N2 not considered a significant source of additional nutrient and trace metals to the stream. The stream would not be expected to support salmon owing to its small size and impaired water quality. Conditions are considered to be suboptimal for trout as a result of high nutrient and potentially toxic effects of dissolved metals (associated with fertiliser input) in such a small stream.

16.3.1.1.6 White-clawed Crayfish

White-clawed crayfish (*Austropotamobius pallipes*) are not a qualifying interest of the River Boyne and Blackwater SAC but are listed on Annex II of the E.U. Habitats Directive (92/43/EEC) and are, in any case, protected in Ireland under the Wildlife Act 1976 as amended. An outbreak of crayfish plague in the 1980s is thought to have almost wiped-out crayfish in the Boyne catchment (Reynolds, 1988). NBDC[6] records show crayfish have since been recorded, intermittently, on mainly smaller tributaries upstream of Navan. There are no existing records for crayfish within 17 km of the Proposed Scheme. Crayfish were absent at Slane Bridge during a survey of the Boyne in 2000 (Demers & Reynolds, 2002) and there are no existing records for the species in the Mattock sub-basin. NBDC hold the following EPA records for crayfish, all located well upstream of the proposed crossing: approx. 18 km upstream in Boyne main channel (2009); approx. 19 km upstream in a tributary of the Skane River (2018); and approx. 17 km upstream in the Blackwater (Kells) (2012).

The most recent identified record of crayfish in the Boyne catchment is that of this author from the upper Athboy River in 2021. It is reasonable to assume that crayfish have a low density, patchy distribution throughout the catchment, depending on habitat availability and the ongoing effects of crayfish plague. Their presence (in low numbers at least) cannot be ruled out in the vicinity of the Proposed Scheme given that water chemistry and in-stream habitat is suitable for the species.

16.3.1.2 N51 Route Improvements

The proposed upgrade of approximately 820 m of the N51, east from Slane village to the proposed bypass, does not directly intercept any EPA delineated watercourses. The drainage layout drawings in **Volume 3** indicate drainage will comprise kerb and gully arrangements along the improved carriageway, with storm water pipes carrying flows via vortex grit separator and hydrocarbon/petrol interceptor to an attenuation pond. Post-treatment, the pond discharges to existing overland surface flows in the direction of the River Boyne main channel. The distance between this outflow and the Boyne is approx. 700 m. Habitat descriptions, fisheries and protected species reviews, provided in **Section 16.3.1.1** for the River Boyne main channel, thus apply to this section.

16.3.1.3 Slane Village Traffic Management Works and Public Realm Works

The existing River Boyne crossing at Slane Bridge is the only interception of the proposed traffic management and public realm works with an aquatic receptor. Habitat descriptions, fisheries and protected species reviews provided in **Section 16.3.1.1** for the River Boyne main channel thus apply to this section.

16.3.1.4 Baseline Summary of Watercourse Valuation and IEFs

Table 16-7 summarises aquatic receptors of potentially affected watercourses and classifies the IEFs that are considered in the impact assessment.

---

[5] Formerly *Apium nodiflorum*

[6] National Biodiversity Data Centre Livemaps: https://maps.biodiversityireland.ie/ (Accessed 12 March 2022)

Table 16-7: Baseline Summary of Watercourse Valuation and IEFs

Watercourse	Fisheries Significance	Designations and QI Habitats/ Species	Water Quality & Biological Status	Ecological Evaluation	IEFs Scoped into Assessment
River Boyne	Main channel in downstream ZoI is principally a migration channel for adult salmonids, lampreys and European eel. The majority of spawning habitats for salmonids and lamprey are upstream of Slane in smaller tributaries of Boyne and Blackwater. Silt at channel margins provide nursery habitat for juvenile lampreys. Some limited salmon nursery habitats in faster water, especially near the old collapsed weir downstream of the proposed crossing point.	Salmonid Water River Boyne and River Blackwater SAC Annex II Atlantic salmon (migration route and limited, patchy nursery) Annex II River lamprey (migration route and lamprey nursery)	EPA 2020 Q-value: Q4 – 'good' biological status (compliant with WFD objectives)	A - International Importance	**Yes**
Mattock (Mooretown) Stream	Upper reaches of a small tributary of the Mattock River, with impaired water quality and hydromorphology (drained). Likely to support low density of brown trout and brook lamprey, although drainage and water quality is not ideal for these species. European eel likely present. Important Sea trout spawning and nursery habitat located 4km downstream in the Mattock main channel.	None	Site survey 2022 Q-value: Q3 – [7]potential 'poor' biological status (not compliant with WFD objectives)	D - Local Importance (Higher Value)	**Yes**
Upper drain of "Slane stream"	None	None	*N/A* (Unsuitable for Q-sampling)	E - Local Importance (Lower Value)	**No**
Thurstianstown stream	Minor	None	Site survey 2022 Q-value: Q3 –potential 'poor' status (not compliant with WFD objectives)	E - Local Importance (Lower Value)	**No**
Boyne Navigation Canal	Minor. European eel may be present.	The canal is within the SAC boundary, but does not support aquatic QI species of the SAC	*N/A* (Unsuitable for Q-sampling)	A - International Importance	**Yes** (only insofar as it is a run-off conduit to the main channel of the Boyne)

[7] Macroinvertebrate status reported as "potential", since ratings outside of the formal EPA river monitoring programme are not official Ecological Status under the Water Framework Directive 2000/60/EC

16.3.2 Evolution of the Environment in the Absence of the Proposed Scheme

Enriched in-stream nutrient conditions on the River Boyne and Mattock (Mooretown) Stream will continue, as the sources for these are unrelated to the proposed N2 Slane Bypass and Public Realm Enhancement scheme. Such conditions will continue to enhance algal growth, possibly to nuisance levels along the River Boyne, which in turn will contribute to ongoing negative pressure on aquatic habitat quality (eutrophication) for aquatic species using the reach between Slane and Oldbridge. This includes salmon (migrating and parr nursery), trout (migrating and resident older fish), lampreys (migrating and juvenile nursery), as well as the macroinvertebrate fauna that are food sources to these species. Elevated nutrient levels along with intermittent spikes in suspended solids are considered to be the primary negative pressures on aquatic habitat quality in the affected reaches of both the Boyne and the Mattock (Mooretown) Stream and this will not alter regardless of the proposed scheme.

The Second (2018-2021) and Third Cycle (2022-2027) River Basin Management Plans will continue to be implemented with the intention of improving water quality even in the absence of the Proposed Scheme. Historical alterations to hydromorphology will continue to have slight to moderate impacts on upstream fish migration at weirs on the Boyne main channel between Oldbridge and Navan.

In addition, unattenuated (and consequently untreated) road run-off pollution from existing road surfaces that currently have inferior or no drainage treatment will continue to enter the watercourses. These will remain as sources of potential operational phase impact as traffic volumes increase into the future. This includes congested, stop-start traffic flows across the existing N2 Slane Bridge, which can give rise to elevated road surface run-off pollution in the form of heavy metal toxicity (Huber et al. 2016) and suspended solids, especially in relation to a high percentage of HGVs (current and predicted) on this route in the absence of a new bypass route. In the absence of the Proposed Scheme, therefore, potential positive effects on water quality and aquatic habitats would not be achieved.

16.4 Description of Likely Significant Effects

Sections 16.4.1 and **16.4.2** provide a description of the likely significant effects of the Proposed Scheme on biodiversity: aquatic ecology in cumulation with other existing development in the area. A description of the likely significant effects in cumulation with approved development i.e., development not yet built, is presented in **Section 16.4.3** based on the detailed methodology for CIA included in **Chapter 25**.

The impact interactions between biodiversity: aquatic ecology and other environmental factors are identified and described in **Chapter 26** and assessed throughout **Sections 16.4.1** to **16.4.3**.

16.4.1 Construction Phase

Impacts resulting from civil engineering works near watercourses are primarily related to three aspects of potential water borne pollutant loss, i.e., suspended sediment, concrete and hydrocarbons.

16.4.1.1 Suspended Sediment

The principal source of road construction related impact on aquatic receptors arises from the potential escape of excessive amounts of suspended sediment. This was confirmed by a critical review involving over 200 peer-reviewed papers on watercourse crossing construction phase effects (Cocchiglia et al., 2012). Sediment export could occur as a result of general earthworks (cut/fill, attenuation pond excavation), soil stockpiling and spreading; construction haul road levelling; pumping of solids-contaminated water from on-site excavations or drainage channels; drainage feature installation (swales, attenuation ponds); vehicular activity in and beside streams; ground investigation and archaeological trenching works; bridging; culverts and realignments. Culverting has a measurably greater impact on in-stream total suspended solids (TSS) and sedimentation compared to bridging. If not managed correctly, the large temporary construction platforms on both sides of the proposed Boyne crossing also have potential to contribute suspended solids run-off throughout the construction phase.

Escaped solids can settle in watercourses, resulting in smothering of plants and macroinvertebrates, causing fish to abandon affected areas at least in the short-term. At worst, such sedimentation could occur over salmonid spawning/nursery areas, which could result in significantly reduced recruitment of young fish from affected reaches as a result of egg and fry mortalities. Elevated concentrations of suspended solids and resulting turbidity within the water column can also potentially damage the gills, physiology and behaviour of fish (e.g. respiration, migration) and/or benthic macroinvertebrates (e.g. respiration, drift responses). Similar to salmonids, lampreys also depend on clean gravels for spawning, although lamprey nursery areas are less likely to be significantly adversely affected by small amounts of sedimentation, since juveniles (*ammocoetes*) inhabit areas of silt deposition during their nursery stage.

Sediment effects in the Mattock (Mooretown) Stream could include localised smothering of macroinvertebrates and their habitat, altering fish prey availability and distribution. Some patchy trout spawning and nursery habitat downstream may be affected, causing mortality of eggs and emerging fry through sediment deposition. If sediment control measures were not in place, such effects could be significant locally, but are unlikely to occur given the construction phase measures are detailed in **Chapter 5** will avoid and prevent excessive sediment loss.

Any effects in the Boyne main channel would be primarily linked to those habitats and species downstream of the new bridge crossing area in the high activity period of the construction. In-stream effects may include patchy deposition of silt in slack water areas downstream, thereby smothering substrates and resulting in changes to diversity and abundance of macroinvertebrate fauna locally. This may reduce prey availability for resident trout and coarse fish temporarily or in the short-term. If levels of silt escape were high enough, this could reduce suitability of habitats for salmonid nursery further downstream, e.g., around the collapsed weir, affecting low densities of salmon parr that may have dropped down to the main channel to feed. But there is very limited habitat for salmonid spawning, so the effects on salmonid recruitment would be imperceptible. Intermittent, elevated turbidity after rainfall could cause temporary changes to distribution and feeding success of mainly older resident trout. Excessive sediment on the riverbed could encourage rooted macrophyte growth which can trap further sediment with further knock-on effects of macroinvertebrate diversity. Excessive sediment may further deposit in areas where juvenile lamprey are burrowing, which could reduce oxygen availability in the hyporheic zone.

Note that a comprehensive methodology for the duration of the construction phase has been provided as part of the planning application for development consent (refer to **Chapter 5 – Description of the Construction Phase**, **Appendix 5.4 – Construction Programme Chapter 5**, **Section 5.10** (Environmental Management During Construction) also covers the implementation of the Environmental Operating Plan [EOP, included in **Chapter 5**, **Appendix 5.6**). The proposed methodology was developed with input from all relevant disciplines and includes details of the temporary bridge construction platforms near the proposed River Boyne crossing site which reduce potential source areas for sediment loss.

The impacts on trout, sea and brook lamprey, and QI species (salmon, river lamprey) and macroinvertebrates could be significant at an international level in the Boyne main channel downstream of Slane (at least as far downstream as slack waters downstream of the old weir) but are very unlikely to occur given the details set out in **Chapter 5** which builds construction design and phasing that avoids and reduces potential sources and pathways of sediment loss. Even if small amounts of sediment do escape the measures built into the construction method, slightly negative, localised effects would be reversible, with recovery possible in a reasonable timeframe following spates over consecutive winters, noting that there is no significant salmonid spawning habitat in this part of the Boyne main channel and fish can still recruit in upstream tributaries.

IN summary, adverse impacts on the River Boyne or the Mattock (Mooretown) Stream during the construction phase as a result of sediment loss effects would be significant at an international level in the Boyne or significant at a local level in the Mattock (Mooretown) if they did occur. However, based on details set out in **Chapters 4 and 5**, the sources and pathways for impacts have been dealt with through design and construction phase commitments and phasing, therefore sediment loss effects are unlikely to occur and the impact of sediment loss on aquatic species and habitats are considered ***unlikely*** and ***not significant***.

16.4.1.2 Cement

Bulk liquid concrete usage is required for many aspects of road construction, giving rise to the possibility that spills could occur and reach nearby surface waters. Liquid cement is highly alkaline and corrosive and can cause very serious fish kills, with similar effects on macroinvertebrates. Wash-off from recently cured cement can also be very alkaline and potentially dangerous to fish. Careful supervision of cement handling, curing times, pump-out water treatment and general good engineering practice can greatly reduce the risk from concrete-related impacts, such that the likelihood of negative effects on the aquatic environment can be described as low. In this regard, a comprehensive methodology for the duration of the construction phase has been provided as part of this application (refer to **Chapter 5 – Description of the Construction Phase**, and **Appendix 5.4 – Construction Programme**). The proposed methodology includes a suite of detailed water quality protection measures to avoid and reduce, and/or control, concrete pollution from the construction site in general, including the use of cofferdam construction at temporary bridge construction areas near the proposed Boyne crossing site. If concrete usage was not well managed in the vicinity of the Boyne main channel and liquid concrete escaped the construction area in large volumes, the effect may be localised mortality of macroinvertebrates and fish impacting a reach downstream that will depend on flow and turbulence at the time (i.e., dilution). Adverse impacts on the River Boyne or the Mattock (Mooretown) Stream during the construction phase as a result of cement toxicity effects would be significant at an international level in the Boyne or significant at a local level in the Mattock (Mooretown) if they did occur. However, based on details set out in **Chapters 4 and 5**, the sources and pathways for impacts have been dealt with through design and construction phase commitments and works phasing, therefore cement toxicity effects are unlikely to occur. The only area where cement effects may cause ***significant*** effects locally in the Boyne is in relation to concrete contaminated pump-out water from cofferdams on the Boyne floodplain during pier foundation construction. This is therefore addressed under mitigation in **Section 16.5.1**, below.

16.4.1.3 Hydrocarbons

Hydrocarbon spills from poorly secured or non-bunded fuel storage areas, leaks from vehicles or plant or spills during re-fuelling can all give rise to the escape of hydrocarbons from construction sites to water courses. These spills have generally not been known to cause fish kills, but can give rise to tainting of fish, which could affect amenity values of the River Boyne fishery downstream. Potential pollution by hydrocarbons during the construction phase can be readily prevented by best practice in terms of site layout including fuel storage and best practice construction management in relation to vehicle and plant maintenance and refuelling. Adverse impacts on the River Boyne or the Mattock (Mooretown) Stream during the construction phase as a result of hydrocarbon effects would be significant at an international level in the Boyne or significant at a local level in the Mattock (Mooretown) if they did occur. However, based on details set out in **Chapters 4 and 5**, the sources and pathways for impacts have been dealt with through design and construction phase commitments and phasing, therefore hydrocarbon toxicity effects are unlikely to occur and the impact of cement loss on aquatic species and habitats are ***unlikely*** and ***not significant***.

16.4.1.4 Watercourse Crossing Construction – River Boyne

A clear span bridge will be constructed over the river and disused Boyne Navigation canal, but no in-stream works are necessary at these locations. Works close to the Boyne main channel are involved, potentially giving rise to wash-out of sediment during installation of piers on the floodplain. The construction methodology provides details of two large, temporary work areas within 50 m of the Boyne channel. Significant construction work is required to secure bridge pier foundations just behind the 10 m exclusion mark at each riverbank.

The overall construction period covers approximately 36 months in total, split into five distinct work phases. Phase 1 includes the construction and seeding/planting of all permanent pre-earthworks ditches (PED) and future permanent attenuation ponds. These areas will be excavated then allowed to revegetate in advance of all other construction works, making them operational for attenuation / settlement of run-off during construction. This reduces potential sediment source areas and risk of untreated or uncontrolled discharges entering the river during the construction phase and is seen as a critical step in avoiding and preventing potentially significant impacts on the Boyne and the SAC. Phase 1 advance drainage works do not occur on the Boyne lower floodplain area or within the 'high probability' flood extents identified by OPW Floodmaps[8].

Phase 2 construction works involve installation of four-layer reno-mattress work platforms and sheet pile cofferdams near the Boyne channel to facilitate bridge pier foundation construction. The timing of these installation works is critical, allowing sufficient time in dry weather for bedding-in of the temporary surfaces. If unexpected over bank flood flows occurred before the temporary works platform area on the south bank was covered by reno-mattresses then there could be excessive levels of sediment loss to the Boyne with effects as described in **Section 16.4.1.1**, above, resulting in negative effects on fish and macroinvertebrates that would be significant negative at an international level. The work platform on the northern side of the river is on higher ground, where flood flows are very unlikely to be problematic. Once reno-mattresses are installed and embedded, the risk of mobilisation of suspended solids from the secured work platforms will be low even if over bank flood flows from the Boyne did occur during the construction. Indeed, the reason these

[8] OPW Floodmaps, Available at: https://www.floodinfo.ie/map/floodmaps/ (Accessed April 2022)

temporary work platforms are being constructed as part of the Proposed Scheme is to avoid sediment source areas in the first instance. These platforms will remain in place throughout pier construction (Phase 3) and girder placement (Phase 4) until Phase 5 when reno-mattresses/cofferdams will be carefully removed, with concurrent reinstatement of the floodplain. Reinstatement will include reseeding with appropriate native damp meadow grasses on the south bank, and coir-matting with hydroseeding if possible, or otherwise resodding with appropriate native species mix, on the northern bank. Once again, if unexpected over bank flood flows occurred in the period between removal of reno-mattresses and reinstatement of floodplain vegetation (south bank in particular) then there could be excessive levels of sediment loss to the Boyne with effects as described in **Section 16.4.1.1**, above, resulting in negative effects on fish and macroinvertebrates that are would be significantly negative at an international level if they did occur.

The relevant aquatic receptors in the Slane reach of the Boyne are seasonally migrating salmon and sea trout (spring/summer/autumn); older resident brown trout; juvenile salmon (parr) over limited patches of nursery habitat; migrating lampreys and temporarily resident lamprey ammocoetes; resident coarse fish (pike, roach); plus macroinvertebrate and in-stream plant communities.

If the works near the Boyne were poorly managed and elevated suspended solids levels were released, this could damage the gills of salmonid fish and benthic macroinvertebrates locally, and/or can smother fish nursery areas when deposited downstream. Significant localised deposition is unlikely given the swift flows. Some more distant deposition could occur in pockets of backwater associated with the historic weir >300m downstream. This may slightly alter the quality of lamprey nursery habitat but would not be considered significantly negative as localised silt deposits form lamprey nursery habitat. Juvenile salmonid fish would be more susceptible to gill damage than older salmonids as a result of temporary increases in suspended solids, although numbers affected would be relatively few owing to localised paucity of nursery habitats. Older resident trout and migrating salmonids would be likely to avoid areas of localised water turbidity.

Cofferdam containment areas around the pier foundation construction areas will be subject to constant water ingress, as works are essentially below the water table. These areas will become constant sources of contaminated water (sediment and concrete washings) which will need to be pumped-out to create dry working conditions. Such pump-out water is likely to be turbid as well as highly alkaline (concrete washings) and potentially contaminated with hydrocarbons (polycyclic aromatic hydrocarbons (PAHs), oils). This cannot be discharged to the general environment or to the permanent attenuation areas in the absence of specialised treatment. During Phase 3 (bridge pier construction), pump-out water from cofferdam containment areas will be pH monitored, and will be removed for off-site treatment, and never discharged directly to the surrounding environment.

If unexpected flooding with out-of-bank flow occurred while heavy plant and machinery and associated fuels, oils and lubricants were stationed on the temporary work platform, there is a risk of hydrocarbon loss to the Boyne, with tainting of fish being possible downstream. Concrete usage will remain contained within the cofferdams proposed to be surrounding bridge foundation construction areas. The height of these are stipulated to be higher than the 1% AEP flood flow and therefore concrete loss linked to unexpected flooding is considered unlikely.

The design of the temporary work platforms as set out in **Chapter 5** (1) reduces and controls sediment source areas and (2) intercepts and treats any entrained sediment along pathways during the construction phase, therefore the likelihood of significant sediment release to the Boyne main channel is relatively low. This is not to discount that adverse effects could be significant if unexpected flooding with out-of-bank flow occurred at key stages of the temporary platform construction and deconstruction as set out in the above paragraphs.

The intricacies of dealing with pump-out water from cofferdam construction areas will require a well thought-out and implemented system of collection, monitoring and off-site treatment. There will be strict implementation of all water pollution control measures and daily monitoring of efficacy and security of such measures whilst the cofferdams are in place (refer to the construction phase monitoring set out in **Section 16.7.1**. This will be enforced by the Council on the contractor through express terms of the contract and the environmental monitoring by an official engaged by the Council (refer to **Chapter 5**, **Section 5.10** Environmental Management During Construction).

In the event that there was to be an absence of mitigation and monitoring that includes dedicated systems of: (1) daily water quality checks and monitoring; and, (2) daily efficacy checks, monitoring and surveillance of the implementation of specific water quality protection measures, there is potential for short-term ***likely significant negative impact at an international level*** with regards to salmon, lampreys, trout and macroinvertebrates in the River Boyne downstream of Slane at each phase of the construction period. The issue of containing and treating ongoing cofferdam ingress water has the most immediate potential for adverse impacts on aquatic receptors locally. Measures to mitigate likely significant impacts are set out in **Section 16.5** and proposed monitoring in **Section 16.7**.

16.4.1.5 Hydroacoustic Effects – River Boyne Crossing Construction

Pile driving is required as part of bridge pier foundation construction. The central and northern piers are located just over 10 m from the Boyne riverbanks, each requiring 14 foundation piles (approximate diameter 1,200 mm). These will be driven using drilling auger and bucket as opposed to hammer techniques. Bucket auger techniques produce continuous sound and vibration, as opposed to impulsive sound and vibration associated with impact techniques. Sounds generated by bucket auger are generally of lower peak frequency compared to hammer driven methods. The sound and vibration associated with drilling auger use during the construction phase near the Boyne main channel will be semi-continuous and temporary.

Ground borne sound and vibration can result in wave propagation through substrates that produce sound pressure waves and particle motion in water. The available evidence shows that fish hear via mechanisms responding to both sound pressure and particle motion (Popper and Hawkins, 2019). Hearing is influenced by presence/absence, and location in relation to the ear of a swim bladder (or gas bubble). The swim bladder/gas bubble can enhance fish hearing, as it reradiates particle motion. As a result, fish species have different hearing capabilities, but the evidence shows the majority of fishes detect various sound levels at frequencies between <50 Hz to 300–500 Hz (Popper and Hawkins, 2019). Fish also detect particle motion in water via the lateral line system which utilises displacement-sensitive cells similar to those of the ear. However, there have been no demonstrations to date of damage to lateral line systems as a result of intense anthropogenic sounds (Popper et al., 2014).

Popper and Hawkins (2019) reviewed available evidence on the effects of anthropogenic noise on fishes noting that there are numerous information gaps that make it difficult to reach clear conclusions on sound levels / types that have potential to cause measurable effects on fish. It was, however, recommended that the interim guidelines for sound exposure on fish (developed by Popper et al., 2014) remain the relevant criteria until further data becomes available. Mickle and Higgs (2018), for example, pointed out that freshwater systems are greatly underrepresented in bio-acoustic studies, meaning the current criteria are derived largely from deep water and marine fish studies which may not translate to riverine environments where, e.g. sound propagation is difficult to model.

The data underpinning the guidelines show that potential effects of anthropogenic sound on fish include behavioural changes, stress, physiological and/or physical damage and mortality (Popper and Hawkins, 2019, Popper et al., 2014). Mickle and Higgs (2018) in their review of effects on (typically shallower water) freshwater fish species, reported impacts of sound levels can be broadly categorized into behavioural changes (e.g. foraging efficiency, avoidance response, startle/shelter response, activity levels) and physiological changes (e.g. cortisol levels, oxygen usage).

With regard to aquatic Annex II species of the SAC, salmon have a swim bladder that is relatively distant from the ear and are therefore primarily sensitive to particle motion (as opposed to sound pressure), resulting in reasonably narrow hearing bandwidth. Similarly, the current evidence suggests that lampreys (*Petromyzontidae*) are also primarily sensitive to particle motion (Popper and Hawkins, 2019).

Eels have a swim bladder that is located close, but not intimately connected to the ear, and are sensitive to particle motion and sound pressure over a more extended frequency range. Cyprinids have special structures mechanically linking the swim bladder to the ear and are primarily sensitive to sound pressure, extending over a wide frequency range.

The hydroacoustic noise assessment is set out in **Chapter 9**, **Section 9.4.1.7.2** (Underwater and Groundborne Noise Impacts). It is noted that bored piling and press-in piling techniques are low impact methodologies. The results at the nearby River Boyne show: 132 dB re 1 µPa [Peak]; 159 dB re 1 μPa^2-s [Sound Exposure Level/ SEL (24 hour)] and 113 dB re 1 µPa [Root Mean Square/ RMS]. The results are conservatively based on a 50% duty cycle over 24 hours. The critical exposure period (i.e. relating to piling of central and north piers) would potentially last for 14 days (estimated as one day needed per pile installation, times 14 piles per pier) on each side of the Boyne main channel, resulting in a total of approximately 28 days times 8 hours. There would be a gap during this period while the drilling rig is moved from one side of the channel to the other. The sound source is therefore continuous while in operation but intermittent and temporary. Furthermore, the sound source is stationary, and the channel width is 40 m, meaning there would at all times be a section of the channel much less affected by underwater noise associated with piling. Ambient noise levels within the Boyne will already be elevated owing to its swift, turbulent nature in the crossing reach.

The most likely fish species proximal to the affected reach are migratory salmon; river and sea lamprey; resident brown trout (larger fish only); eel; and juvenile lamprey (mainly sea/river, possibly brook lampreys). Numbers and densities will vary over the course of the approximate 28-day foundation piling activity. Several non-native cyprinid fish species (roach, pike, gudgeon, perch) may be present from time to time, although the riverine habitat is not ideal in the crossing reach for these species owing to reasonably swift flows and paucity of in-stream vegetation. Cyprinids would be more commonly found further upstream and downstream in slacker flows with a greater cover of emergent and/or submerged macrophytes.

Sound exposure guidelines (Popper et al., 2014) and evidence from Mickle and Higgs (2018) set out in **Appendix 16.3** suggests the following for salmon and lamprey (particle motion-sensitive – little if any swim bladder involvement):

- Potential moderate risk of behavioural and physiological responses in any nearby individuals (Popper et al., 2014), perhaps measurable as stress (increased cortisol) and resulting in startle and avoidance responses (Mickle and Higgs, 2018);
- Potential moderate risk of temporary hearing threshold shift (Popper et al., 2014) but this is unlikely at predicted levels of 113 dB RMS compared to ambient levels; and
- Potential high risk of masking of ambient sound cues (Popper et al., 2014), although this is not certain for the river environment, where ambient noise differs compared to open water conditions upon which criteria are based.

For fish with swim bladder involvement in hearing, i.e., eel, cyprinids:

- Potential high risk of behavioural and physiological responses in any nearby individuals (Popper et al., 2014), possibly resulting in masking of ambient sounds and/or startle and avoidance responses; and
- The risk of temporary hearing threshold shift is estimated to occur at 158 dB RMS for 12 hrs (Popper et al., 2014), a level that is not predicted to be reached.

It is estimated that mild avoidance reactions will occur for salmon and lamprey that happen to pass nearby the pile driving sound source, with perhaps a slightly stronger reaction in more sensitive (swim bladder influenced) species, noting that eel and cyprinids would not normally be resident in the reach owing to swift currents. In summary, impacts on the freshwater fish species, including migrating salmonids and lamprey and any resident juvenile lamprey are predicted to be temporary and very minor for relatively small numbers of localised individuals and ***not significant*** at a population level. The most likely fish response is avoidance, meaning individuals can move laterally or longitudinally in the large channel to escape and reduce stress.

16.4.1.6 Watercourse Crossing Construction – Mattock (Mooretown) Stream

A series of three culverts will be constructed to facilitate the northern tie-in of the Proposed Scheme. The construction directly affects approx. 200 m of the stream, with the culverts separated by short sections of realigned channel. This water course is of relatively minor ecological value with currently impaired water quality, including regularly high background TSS concentrations. It is however a fish bearing channel, capable of supporting trout, brook lamprey and eel. It is located well upstream of the more sensitive salmon and trout spawning habitat of the River Mattock. Even so, the scale of the proposed culverting and channel realignment works could, if they were not carefully managed, result in export of pollutants (sediment, cement, hydrocarbons) for some distance downstream during the construction phase.

Culvert installation will require in-stream works with a direct footprint on existing low quality fish habitats. The construction methodology in **Chapter 5 – Description of the Construction Phase** proposes a permanent stream diversion which allows culverts 6A (approx. 41 m length) and 6B (approx. 55 m length) to be constructed offline, in the dry. Installation of the small culvert 6C (approx. 9.7 m length), plus the removal of the existing N2 culvert requires in-stream works. There may be small to moderate numbers of trout, lamprey and eel mortality if the works did not include fish removal prior to channel dewatering.

The proposed bypass carriageway also traverses a number of small field boundary drains that feed into the Mattock (Mooretown) Stream. Whilst these drains have low ecological sensitivity in themselves, they form pathways to more sensitive habitats of the lower Mooretown, and Mattock River main channel downstream.

Adverse impacts on the Mattock (Mooretown) Stream during the construction phase as a result of sediment, cement or hydrocarbon toxicity effects would be significant at a local level if they did occur. Based on details set out in **Chapters 4** and **5**, the sources and pathways for such impacts have been dealt with through design and construction phase commitments and works phasing, and any such effects are unlikely to occur, with the impact on aquatic species and habitats considered unlikely and not significant in this regard. In the absence of mitigation in the area of in-stream works, there would be ***likely moderate to significant negative impacts at a local level*** on aquatic receptors, specifically direct mortality of small numbers of fish (brown trout, eel, brook lamprey) and macroinvertebrates locally at the N2 tie-in. Measures to mitigate significant negative impacts are set out in **Section 16.5** and proposed monitoring in **Section 16.7**.

16.4.1.7 Construction Phase Run-off to Thurstianstown Stream

This watercourse is not directly intercepted by the proposed scheme, but the construction footprint at the southern end of the proposed scheme drains via a low gradient field drain towards this stream. The Thurstianstown Stream itself is of low ecological value, being highly modified with little or no fisheries value and not considered a sensitive aquatic receptor. It does, however, form a potential pathway for waterborne pollutants that (if in high enough concentrations) could reach and affect the main channel of the River Boyne upstream of Slane Bridge.

It is noted that a pre-established (permanent) attenuation pond will allow for settlement/treatment of construction phase run-off at the southern end of the scheme. Design and construction phase measures have been addressed in **Chapter 5,** including the Pre-Main Construction Works (Enabling Works) phase (Chapter 5, **Section 5.2)** which establishes the attenuation pond prior to the main road construction phase. With careful implementation of sediment and erosion control measures as detailed in **Chapter 5, Section 5.3**, the risk of pollutant loss and subsequent adverse impacts on the River Boyne via the Thurstianstown Stream will be very low. Given the low sensitivity of the Thurstianstown stream itself, and the low probability that any potential pollutants will have a pathway to the downstream River Boyne, any construction phase impact in relation to the Thurstianstown stream is therefore considered unlikely and ***Not Significant***.

16.4.2 Operational Phase

16.4.2.1 Potential Road Drainage Pollution

The principal contaminants in road surface drainage with potential for effects on aquatic organisms are suspended solids, often with associated trace contaminants: heavy metals and hydrocarbons, including oils and polycyclic aromatic hydrocarbons (PAH). Principal metals of concern in road run-off are copper, zinc and cadmium (the latter to a lesser extent). Lead is no longer considered a major concern in Ireland since the introduction of unleaded petrol (Bruen et al. 2006). Whilst the majority of the pollutant load including the metals and PAH are sediment-bound, fractionation into particulate and dissolved phases affects potential impact.

Sources of traffic-related pollutants include tyre and brake lining abrasion, fuel and oil leakage, fuel combustion residues, and wear of asphalt surfaces (Healy et al., 2008). Contaminants can also arise from road structures, e.g., zinc from bridge structures and fencing (Huber et al., 2016). Such substances accumulate on the pavement surface until a rainfall event washes them into the drainage system. The longer the interval between rainfall events, the greater the concentration of contaminants in the initial stage of the next run-off event. Highest concentrations of run-off pollutants have been reported to routinely occur in the first two hours of an event (O'Riley et al., 2002).

Suspended solids can cause physical impacts on aquatic organisms (gill abrasion) and degradation of their habitats (sedimentation and smothering). Excessive levels of metals and PAH can be acutely toxic (in soluble form) and/or chronically toxic (sediment-bound) in aquatic ecosystems (Bruen et al., 2006). Regarding metals in highway run-off, dissolved copper is potentially more acutely toxic than zinc, but zinc is generally present in higher concentrations. Of note is that aquatic toxicity of zinc (and copper to a lesser extent) is ameliorated by increased water hardness. This is relevant in the case of both the River Boyne and Mattock (Mooretown) Stream, which both have high mean annual alkalinity (>200 mg/l $CaCO_3$), thus reducing potential for metal toxicity.

Noted also from EPA and site-specific data are the consistently low concentrations for metals (zinc, copper, cadmium) and PAH on the River Boyne along the reach between Slane and Oldbridge. Concentrations of these parameters were most often below the laboratory limit of detection and showed no exceedance of statutory EQS for 'good' status. Such low background concentrations upstream and downstream of the existing Slane Bridge crossing suggests a negligible impact from existing traffic related drainage.

On initial examination, high background concentrations of metals (zinc, copper, cadmium) at Site C on the Mattock (Mooretown) Stream were recorded upstream of the existing N2 crossing. These are clearly not related to existing N2 road drainage, instead most likely indicative of upstream agricultural (fertiliser) inputs. Metal concentrations currently diminish to very low levels (below detection limits) downstream of the existing N2 road crossing of the Mattock, probably as a result of in-stream natural processes (e.g. uptake by plants; adsorption onto substrates). Road drainage from the proposed N2 Slane Bypass tie-in will be attenuated in a proposed hybrid wetland/pond before discharging to the Mattock (Mooretown) Stream and does not represent a significant additional source of pollutants.

The main factors influencing contaminant concentration in run-off are considered to be Annual Average Daily Traffic (AADT) and rainfall regime (volume, duration and antecedent conditions) (TII, 2015). Most research has focused on road run-off impacts in relation to roads carrying much higher traffic volumes than the proposed bypass. But it is not possible to identify a traffic volume that would be considered so low that any adverse impact could be entirely ruled out (e.g. Huber et al., 2016). Irish national roads produce run-off with similar characteristics to those in the UK where studies have shown in that, in the absence of treatment, impact on water quality can be expected from highways with >30,000 AADT, although AADT of >15,000 has been proposed as a traffic density that could be of concern (Bruen et al., 2006).

The following evidence was considered in the current operational assessment:

- In a critical review of studies relating to heavy metals in road run-off by Huber et al. (2016), AADT explained only about 30% of dissolved metal variation, with other important factors being, for example, (1) braking and acceleration activity at traffic signals or congestion areas, (2) additional braking on exit and link roads compared to highways; (3) speed of travel during rain events, influencing wash off of pollutants. Roads with AADT >5000 are often more polluted than highways of up to 30,000 AADT, attributed to site-specific braking and acceleration factors.
- UK studies (Maltby et al., 1995a; Perdikaki and Mason, 1999 cited in O'Riley, 2002) found no significant impact of road run-off on macroinvertebrate communities. The localised, non-significant effects noted were confined to smaller streams for: (i) relatively short distances downstream of the road drainage discharge points and/or (ii) during summer low flows.
- An Irish study (Bruen et al. 2006) sampled 14 streams between 2002-2005 upstream and downstream of highway drainage (N5, N7, N11, N59, M1, M4) covering a range of AADT: 2,513 (6.8% HGV) to 50,729 (12.8% HGV). There was no evidence of negative impact from road drainage on macroinvertebrate communities in the downstream sections of the streams examined.
- A sub-set of the above Irish highway sites were also electro-fished as part of the same study, showing no evidence of impact on fish community structure or fish condition as a result of road drainage. It was noted however that the streams generally had background organic pollution issues, so that any isolated effect of road drainage was confounded to some extent (Bruen et al., 2006).
- A study by Wellman et al. (2000) showed that sediment accumulation is linked to culverting but not bridging, but that the impact was not sufficient to impact on fish communities.
- Irish road drainage standards (TII, 2015) apply the UK surface water risk assessment for road run-off pollution (HEWRAT[9]) which models potential for acutely toxic effects of dissolved metals and risk of sedimentation, i.e. related to chronic metal and PAH toxicity from sediment-bound contaminants. HEWRAT outputs for the proposed scheme are presented in **Chapter 4** (refer to **Sections 4.4.11.5 – 4.4.11.7**), confirming that with the proposed level of drainage attenuation there is no risk of exceedance of acute or chronic threshold values for copper or zinc in the River Boyne or Mattock (Mooretown) Stream.

With respect to the above, the traffic projections (AADT) for the proposed bypass are considered low. AADT values are presented for specific road sections in proximity to the proposed watercourse crossings of the River Boyne and Mattock (Mooretown) Stream in **Table 16-8**. The figures are from **Chapter 7 – Traffic and Transport**, noting that AADT is equivalent to traffic 'daily flow' values.

[9] Highways England Water Risk Assessment Tool, which goes by the previous acronym HAWRAT (Highways Agency Risk Assessment Tool) in TII (2015).

Table 16-8: AADT Figures – Existing Versus Proposed as Relevant to Aquatic Impacts

Scenario	Boyne Crossing – Existing Slane Bridge		Boyne Crossing – Proposed Slane Bypass		Mattock (Mooretown) Stream Crossing	
	AADT	HGV%	AADT	HGV%	AADT	HGV%
Do-Minimum (2041)	8,310	20%	–	–	10,830	16%
Do-Scheme (2041)	820	10%	13,610	15.5%	11,800	16.7%

The Proposed Scheme leads to 88% reduction of overall traffic volume across the existing N2 Slane Bridge: a signal-controlled, alternating one-way system. The proposed HGV ban as part of the Proposed Scheme results in a 95% reduction in daily heavy vehicle volume over Slane Bridge. This greatly reduces braking, deceleration/ acceleration, tyre wear and idling of traffic on the approaches to the River Boyne. A significant decrease in potential pollutant sources is therefore predicted, i.e., less wear and tear on road surfaces, tyres and brake linings (copper and zinc sources); reduction in fuel combustion and hydrocarbon emissions (oil and PAH sources). The new Slane Bridge would allow free flow of traffic across the Boyne, with road surface drainage diverted through hybrid wetland attenuation ponds.

Because design year (2041) traffic levels for the proposed N2 Slane Bypass are low, the impact risk for aquatic receptors even in the absence of mitigation is expected to be low. At worst there may be slight disturbance of the macroinvertebrate community confined to a short distance immediately downstream of the road outfall on the Mattock (Mooretown) Stream, with a likely negligible impact on the much larger River Boyne. However, given the high sensitivity of the River Boyne (SAC / SPA), environmental control measures have been incorporated into the design of the road drainage system in order to attenuate suspended solids, trace metals and hydrocarbons from routine road drainage.

Attenuation basins will contain sections of constructed surface flow wetlands, planted with appropriate native aquatic vegetation. This is one of the better means of treating road drainage and provides biodiversity enhancement opportunities. Bruen et al. (2006) reported removal efficacy of a wetland treating run-off from Ireland's M7 at Monasterevin (25,000-30,000 AADT; 12.7% HGV) of up to 94% of the total suspended solids, 67% of total phosphate, 91% of total zinc, 67% of total cadmium, 60% of total lead and 78% of total copper. Attenuation basin/ hybrid wetlands will be used to treat the run-off from the roadway before it is directed to the River Boyne and the Mattock (Mooretown) Stream.

With regards to road run-off pollution in the operational phase, there is potential for a net-positive, long-term impact on water quality and aquatic ecology as a result of removal of 90% of vehicles (including a 95% reduction in HGVs) across the existing N2 Slane Bridge. It would be expected that the combination of: (1) predicted AADT on the proposed bypass route, and (2) attenuation and treatment of run-off via hybrid ponds/wetlands would lead to at worst an imperceptible-to neutral impact on receiving water quality, with potential for long-term positive impact compared to the Do-Nothing scenario

It is noted there is potential for long-term **positive** impact on aquatic ecology of (in particular) the River Boyne as a result of water quality improvement that may arise by introducing modern road drainage features, e.g., attenuation ponds. The Proposed Scheme removes significant sources of unattenuated (and consequently untreated) road run-off pollution from existing road surfaces that currently have inferior or no drainage treatment which would otherwise remain as sources of potential operational phase impact as traffic volumes increase into the future. This includes congested, stop-start traffic flows across the existing N2 Slane Bridge, which can give rise to elevated road surface run-off pollution in the form of heavy metal toxicity (Huber et al. 2016) and suspended solids, especially in relation to a high percentage of HGVs (current and predicted) on this route in the absence of a new bypass route.

The conclusion is that operational impacts (if any) of road surface drainage pollution on aquatic receptors will be ***Not Significant*** and are ***likely*** to be ***positive*** in the long-term, both locally and in the downstream zone of influence. There will be no significant operational phase impact on aquatic QI species (salmon, river lamprey) of the River Boyne and River Blackwater SAC.

16.4.2.2 Potential Bridge Shade Effects

In-stream plants require light to conduct photosynthesis, propagate and survive, in turn affecting aquatic macroinvertebrate production and fish productivity. On the other hand, shade can be highly beneficial to rivers and streams through regulation of water temperature and provision of physical cover to in-stream organisms. Shade, for example, is suggested as a potential management strategy to mitigate climate-change induced in-stream water temperature increases in UK river catchments (Johnson & Wilby, 2015) and to improve water quality conditions in small and moderate-size watercourses that are exposed to excessive algal growth during summer periods (Ghermandi et al., 2009).

The proposed N2 Slane Bypass bridge deck over the Boyne is approximately 23.55 m wide and 12.0 m above median river level at the crossing point. The bridge orientation is north-south, with a wide, generally open, locally treeless floodplain to the east and west. This means that, other than the elevated bridge structure itself, incident solar radiation to the Boyne channel would not be otherwise obstructed. Light incidence would still occur upon most of the channel beneath the bridge at various times throughout the day as a function of the changing angles of solar radiance moving east-west (with low angles morning and evening), in contrast to the north-south bridge orientation.

Owing to the size of the Boyne in relation to the bridge shadow, there is likely to be an imperceptible effect on overall river water temperature. There may be beneficial microclimates created in small areas for fish, which often show preference for shaded (covered) river habitats.

With regards to in-stream vegetation, the river is wide and deep in the crossing reach with plant growth primarily confined to margins, generally characterised by commonly occurring emergent species including: *Phalaris arundinacea (*reed canary-grass)*, Glyceria maxima (*reed sweet-grass*), Veronica spp.*[10] *(*brooklime*),* and yellow iris, as opposed to submerged species which are photo-sensitive and are precluded by water depth and turbidity. The in-stream plant community present is not, therefore, considered highly sensitive to any changes in light incidence as depth/turbidity characteristics are overriding determinants.

There is likely to be a slight reduction in ephemeral algal production along a short reach directly below the bridge, but this will not result in negative ecological impacts. If anything, this represents a positive effect overall, linked to reduced levels of macroalgae growth along the shaded reach. The Boyne currently suffers from intermittently high levels of macroalgae production (pollution tolerant *Cladophora* and *Vaucheria*) because of nutrient enrichment, which leads to increased BOD and changes to in-stream oxygen conditions that negatively affect in-stream fauna. Any reduction in excessive levels of algal growth would be regarded as positive for fish and macroinvertebrate communities. Potential shading effects on the River Boyne main channel in the operational phase will be ***Not Significant***.

16.4.2.3 Potential Scouring Effects – Boyne Crossing

The bridge piers on the banks of the River Boyne have a 10 m set-back from each bank. These are piled and secured below ground: approximately 1.2 m diameter piles below concrete foundations of 2 m depth, with three circular diameter 1.5 m struts supporting the bridge deck girders. If not correctly designed at the outset, and subsequently maintained through the operational phase there is potential for scouring effects during over bank flow around the base of piers. Scouring can be a source of suspended solids, though would not generate high concentrations most of the time. The main issue, with such large structures situated close to the riverbank, would (over time) be potential for localised scouring to cause local bank collapse.

The floodplain in the immediate vicinity of the proposed Boyne crossing location floods when water level reaches 12.0 – 12.5 mAOD. The corresponding flow according to the rating curve is 127 m^3/s, which equates to between 5%ile and 1%ile flow using statistics for the Boyne (OPW[11] Hydro-data: Station 7012; Slane Castle). This equates, conservatively, to over bank flow occurring on average approx. 13 days per annum (assuming 3.5%ile flow). Given the generally flat topography, the south bank floodplain may be inundated for a period following overbank flow, surrounding mainly the 'central' pier of the bridge. The northern floodplain, with steeper topography, would drain more rapidly following an event, meaning extended inundation would be less of an issue there. The 'wet' nature of the southern floodplain (**Plate 1(a)**, **(b)**) where the 'central' bridge pier foundation is proposed exhibits wet-floodplain vegetation with that soils that are waterlogged for a portion of the year and subject to regular flooding during winter months.

Hydraulic modelling for the river in the bridge crossing reach included estimation of out-of-bank flow velocities, and a bridge scour assessment was completed by bridge engineers. Each of the piers were subject to scour assessment using conservative values for input parameters, (i.e. 1 in 1,000 year event, 50 mm diameter bed material). The result of the assessments gave the bridge a risk rating of 5 which is the lowest risk rating with "*no action required other than routine inspections in accordance with DMRB CS 450*

---

[10] The term 'spp.' refers to the plural for 'species' or 'several species'.

[11] https://waterlevel.ie/0000007012/

[formerly BD63] *(Highways Agency, 2021)*" (see **Chapter 4**, **Section 4.4.9.8.5**). The effects on in-stream aquatic habitats, macroinvertebrates and fish arising from scour are therefore ***unlikely and not significant***.

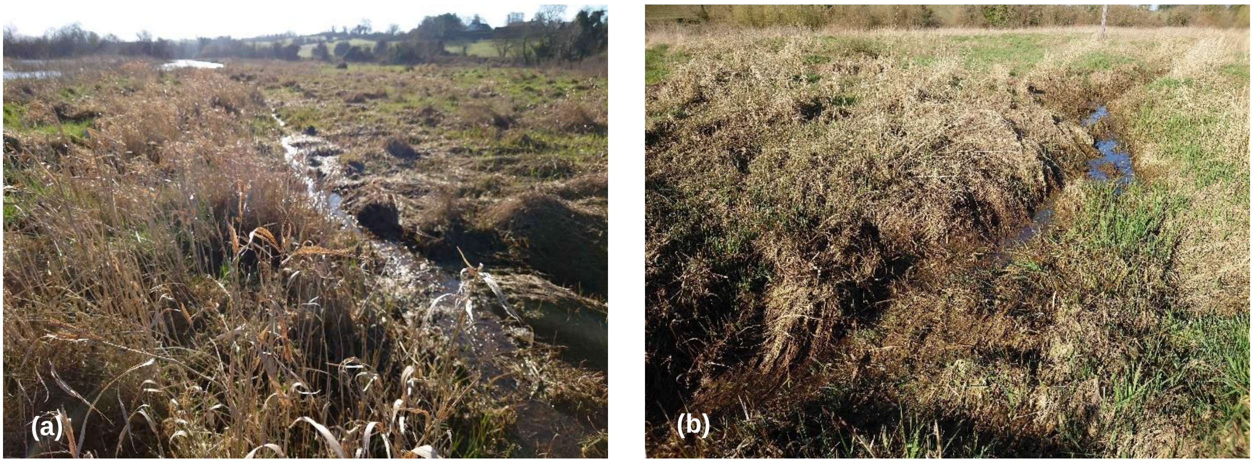


Plate 1: River Boyne South-bank Floodplain (a) 'Wet' Vegetation – View East from Proposed Crossing Location; (b) View South – from Proposed Crossing Location

16.4.2.4 Potential Habitat Loss and Fragmentation

Clear-span bridges have no impact on fish migration, but improperly designed or poorly maintained culverts can form barriers to migratory fish passage, fragmenting habitats in streams that currently or potentially support fish. There is risk of such impact if box culverts were not correctly dimensioned, designed and installed at the Mattock (Mooretown) Stream (proposed bypass northern roundabout tie-in).

An Irish study (Cocchiglia et al., 2012) that investigated operational impact on fish passage at culverts on a modern highway project (M3) showed that fish passage was possible through culverts designed to current standards, although dry-weather water depths and measured water velocities in some culverts were below permissible limits and were at risk of impeding fish passage under low-flow conditions. This emphasises the importance of well-designed and properly installed culverts with baffles and/or low-flow channels in fish bearing waters.

The Mattock (Mooretown) Stream has poor water quality (Q3) and is subject to dredging as part of agricultural land drainage, but it still supports small numbers of trout, lamprey (likely brook lamprey, *Lampetra planeri*), with eel also possible.

A series of three box culverts, separated by a short reach of open (realigned) channel are proposed on the Mattock (Mooretown) Stream. This will result in approx. 97 m of channel habitat lost to culvert footprint, plus an additional approx. 100 m of realignment. Culverted reaches will tend to become unusable to fish, apart from migration, owing to lack of suitable nursery substrates and/or reduced in-stream productivity. The Mattock (Mooretown) culverts have been designed to meet fish passage criteria according to IFI guidelines (IFI, 2016) and have been agreed with IFI as per consultation of 15 May 2023. **Table 16-9** analyses individual culvert (6A, 6B, 6C) specifications, showing they do not exceed 3% effective slope. Each culvert will be embedded to 500mm and are straight with light penetrating at both ends to aid passage. The effect on potential fish passage (brown trout, brook lamprey, eel) in the Mattock (Mooretown) Stream as a result of these culverts is considered to be slightly negative in that fish will need to expend perhaps slightly greater energy to negotiate the series of culverts at a local level, however the overall effect owing to careful culvert design is ***Not significant*** in the operation phase.

Table 16-9: Mattock (Mooretown) Culverts – Operational Impact Assessment

Culvert	6A	6B	6C
Length (m)	40.7	55.8	9.7
Elevation (Z) (mOD) Upstream	73.267	71.068	68.383
Elevation (Z) (mOD) Downstream	72.045	69.395	68.289
Δ Z	1.17	2.34	0.34
Effective slope (%)	3%	3%	0.97%
Assessment	Meets fish passage requirements (IFI, 2016)	Meets fish passage requirements (IFI, 2016)	Meets fish passage requirements (IFI, 2016)

16.4.2.5 Potential Hydromorphological Changes – Mattock (Mooretown) Stream

Permanent channel realignment at the Mattock (Mooretown) Stream, in the absence of sensitive channel reinstatements, has potential to alter physical conditions to the point that fish and macroinvertebrates cannot recolonise. Any effects would be localised to a reach of approximately 200m, with potential to fragment linear habitat. This can, in turn, impact on WFD objectives for water body status whereby hydromorphological conditions must continue to support the resident biological communities in order to avoid ‘deterioration’ of status or ‘non-attainment’ of good status.

Such impacts can be avoided by careful design and/or reinstatement of suitable habitat that broadly matches, or improves, pre-existing habitats, along with the culverts that have been designed to facilitate fish passage.

In respect of the latter, the existing Mattock (Mooretown) Stream N2 culvert will be removed as part of the works, which remediates an existing fish migration barrier resulting in a permanent positive impact on the continuity element of waterbody hydromorphology and on fish migration. With culverts installed as per **Table 16-9** and **Table 16-11**and realigned channel reaches reinstated to mimic natural channel characteristics as described in **Chapter 4**, operational phase impacts are considered unlikely and ***Not Significant***.

16.4.2.6 Potential Hydraulic Changes

Poorly designed crossing structures and insufficient storm water discharge attenuation can disrupt natural river hydraulics leading to increased erosion and flooding as a result of flow changes. Poorly maintained culverts can encourage blockage by debris and problems with fish passage through structures (Cocchiglia et al., 2012).

In this regard, it is first noted that appropriately sized attenuation ponds (with hybrid wetlands) will be provided at all major surface water outfalls along the length of the road scheme, designed in accordance with DN-DNG-03063 Vegetated Drainage Systems for Road Runoff and DN-DNG-03065 Road Drainage and the Water Environment. These are designed to accommodate and contain flows from a 1% AEP (1 in 100 year) rainfall event, taking into account the effects of climate change on rainfall. The effect on river hydraulics /or localised sediment transport associated with discharge from these features is not significant compared to baseline and consequent impacts on fish and macroinvertebrates and will be ***Not significant***.

Secondly, the series of Mattock (Mooretown) culverts have been sized and positioned according to pre-existing natural topographical fall and stream flow and are of specification required to meet requirements for Section 50 consent, specifically that they are capable of passing a fluvial flood flow of 1% AEP without significantly changing the hydraulic characteristics of the watercourse. The effect on river hydraulics and/or localised sediment transport associated with discharge from these features will be ***Not significant*** for aquatic habitats, macroinvertebrates and fish (brown trout, brook lamprey and eel).

16.4.2.7 Potential for Accidental Hazardous Spillage

It is not envisaged that the proposed road will require any special containment measures to be installed to deal with accidental spillage of hazardous liquids because of the predicted traffic levels and in addition, a spillage pollution risk assessment was conducted in accordance with DN-DNG-03065 Road Drainage and the Water Environment, which showed no significant risk of a serious pollution incident occurring. In addition, the proximity to urban centres (Slane, Drogheda and/or Navan) would facilitate a rapid response from emergency services in the event of an accidental spillage. Outlet designs from the surface water drainage controls systems (attenuation ponds with 100-year event capacity, plus 20% climate change allowance) would enable a degree of containment in the very unlikely event of a significant hazardous spill occurring on the new road. All of these factors combine to significantly reduce the likelihood of a hazardous spill occurring and giving rise to adverse impacts in receiving waters and the potential impact is therefore unlikely and ***Not significant***. In addition, the removal of traffic from old road infrastructure with no drainage attenuation / treatment features and transfer onto modern road infrastructure with attenuation and treatment of road run-off via attenuation basins means the risk of accidental spills reaching aquatic receptors of the Boyne and Mattock sub-catchments is reduced compared to the current scenario.

16.4.2.8 Traffic Management and Public Realm Works

The proposed traffic management and public realm works will result in removal of the large majority of HGVs from the existing N2 northern and southern approaches and existing N2 Slane Bridge crossing. This is expected to decrease sources of road run-off pollutants and reduce potential for such substances entering drainage that currently flows (as part of existing surface storm water collection) into the Boyne at Slane Bridge. The operational impact of these measures will be to reduce potential road run-off toxicity and sediment related effects on fish and macroinvertebrates, therefore leading to slight improvement of water quality of the Boyne. The effect on aquatic habitats and species is expected to be either ***Not significant*** or long-term slightly **positive** owing to removal of traffic from old road infrastructure with no drainage attenuation / treatment features and transfer onto modern road infrastructure with attenuation and treatment of road run-off via attenuation basins.

16.4.2.9 N51 Route Improvements

The proposed N51 route improvement east of Slane village will result in an increase in traffic density on this 820m stretch of road. Design year (2041) traffic projections show that with the proposed bypass in place, AADT on the improved N51 east of the village are predicted to increase from 6,600 (8% HGV) to 8,210 (18% HGV): a 24% increase, with over double the HGV density. This is expected to increase sources of road run-off pollutants and increase potential for such substances entering drainage. However, the traffic densities are still relatively low and are not expected to generate excessive levels of potential pollutants (see above for discussion on road run-off and traffic density).

In addition, as opposed to the current situation, the proposed N51 improvements will result in collected storm water flows being pre-treated (hydrocarbon/petrol interceptor, vortex grit separator) before entering an appropriately sized attenuation pond (capacity of 1% AEP event flow plus 20% climate change allowance). There is potential, therefore, that storm water quality will be improved compared to the existing scenario, in spite of the relative increase in traffic flows. The impact of these measures will likely be a net reduction in potential toxicity and sediment related effects of storm water discharged towards the Boyne. The operational phase effects on aquatic habitats and species of the River Boyne are expected to be either neutral or long-term slightly positive and ***Not Significant***.

16.4.3 Cumulative Impact

A cumulative impact assessment (CIA) has been undertaken to consider potential for cumulative impact of the Proposed Scheme with other approved development. The detailed methodology for the CIA is described in **Chapter 25 – Cumulative Effects**. The assessment has considered cumulative sources and impact pathways which could impact on water.

The projects listed in **Appendix 25.2** have been assessed. Each project has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/ temporal scales involved. Projects were screened-in to the aquatic CIA where they involve discharges to the Boyne or the Mattock, where those discharges involve parameters related to road construction (i.e. sediment, concrete, hydrocarbons) or road operation/ maintenance (i.e. sediment, heavy metals, hydrocarbons). Projects that involve discharges of nutrients (i.e. waste water discharges of organic origin) were not included, as nutrients are not significant parameters of concern with regards to road construction or operation. Equally, residential development projects were excluded as these will each connect to the public sewer. Such discharges are ultimately controlled via appropriate emission limit values as conditions of emission licences e.g. wastewater treatment plants, meat processing factories, pig farms etc.

A total of four projects were therefore screened-in to the Biodiversity: Aquatic Ecology CIA, as set out in **Table 16-10**.

Table 16-10: Projects Screened-in for Potential Cumulative Effects on Biodiversity: Aquatic Ecology

Project Code	Project Location	Project Type	Potential for Cumulative Effect
PR 12	Mullaghdillon, Slane, Co. Meath	Quarry	Possible – 250 m drain, then 4.3 km hydrological distance along Knockerk and Harlinstown Stream to River Boyne
PR 37	Stoneyford Quarry, Downestown and Longford townlands, Duleek, County Meath A92 K162	Quarry	No possible cumulative effects – No hydrological connectivity to River Boyne, drains south to the River Nanny
PR 24	Staleen, Donore, Co. Meath *(now constructed)*	Lock Renovation Works	No possible cumulative effects – These works have since been completed
PR 40	Platin and Cruicerath	Overburden Management Facility (Irish Cement)	No possible cumulative effects – No hydrological connectivity to River Boyne, development is in the Platin Stream subcatchment and drains to the River Nanny

Of the four projects screened-in, only one (PR 12, Mullaghdillon Quarry) has potential for cumulative impact, relating to suspended sediment concentrations in the River Boyne. On examination of the planning files, it is evident the quarry site is relatively small (approx. 4.4 ha) and that all surface water within the site drains to a settlement pond which is then pumped to a dedicated settlement tank. Only clean water is then pumped to a nearby drain that connects to the Knockerk Stream, a small tributary of the Harlinstown Stream. There is no rock crushing or washing on-site, therefore sediment generation is only linked to excavation, with lower levels of fine solids potentially generated. The planning is for continuation of extraction from the site for a further three years, with planning granted in 2020. It is therefore very unlikely that operation of the quarry will coincide with the construction of the Proposed Scheme. In any case, given that the quarry deals with any suspended solids generated on-site prior to discharge, the effect on suspended solids concentrations approx. 4.3 km downstream in the River Boyne will be negligible over the normal range of this parameter in the Boyne main channel. The potential for cumulative effects on aquatic receptors as a result of in-combination suspended solids concentrations associated with the quarry and the Proposed Scheme construction phase are therefore highly unlikely and not significant.

In addition to the above single project screened-in for CIA (PR 12), it is noted from long-term EPA water chemistry data for the Boyne_160 (River Station RS07B042100 – Slane Bridge) that the average of mean annual suspended solids concentrations is 8.5 mg/l (2007-2021). The mean of samples taken specifically for the Proposed Scheme (August 2021 – August 2022) was 15 mg/l suspended solids at the location just upstream of Slane Bridge, and 10 mg/l at the location just upstream of the proposed bridge crossing. It is therefore evident that the River Boyne experiences periods of elevated suspended solids, which is typical for a large and highly agricultural catchment. There is potential for cumulative suspended solids increases in the Boyne main channel during the construction phase of the Proposed Scheme (mainly relating to works on the Boyne floodplain). The effect would be short-term and slightly negative, cumulatively, by slightly increasing turbidity locally. However, any cumulative increases in suspended solids can be avoided and/or reduced by good construction site management and mitigation to control suspended solids levels at source within the Proposed Scheme.

16.5 Mitigation Measures

16.5.1 Construction Phase

Table 16-11 sets out specific mitigations only for impact categories where likely and potentially ***Significant*** impacts were identified in **Section 16.4.1**.

Table 16-11: Construction Phase Mitigation Measures

Potentially Significant Impact Category Identified	Mitigation
General waterborne pollutant loss - River Boyne during N2 Slane bypass bridge and floodplain crossing construction	• Monitoring of weather forecasting reports will be undertaken in the lead up to construction of the temporary work platform such that installation of reno-mattresses will be carried out during an extended settled weather period in which time platforms can be installed when there is low risk of over-bank river flows on the Boyne. • General sediment loss controls: all sources and pathways of sediment loss shall be controlled according to details set out in Phases 1-5 of the construction methodology. Whilst specific mitigation measures are not required in the area of sediment and erosion control, it is necessary that a clear system of checks/ monitoring of mitigation efficacy throughout the construction phase be employed. This will require a documented schedule of daily (during key construction periods near the Boyne for instance), weekly and monthly implementation and efficacy checks of all water quality protection measures in the areas of sediment control and treatment (e.g. silt fences, check-dams, attenuation ponds). A proposed monitoring schedule, including trigger points for certain parameters (suspended solids, pH) are set out in **Section 16.7**. • During and immediately after heavy periods of rain, earthmoving activities shall be reviewed with temporary restrictions where necessary while sediment control measures are bolstered and/or ground dries out to the point that sediment wash-out is not occurring. • General concrete loss controls: all sources and pathways of concrete loss shall be controlled according to details set out in Phases 1-5 of the construction methodology. This will require a documented schedule of daily, weekly and monthly implementation and efficacy checks of all water quality protection measures in the areas of concrete and concrete wash-water control and treatment (e.g. pH monitoring of pump-out waters and attenuation ponds). A proposed monitoring schedule is set out in **Section 16.7**. • General hydrocarbon loss controls: all sources and pathways of hydrocarbon loss shall be controlled according to details set out in **Chapter 5** for Phases 1-5 of the construction methodology. This will require a documented schedule of daily, weekly and monthly implementation and efficacy checks of all water quality protection measures in the areas of hydro-carbon storage and control (e.g. storage and refuelling areas). A proposed monitoring schedule is set out in **Section 16.7**. • All general pollutant loss control measures (as above) also apply for the Pre-Main Construction – Enabling Works (refer to **Chapter 5**, **Section 5.2.2**). In relation to the River Boyne, there shall be no ground disturbance within 10 m from the River Boyne main channel and Mattock (Mooretown) Stream i.e. associated with Ground Investigation Works or Archaeological Surveys and testing. • Archaeological core sampling within the River Boyne floodplain will take place during the bridge foundation construction period and only within the cofferdam areas around bridge piers; • A Surface Water Monitoring Programme shall be prepared by the contractor and employed to monitor functionality and effectiveness of the prescribed mitigation measures throughout the proposed Boyne bridge construction period (see **Section 16.7**). The programme shall include identified trigger points and actions relating to principal pollutants (sediment or concrete wash out).
Cofferdam ingress water – River Boyne during N2 Slane bypass bridge and floodplain crossing construction	• On-site pumps will be present to dewater as required at cofferdam containment areas. • On-site containment storage facilities of sufficient volume will be present to hold this pump out water prior to removal for appropriate treatment. • Ingress water will not be directly discharged to either the River Boyne or any adjoined drainage channels. In the absence of appropriate treatment, pump-out water will not be directly discharged to the attenuation ponds or general environment at any other location. • Pump-out water will be regularly monitored for pH, hydrocarbons and TSS. The monitoring schedule is set out in **Section 16.7**. • Stored contaminated cofferdam pump-out water will be pH monitored (see **Section 16.7**) and removed for treatment at an appropriate licenced off-site facility. If treated for pH, the pump-out water will be discharged to the site attenuation ponds for attenuation of TSS and hydrocarbon.

Potentially Significant Impact Category Identified	Mitigation
Floodplain reinstatement – River Boyne	• Monitoring of weather forecasting reports will be undertaken in the lead up to removal of the temporary reno mattress work platforms such that the works including the subsequent reinstatement will be carried out during an extended settled weather period in which time platforms can be installed when there is low risk of over-bank river flows on the Boyne. This will occur in the spring/summer months when grasses can re-establish within that growing season for protection over the ensuing winter. • Reinstatement of the Boyne floodplain following removal of the temporary work platform will include reseeding with appropriate native damp meadow grasses on the south bank, and coir-matting with hydroseeding if possible, or otherwise resodding with appropriate native species mix, on the northern bank.
Aquatic habitat and species protection – Mattock (Mooretown) Stream	• No in-stream works on the Mattock (Mooretown) Stream shall be carried out without the agreement of Inland Fisheries Ireland (IFI) in advance and IFI will be given sufficient notice before consented in-stream works commence. • The Mattock (Mooretown) Stream will be treated as fish-bearing (trout, eel, brook lamprey). As per fisheries restrictions stipulated by IFI, any in-stream works shall therefore only be carried out during the period 1 May to 30 September of any year. • Culvert designs (slope, dimensions) have been agreed with IFI as per consultation on 15 May 2023. The finalised stream crossing methodology as set out in **Chapter 5** will be agreed with IFI at detailed design stage and agreed with IFI prior to works commencing. • As a precaution, the Mattock (Mooretown) Stream will be de-stocked of fish as part of in-stream works covering the reach of the three locations for culvert installation. Fish removal shall be carried out only by authorised personnel under electro-fishing licence and in agreement with, or under supervision of IFI as agreed with IFI in consultation of 15 May 2023.
Pollutant Loss during installation of Mattock (Mooretown) Stream Culverts	• The method statement for culvert installation and channel realignment will be agreed with IFI prior to works commencing. • A temporary diversion will occur to complete culvert installation and channel realignment in 'dry' working conditions with no severance of channel continuity during the construction period. • The temporary diversion channel will be of a calculated width and depth that will pass high frequency flood events (at least Q_{med}). It will be constructed in advance, off-line, with a soil/vegetation bund between it and the stream. • The channel will be lined with appropriate waterproof geotextile material and the bottom of the channel lined with appropriate, locally sourced, low-fine content gravels of a size class agreed in advance with IFI. • There will be no crossing of the temporary channel by machines and no direct discharge of pollutants or pump-out water to the diversion channel from the construction works area. Water may ingress to the works area, and all such construction related pump-out water will be directed to Attenuation Pond 6A (which will be constructed in advance of main works) for settlement of suspended solids.
Prevention of spread of pathogens and invasive species	• Adherence to IFI biosecurity protocol (Caffrey, 2010) for avoidance of spread of pathogens will be followed by contractors and surveyors. • Extremely careful disinfection and biosecurity measures is essential to prevent transfer of damaging pathogens e.g. crayfish plague disease, between sites and river catchments within and outside of the watercourses. This will apply to all personnel (contractors, surveyors etc.) and machinery that come in contact with surface water and/or drainage to surface waters. • Transfer of invasive plant species between sites within catchments and to other catchments will be prevented. An invasive species management plan must identify specific locations of invasive plants (e.g. Japanese knotweed) at watercourse crossings and along any cable trenching routes. The final Construction Method Statement must set out methods for management and prevention of invasive species transfer.
Overseeing of environmental controls	• The developer will be required to employ a suitably qualified technical professional (Environmental Clerk of Works [ECoW]) for the duration of the construction phase in order to protect water quality and avoid potential impacts on aquatic receptors. See **Section 16.7** for details of the ECoW role and responsibilities.

16.5.2 Operational Phase

Table 16-12 sets out specific mitigations only for impact categories where potentially ***Significant*** impacts were identified in **Section 16.4.2**.

Table 16-12: Operational Phase Mitigation Measures

Potentially Significant Impact Category Identified	Mitigation
Potential Habitat Loss and Fragmentation – Mattock (Mooretown) Stream	Proposed culverts have been designed to meet IFI 2016 guidelines in terms of fish passage requirements (trout, brook lamprey, eel in this stream). Box culverts will be subject to minimum embeddedness of 500 mm below exiting bed level at upstream and downstream end. The culverts do not exceed 3.0% effective slope.
Potential Habitat Fragmentation – Mattock (Mooretown) Stream	The existing fish barrier at upstream end of existing N2 culvert shall be removed to comply with fish passage requirements in accordance with NRA (2008) guidelines. The streambed flowing towards the new Culvert 6A shall be graded at the upstream end using appropriate local gravels and rocky bank material to mimic natural channel morphology.
Potential Hydromorphological Changes – Mattock (Mooretown) Stream	Reinstatement of in-stream habitats in realigned sections of the Mattock (Mooretown) Stream shall be carried out to mimic existing morphology and habitats, incorporating in-stream structures and features e.g. gravel substrates, that will give rise to flow type variation as found in fish bearing waters. IFI have agreed in principle to in-stream habitat reinstatement of the stream as part of consultation (15 May 2023), but materials (i.e. locally sourced gravels) and method statement for channel reinstatement will be agreed with IFI prior to commencement of works.

In addition to **Table 16-12**, the following paragraphs describe the wider approach that shall be applied to operational phase mitigation measures. The primary aims are to ensure: (1) fish passage at the Mattock (Mooretown) Stream culverts, (2) reinstatement of suitable habitats for fish and macroinvertebrates in the Mattock (Mooretown) Stream, (3) ongoing efficacy of road surface drainage treatment measures (hybrid constructed wetlands).

General Measures

The following guidance shall be adhered to in relation to design of culverts and sections of channel realignment in watercourses:

- NRA (2008) Guidelines for the crossing of Watercourses During Construction of National Road Schemes, and;
- IFI (2016) Guidelines on protection of fisheries during construction works in and adjacent to waters.

Channel Realignment Measures (to ensure near natural recovery)

- Newly formed channel sections shall mimic (or improve) the existing habitats e.g. incorporating in-stream structures, features and meanders that will give rise to flow type variation as found in fish-bearing waters;
- Any additional coarse material shall match the existing gravel size and be of local rock type origin;
- Newly formed channel base widths shall be designed to match the width of the original channel. There will be low flow channels incorporated into the new channel design as part of the construction phase to concentrate flow and maintain depth for fish passage; and
- Riparian margins shall be planted with native species, set back from the bank and spaced to provide dappled (not tunnelled) shade.

Attenuation Ponds and Wetlands

Attenuation ponds shall be provided at all major surface water outfalls along the length of the road scheme and are designed in accordance with DN-DNG-03063 Vegetated Drainage Systems for Road Runoff Attenuation and DN-DNG-03065 Road Drainage and the Water Environment. Ponds shall be designed as hybrid wetlands, so they provide both attenuation and consequent water treatment function. They will be planted with vegetation suitable for the specific zone of the pond the planting is located i.e. permanently wet, marginal zones, dry earthworks slopes.

Irish studies have shown surface flow constructed wetlands to be highly effective at removing road run-off pollutants (Healy et al, 2008; Bruen et al, 2006; NRA, 2014), which are removed through physical (settlement and sedimentation), chemical (cation exchange and adsorption, oxidation and hydrolysis, precipitation) and biological processes including uptake of metals by wetland plants (Healy et al. 2008).

Constructed wetlands shall be maintained according to TII Vegetated Drainage Systems for Road Runoff DN-DNG-03063-02. Constructed wetland planting will include (amongst other species) Reed canary-grass (*Phalaris arundinacea)* and Bulrush (*Typha latifolia*), both of which occur naturally in the Boyne Valley. These species are metal-tolerant and are useful for phytoextraction of Cd, Cu, and Zn (Kacprzak et al., 2014), hence suitable to support constructed wetland treatment function (Healy et al., 2008). Maintenance of CW requires sediment removal a minimum of every 25 years, regular monitoring (for blockages) of inlet and outlet, and repair of planting and landscaping where necessary (NRA, 2014).

Constructed wetlands and infiltration basins will be lined either naturally with a low permeability clay, or with an artificial membrane liner to protect groundwater, and adjoining surface waters, in accordance with groundwater regulations[12] and surface water regulations.[13] This will ensure separation of surface and groundwater and prevent potential leakage of contaminants to groundwater, which can be a subsurface pathway to surface waters.

16.6 Residual Impacts

16.6.1 Construction Phase

With all mitigation measures and environmental controls as set out in the EIAR including **Section 16.5.1**, above, the likelihood of significant residual impacts on aquatic IEFs of the River Boyne and Mattock (Mooretown) Stream is low during the construction phase.

16.6.2 Operational Phase

With all mitigation measures and environmental controls as set out in the EIAR including **Section 16.5.2**, above, the likelihood of significant residual impacts is very low during the operation phase.

16.7 Monitoring

16.7.1 Construction Phase

16.7.1.1 Responsibilities

As part of this EIAR, as transposed to the Environmental Operating Plan (EOP) for the Proposed Scheme, surface water quality monitoring procedures have been proposed during the construction works.

In addition to the Project Ecologist, the developer will be required to employ a suitably qualified technical professional(s) (Environmental Clerk of Works (ECoW)) for the duration of the construction phase. The ECoW shall be based on site and shall oversee the implementation of pollution mitigation measures, compliance with environmental planning conditions, monitoring and reporting on environmental aspects of the development, and liaison with third parties and the Planning Authority. The ECoW appointment and role must cover all phases of the construction including advance works and accommodation works:

- The proposed works and associated in situ control measures will be supervised full-time by the ECoW.
- The ECoW is responsible for all monitoring duties and shall not delegate duties to other staff. The only exception is for unforeseen absence and annual leave cover, in which case the Site Manager shall appoint a suitably qualified back-up ECoW to temporarily fulfil the role. Training for each member of

---

[12] European Communities Environmental Objectives (Groundwater) Regulations, 2010 (S.I. No. 9 of 2010), as amended.

[13] European Union Environmental Objectives (Surface Waters) (Amendment) Regulations (S.I. 77 of 2019) and European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No 272 of 2009), as amended.

staff on their specific area of responsibility to implement environmental controls shall be carried out before the commencement of that operation. A record of all training carried out shall be maintained in the EOP.

- Toolbox talks on the EOP will be presented by the ECoW to all site staff immediately before works commence. The subject shall be the measures that have been put in place to protect the environment and the procedures, monitoring and recording that is to be undertaken in accordance with the Construction Methodology, environmental commitments and the EOP. Site personnel will also be made aware of the ecological sensitivity of the site and its surrounds.

16.7.1.2 Site Daily Monitoring Procedure

16.7.1.2.1 Weather Forecasts

Future seven-day forecasts will be checked daily by the ECoW, with construction works programmed accordingly in the event that heavy rainfall is forecast. Prior to any forecast heavy rainfall, the ECoW will ensure that all sediment loss prevention measures and environmental controls are functioning correctly. During and immediately after heavy periods of rain, earthmoving activities must be reviewed with temporary restrictions where necessary.

16.7.1.2.2 General Procedures

The following environmental monitoring procedure will be carried out to ensure that environmental protection and management requirements are being implemented and are meeting their objectives:

- All mitigation/ control measures shall be inspected daily by the ECoW during specific construction area working days with any maintenance and repairs carried out immediately.
- All environmental monitoring and checklists shall be recorded and added to the EOP on a daily basis.
- The ECoW will report any instances of failure of mitigations, spillage, maintenance and repair by way of specific Incident Reporting sheets that include how the issue was remedied.
- The ECoW will attend all relevant stakeholder meetings (IFI, NPWS etc.).

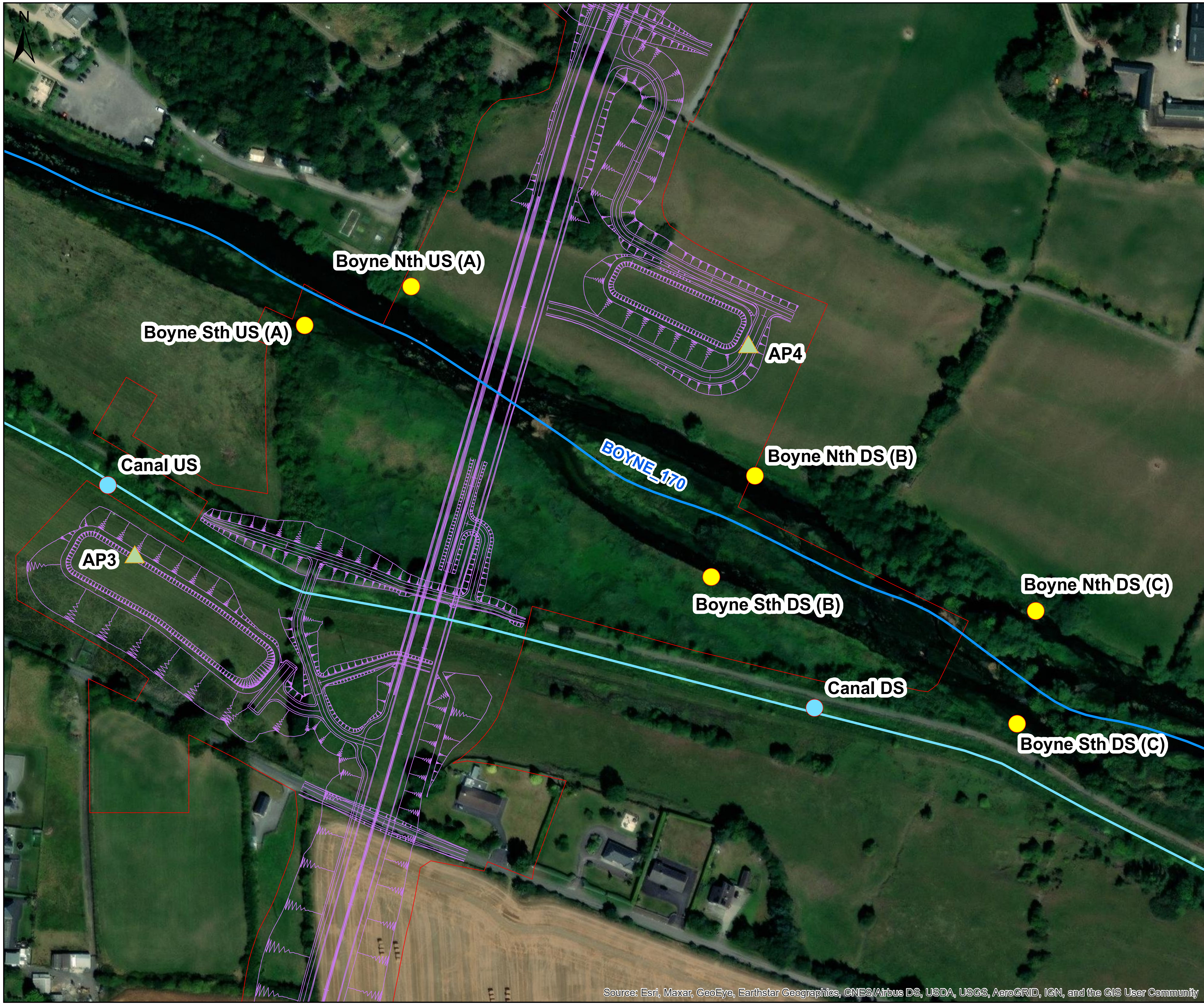
16.7.1.3 Surface Water Monitoring Procedure

16.7.1.3.1 River Boyne Monitoring Locations

Samples must be taken from each bank (north and south) with a long reach sampling pole, collecting from as far out into the channel as is practicable. There will be 6 No. monitoring points on the River Boyne in relation to the bridge crossing reach, 2 No. attenuation pond outfalls and 2 No. locations on the canal as illustrated in **Figure 16.2** and explained as follows:

- 2 No. upstream A sites: one from each bank at locations immediately upstream of the crossing works reach that are outside the influence of the project;
- 2 No. downstream B sites: one sample from each branch of the Boyne, north and south of the mid-channel island, 100 m downstream of the Boyne bridge pier work platforms;
- 2 No. downstream C sites: one sample taken from each bank of the river a further 200 m downstream of the above sites i.e. a total of 300 m downstream of the Boyne bridge pier work platforms;
- Canal: one sample upstream of Attenuation Pond 2 outfall and one sample approx. 250 m downstream; and
- Outfall channels of Attenuation Ponds 2 and 3.

See **Section 16.7.1.3.4** (Sample Frequency) for the schedule of sampling.



Legend

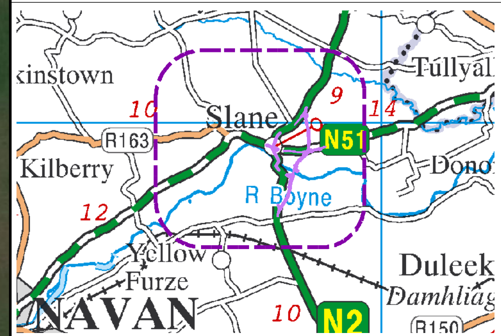
- Proposed Scheme
- Proposed Scheme Boundary
- EPA River Water Body
- Boyne Navigation Canal

Monitoring Location

- River Sample Site
- Canal Sample Site
- Attenuation Pond Outfall (AP)

Data Source: EPA River Water Bodies Cycle 3 2021

0 25 50 100 Meters



Client

Meath County Council

N2 Slane Bypass and Public Realm Enhancement Scheme

Title

Figure 16.2

River Boyne Construction Phase Monitoring Locations

rps
West Pier Business Campus, Dun Laoghaire, Co Dublin, Ireland.
T +353 (0) 1 4882900
E ireland@rpsgroup.com
W rpsgroup.com/ireland

Issue Details

File Identifier: MDT0806-RPS-00-N2-DR-Z-AG-3052

Status:	Rev:	Model File Identifier:
A1	C01	MDT0806-RPS-01-N2-M2-C-XM1001 MDT0806-RPS-01-PR-M2-C-XR9000

Drawn:	NR	**Date:**	24/05/2023
Checked:	LW	**Scale:**	1:2,000 (A3)
Approved:	NO'N	**Projection:**	ITM

NOTE:

16.7.1.3.2 Mattock (Mooretown) Stream Construction Phase Monitoring Locations

There will be 2 No. monitoring points on the Mattock (Mooretown) Stream relating to culverting works and 3 No. attenuation pond outfalls as illustrated in **Figure 16.3** and explained as follows:

- 2 No. downstream C sites; one sample taken from each bank of the river a further 200 m downstream of the above sites, i.e. a total of 300 m downstream of the Boyne bridge pier work platforms.
- Attenuation ponds 5A, 5B and 6A outfall channels.

See **Section 16.7.1.3.4** (Sample Frequency) below for the schedule of sampling.

Legend

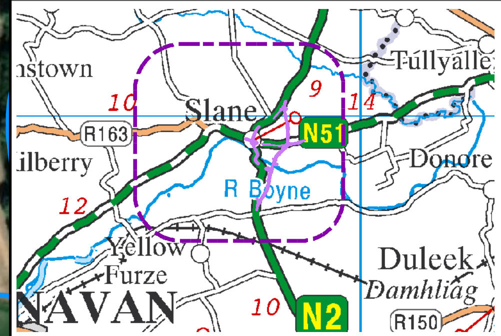
- Proposed Scheme
- Proposed Scheme Boundary
- EPA River Water Body

Monitoring Location

- River Sample Site
- Attenuation Pond Outfall (AP)

Data Source: EPA River Waterbodies Cycle 3 2021

0 50 100 200
Meters



Client

Meath County Council

N2 Slane Bypass and Public Realm Enhancement Scheme

Title

Figure 16.3

River Mattock Construction Phase Monitoring Locations

rps
West Pier Business Campus, Dun Laoghaire, Co Dublin, Ireland.
T +353 (0) 1 4882900
E ireland@rpsgroup.com
W rpsgroup.com/ireland

Issue Details

File Identifier: MDT0806-RPS-00-N2-DR-Z-AG-3053

Status: A1	**Rev:** C01	**Model File Identifier:** MDT0806-RPS-01-N2-M2-C-XM1001 MDT0806-RPS-01-PR-M2-C-XR9000
Drawn: NR		**Date:** 24/05/2023
Checked: LW		**Scale:** 1:4,000 (A3)
Approved: NO'N		**Projection:** ITM

16.7.1.3.3 Sample Parameters

The meaningful parameters for this construction phase surface monitoring programme are suspended solids/ turbidity (related to potential sediment loss from the site) and pH (related to potential concrete run-off).

Turbidity and pH measurements must be taken at all sampling sites during construction using a portable probe. In situ measurements have the advantage of providing site management with immediate (and actionable) data. In contrast, TSS for example may take a week or more to be analysed and reported. Notable pH changes upstream and downstream of the construction area may indicate concrete contamination and would trigger a stop-work response to identify and remove the source of contamination.

Where routine turbidity measurements show that there may be impact on the receiving waters, additional measurements must be taken with the probe (working back towards the possible source areas) to determine the source of elevated suspended sediment, e.g. by checking attenuation pond outflows etc. This will trigger works to stop until the offending sediment source is remedied.

16.7.1.3.4 Sample Frequency

River Boyne – Sampling Plan

The 8 No. river/canal sampling sites shown in **Figure 16.2**, plus the outflows from Attenuation Ponds 2 and 3 will be sampled by the ECoW on during the period of construction on the Boyne floodplain with the following frequency:

Daily sampling during the active construction period at each site:

- Turbidity measurement in situ, using a hand-held (portable) turbidity meter (NTU[14]); and
- pH measurement in situ, using hand-held (portable) calibrated meter (pH units).

Twice weekly sampling (fixed days – Monday and Thursday) at each site:

- Discrete grab sample and laboratory analysis for suspended solids (mg/l) and turbidity.

Additional sampling during 2 elevated flow (rainfall) events per month at each site:

- Turbidity measurement in situ, using a hand-held (portable) turbidity meter (NTU);
- pH measurement in situ, using handheld (portable) calibrated meter (pH units); and
- Discrete grab sample and laboratory analysis for suspended solids (mg/l) and turbidity.

There are likely to be days when there is no outflow from the Attenuation Ponds, and hence no grab sample or in situ readings from those locations. This will be logged as "*No sample – No flow*" in the daily monitoring sheet. Upstream (US) and downstream (DS) samples on the Boyne River and Boyne Canal will still be taken on such days.

The ECoW will ensure that samples are taken during or immediately after heavy rainfall whenever a rain event is occurring because these are the periods during which water in on-site drains and ground surfaces become hydrologically active and export diffuse contaminants including suspended solids.

Mattock (Mooretown) Stream – Sampling Plan

Water monitoring for the Proposed Scheme revealed persistently high suspended sediment concentrations in the Mattock (Mooretown) Stream. For this reason, a scaled-back monitoring schedule will be undertaken for this tributary. The two stream sites shown in **Figure 16.3**, will be sampled by the ECoW on during the period of construction in the vicinity of the proposed N2 tie-in with the following frequency:

Twice weekly sampling (fixed days – Tuesday and Friday) at each site:

- Turbidity measurement in situ, using a handheld (portable) turbidity meter (NTU); and
- pH measurement in situ, using handheld (portable) calibrated meter (pH units).

[14] NTU: Nephelometric Turbidity Unit, or the unit used to measure the turbidity of a fluid or the presence of suspended solids in water. NTU is a calibrations standard indicating the instrument is measuring scattered light from the sample at a 90-degree angle from the incident light.

Sampling during 2 no. elevated flow (rainfall) events per month at each site:

- Turbidity measurement in situ, using a hand-held (portable) turbidity meter (NTU);
- pH measurement in situ, using hand-held (portable) calibrated meter (pH units); and
- Discrete grab sample and laboratory analysis for turbidity and suspended solids (mg/l) and turbidity.

The outflows from Attenuation Ponds 5A and 5B will be checked following every heavy rainfall event and when they are actively flowing will be sampled as follows:

- Turbidity measurement in situ, using a handheld (portable) turbidity meter (NTU);
- pH measurement in situ, using handheld (portable) calibrated meter (pH units); and
- Discrete grab sample and laboratory analysis for turbidity and suspended solids (mg/l) and turbidity.

16.7.1.3.5 Visual Checks

Underpinning the monitoring approach will be daily visual checks conducted by the ECoW to ensure all mitigation measures are implemented as set out in the EOP. These visual checks will include checks on integrity of all on-site mitigation infrastructure, e.g. attenuation ponds, silt fencing, on-site drainage flow paths etc. Any required maintenance will be carried out immediately. The ECoW will have powers to stop works if there are obvious sediment plumes in watercourses or any obvious pathways from the construction areas that are conveying sediment laden water to nearby drains or watercourses. In the instance that works must stop, the source(s) and/or reasons for observed sediment loss will be identified and controls will be bolstered through additional silt fencing, check-dams or pump-out and containment of runoff for off-site treatment.

16.7.1.3.6 Monitoring Records

A daily Water Monitoring Sheet (see example in **Appendix 16.4**) will be filled in by the ECoW at each sample location recording sampling date and times for each individual sample, plus general flow condition (High, > Average, Average, < Average, Low). Any visible turbidity or discoloration of the water will be recorded. The register of daily monitoring sheets will be kept on-site and entered into an Excel spreadsheet and will be updated regularly for inspection by the construction Site Manager.

16.7.1.3.7 TSS versus Turbidity Correlation

Turbidity data is not possible to interpret in any meaningful way in the absence of data on suspended solids, and/or without being continuously monitored using upstream/downstream in-stream sondes. Experience during the EIAR water monitoring phase proved that continuous turbidity measurement on the Boyne is unreliable owing to the swift flows and possible issues with turbulence and biofouling.

Furthermore, there is no standard conversion factor between turbidity and suspended solids; each river is different owing to variable geology, soil type etc. Handheld turbidity meter data must be correlated with concurrent suspended solids data in order to interpret the information. It is considered that suspended solids sampling (whether correlated with turbidity or not) is cost effective, reliable and produces more easily interpretable data which can be compared to existing Irish water quality standards (e.g. 25 mg/l threshold for salmonid waters).

In order to utilise in situ turbidity information for actionable indications of construction impact, a correlation will be made between the in-situ turbidity data and laboratory analysed suspended solids concentrations.

A once-off professional TSS/ turbidity correlation shall be undertaken using an approved laboratory and laboratory-based methods to form a reliable relationship between the parameters. The relationship is sediment-specific and unique for each river system, the method therefore requires samples of local sediments and river waters to be taken to the lab for gravimetric analysis of TSS and concurrent turbidity. The samples are mixed in increasing dilutions to provide the specific TSS/ turbidity relationship. The exact turbidity meter type that will be deployed in the field will be calibrated by this relationship.

Once a rational correlation is made, in situ daily turbidity readings will be used in lieu of ongoing additional monthly high flow grab sampling for suspended solids. Turbidity probes will be regularly re-calibrated. Twice weekly (Monday and Thursday) suspended solids sampling will continue throughout the construction period on the Boyne.

16.7.1.3.8 Trigger Levels

Watercourses – Suspended Solids / Turbidity

Once the relationship between suspended solids and turbidity is established, a suspended solids/ turbidity trigger level will be set for works to stop in order to implement additional on-site measures for sediment control. The trigger level to stop work and implement additional sediment control measures is if there is an upstream/ downstream difference of 25 mg/l suspended solids, or the correlated (as above in **Section 16.7.1.3.7**) turbidity equivalent (NTU). Alternatively, the trigger level will be set at any change in turbidity between upstream and downstream sites on the Boyne River, although it will be necessary to continue collecting twice weekly and three times monthly suspended solids samples for analysis as a log of efficacy and to assist interpretation of turbidity data.

Watercourses – pH

According to the Surface Water Regulations 2009, as amended, the acceptable pH range for these surface waters is: 6 < pH < 9.0.[15] The Boyne and Mattock (Mooretown) Stream both had ambient values of pH 7.3-8.3, with means (across August 2021 – March 2022) of pH approx. 7.8.

The trigger level to stop (concrete related) works will be if there is any in situ upstream/ downstream difference in pH that indicates more alkaline conditions downstream with pH approaching 8.5-9.0 at the downstream site, along with a clear difference compared to upstream in situ pH value.

Attenuation Pond Outfalls

Suspended solids concentrations in the attenuation pond outfall channels to surface waters will not exceed 25 mg/l TSS or the turbidity (NTU) equivalent and pH will not exceed 9.0. These are the trigger levels, either separately or together, that trigger works to stop and additional appropriate control measures to be implemented following investigation/ evaluation of the source by the ECoW. Works will not recommence without agreement from the ECoW.

16.7.1.3.9 Cofferdam Pump-out Water Monitoring

Constant water ingress is expected to the cofferdams surrounding bridge pier foundations during their construction. These containment areas will require regular if not constant pumping out to retain dry conditions.

The pump-out water is likely to be contaminated with sediment and concrete, and to a lesser extent hydrocarbons. These waters shall not be pumped directly to the Boyne or to any other watercourse. The contractor will be required to tanker and remove to a suitably licensed treatment facility; refer to **Chapter 5**.

Before any concrete pouring has commenced, i.e. in the earth excavation stage, the ECoW will take daily pH readings of a sample of the pump-out water. This water will be transported by tanker and discharged into Attenuation Pond 2 or 3 for settlement of suspended solids. Once bulk liquid concrete pouring has commenced and concrete is curing, the ECoW will continue daily in situ measurement of pump-out water. If pH remains between 6.0 and 9.0, then this water can still be discharged into the Attenuation Ponds for settlement of suspended solids. If pump-out water pH exceeds 9.0, the water will be treated to reduce pH or transported off-site for disposal at a licenced facility.

16.7.2 Operational Phase

Refer to **Chapter 17 – Water**, **Section 17.7.2** for details of operational phase monitoring requirements.

In addition to maintenance over the life cycle of the constructed wetlands i.e. sediment removal every 25 years, regular monitoring (for blockages) of inlet and outlet, and repair of planting and landscaping where necessary (NRA, 2014) shall be undertaken by the road operator to ensure: (1) regular base flow through the system to maintain plants and micro-organisms; (2) sufficient residence time to allow for sediment particles to settle and the removal of pollutants through adhesion to vegetation.

[15] European Communities Environmental Objectives (Surface Waters) Regulations (S.I. No. 272 of 2009), as amended.

16.8 Chapter References

Bruen, M., Johnston, P., Quinn, M. K., Desta, M., Higgins, N., Bradley, C. and Burns, S. (2006) Impact Assessment of Highway Drainage on Surface Water Quality. Synthesis Report, Ref. No 2000-MS-13-M2, EPA, Wexford.

Caffrey, J. (2010) IFI Biosecurity Protocol for Field Survey Work.

CIEEM (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Chartered Institute of Ecology and Environmental Management, Winchester.

CIS (2017) WFD Common Implementation Strategy Guidance Document No.36 – Exemptions to the Environmental Objectives according to Article 4(7) New modifications to the physical characteristics of surface water bodies, alterations to the level of groundwater, or new sustainable human development activities.

Cocchiglia, L., Purcell, P. J. and Kelly-Quinn, M (2012) A critical review of the effects of motorway river-crossing construction on the aquatic environment. Freshwater Review 5: 141-168 Available at: https://www.fba.org.uk/journals/index.php/FRJ/article/viewFile/489/329 (June 2020)

Davidson, J. Julie Bebak, J. and Patricia Mazik, P. (2009) The effects of aquaculture production noise on the growth, condition factor, feed conversion, and survival of rainbow trout, Oncorhynchus mykiss. Aquaculture, Volume 288 (3–4): 337-343.

DCHG, (2017), The 3rd National Biodiversity Action Plan 2017-2021.

Demers & Reynolds, (2002) A survey of the White Clawed Crayfish, Austrotamobius Pallipes (Lereboullet) and of Water Quality in Two Catchments of Eastern Ireland.

EPA (2022), Guidelines on the information to be contained in Environmental Impact Assessment Reports

Gargan, P., Fitzgerald, C., Kennedy, R., Maxwell, H., McLean, S. and Millane, M. (2022). The Status of Irish Salmon Stocks in 2021 with Catch Advice for 2022. Report of the Technical Expert Group on Salmon (TEGOS) to the North-South Standing Scientific Committee for Inland Fisheries. 55 pp.

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.

Ghermandi, A., Vandenberghe, V., Benedetti, L., Bauwens, W. and Vanrolleghem, P. A. (2009) Model-based assessment of shading effect by riparian vegetation on river water quality, Ecological Engineering 35(1), 92-104.

Healy, M. G., Rodgers, M. and Keating, E. (2008) Constructed wetlands for the treatment of highway runoff. Chapter 5. pp. 139 – 160. In: Robert H. Theobald (Ed.) Environmental Management. Nova Publishers, NY.

Huber, M., Welker, A., Helmreich, B. (2016) Critical review of heavy metal pollution of traffic area runoff: Occurrence, influencing factors, and partitioning. Science of the Total Environment 15 (541): 895-919.

IFI (2020) Report on salmon monitoring programmes 2018 funded under Salmon Conservation Fund. Inland Fisheries Ireland/2020/104512.

IFI (2016) Guidelines on protection of fisheries during construction works in and adjacent to waters. Inland Fisheries Ireland.

Johnson, M. F. and R. L. Wilby (2015) Seeing the landscape for the trees: Metrics to guide riparian shade management in river catchments. Water Resources Research 51, 3754–3769, doi:10.1002/2014WR016802.

Kacprzak, M., Rosikoń, K., Fijałkowski, K. and Grobelak, A. (2014). The Effect of Trichoderma on Heavy Metal Mobility and Uptake by *Miscanthus giganteus, Salix sp., Phalaris arundinacea,* and *Panicum virgatum*. Applied and Environmental Soil Science. Vol 2014;1-10. 10.1155/2014/506142.

Kelly, F. L., Matson, R., Delanty, K., Connor, L., O'Briain, R., Gordon, P., Corcoran, W., McLoone, P., Connor, L., Coyne, J., Morrissey, E., Cierpal, D., Rocks, K., Buckley, S., Kelly, K., McWeeney, D. and Puttharee, D. (2017) Sampling Fish in Rivers 2016. National Research Survey Programme. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland.

Kelly, F. L., Connor, L., Matson, R., Feeney, R., Morrissey, E., Coyne, J. and Rocks, K. (2015) Sampling Fish for the Water Framework Directive, Rivers 2014. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland.

Kelly, F. L., Matson, R., Connor, L., Feeney, R., Morrissey, E., Coyne, J. and Rocks, K. (2014) Water Framework Directive Fish Stock Survey of Rivers in the Eastern River Basin District. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland

Kelly, F. L., Matson, R., Connor, L., Feeney, R., Morrissey, E., Wogerbauer, C. and Rocks, K. (2013) Water Framework Directive Fish Stock Survey of Rivers in the Eastern River Basin District. Inland Fisheries Ireland, Swords Business Campus, Swords, Co. Dublin, Ireland.

Kelly, F. L., Matson, R., Connor, L., Feeney, R., Morrissey, Hanna, G., Wightman, G., O'Callaghan, R., Wogerbauer, C. and Rocks, K. (2010) Sampling Fish for the Water Framework Directive. Eastern River Basin District. The Central and Regional Fisheries Boards (now IFI). Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland.

Maltby, L Forrow, D.,Alistair B.A. Calow, P, Clifford B (1995) .The effects of motorway runoff on freshwater ecosystems: 1. Field study

Massa-Gallucci, A. and Mariani, S. (2011) A genetic study of the mixed trout populations of the Boyne and Suir River catchments. Technical Report. Inland Fisheries Ireland.

MCC (2021) Meath County Development Plan 2021 – 2027.

MCC (2015) County Meath Biodiversity Action Plan 2015-2020.

McCollom, A., Coghlan, B. and King, J.J. (2019). Environmental River Enhancement Programme Report 2018. Inland Fisheries Ireland, 3044 Lake Drive, Citywest, Dublin 24, Ireland.

Mickle, M.F. and Higgs, D.M. (2018). Integrating techniques: a review of the effects of anthropogenic noise on freshwater fish. Canadian Journal of Fisheries and Aquatic Sciences, 75, 1535–1541.

NIEA/EPA (2014) River Hydromorphological Assessment Technique (RHAT) Training Manual. Northern Ireland Environment Agency and Environmental Protection Agency.

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 (2014) Site Synopsis for River Boyne and River Blackwater (SAC 002299). Rev 13. Department of Arts Heritage, Regional, Rural and Gaeltacht Affairs.

NRA (2014) Drainage Design for National Road Schemes – Sustainable Drainage Options.

NRA (2009) Guidelines for Assessment of Ecological Impacts of National Roads Schemes. Revision 2, 1 June 2009.

NRA (2008) Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes. Prepared by NATURA Environmental Consultants in association with the National Roads Authority.

NRA (2003) Guidelines for Assessment of Ecological Impacts of National Roads Schemes. Revision 1.

O'Connor, W. (2006) A survey of juvenile lamprey populations in the Boyne Catchment. Irish Wildlife Manuals, No. 24 National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

O'Grady, M., Delanty, K., Coghlan, B., O'Briain, R. and Gilligan, N. (2017) River Enhancement Programmes in Ireland. Inland Fisheries Ireland, 3044 Lake Drive, Citywest Business Campus, Dublin 24, Ireland.

O'Grady, M. F. (2006) Channels & challenges: Enhancing Salmonid Rivers. Irish Freshwater Fisheries Ecology & Management Series: No. 4. Central Fisheries Board, Dublin.

O'Grady, M. F. (1998) The Boyne: Studies of Irish Rivers and Lakes, Ed. Christopher Moriarty, XXVII.

O' Riley, A. Pandey, S. Langdon, A. and Wilkins, A. (2002) Characterisation of road runoff contaminants from New Zealand roads and effect of rainfall events. Transfund New Zealand Research Report No. 228. 119pp.

Perdikaki and Mason, (1999) Impact of road run-off on receiving streams in eastern England.

Popper, A. N. and Hawkins, A. D. (2019) An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. Journal of Fish Biology; 94: 692–713.

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Løkkeborg, S., Rogers, P., Southall, B., Zeddies and D., Tavolga, W. (2014). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI (20 April 2014) 10.1007/978-3-319-06659-2_7.

Purcell, P., Cocchiglia, L. and Kelly-Quinn, M. (2014) Construction impacts of road-crossing structures on watercourses in special areas of conservation in Ireland, International Journal of Environmental Studies, 71 (3), 315-330.

Purcell, P., Bruen, M., O'Sullivan, J., Cocchiglia, L. and Kelly-Quinn, M. (2012) Water quality monitoring during the construction of the M3 motorway in Ireland. Water and Environment Journal 26, 175-183.

Reynolds J (1988). Crayfish extinctions and crayfish plague in Ireland.

Teagasc (2020) Major and Micro nutrient advice for productive agricultural crops. 5th Edition. Eds. David P. Wall, D. P. and Plunkett. M. Teagasc, Johnstown Castle, Wexford, Ireland.

TII (2015) Road Drainage and the Water Environment Volume 4 (Geotechnics and Drainage) Section 2 (Drainage) Part 1 NRA HD 45/15 TII Publication DN-DNG-03065.

Toner, P. Bowman, J. Clabby, K. Lucey, J. (2005), Water Quality in Ireland 2001-2003.

Wellman, J.C., Combs, D.L. and Cook, S.B. (2000) Long-Term Impacts of Bridge and Culvert Construction or Replacement on Fish Communities and Sediment Characteristics of Streams. Journal of Freshwater Ecology, 15 (3), 317–328.

Wenger, A. S., Harvey, E., Wilson, S., et al. (2017) A critical analysis of the direct effects of dredging on fish. Fish and Fisheries; 18: 967– 985.