# Appendix F

## EIAR Hydrology Chapter

# APPENDIX F
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# PLEASE NOTE

1. The relevant drawings from Volume 3 of the EIAR are presented in Volume 2, Appendix K of this NIS.

# Chapter 10 Hydrology

## 10.1 Introduction

This chapter of the EIAR presents the hydrological assessment of the proposed Foynes to Limerick Road (including Adare Bypass). The chapter sets out the methodology used in the assessment, describes the existing hydrological environment, details the likely significant hydrological impacts associated with the construction and operational phase of the proposed road development and describes measures to mitigate identified significant impacts and details residual impacts post mitigation.

The principal potential hydrological impacts to the character of the receiving waters are associated with the proposed road development crossing points and the potential for sediment loading and associated road drainage pollutants entering such watercourses during both construction and operational phases. There is also potential for hydrological and hydrogeological impacts to interact in the context of the karst geology along much of the route. The assessed potential impacts include:

- Surface watercourses crossed by the proposed road development, involving culvert and bridge structures with some associated realignment of the watercourse channel;
- Surface watercourses discharged to via proposed road drainage outfalls and downstream impacts;
- Potential impact to flooding and flood risk, upstream and downstream of the proposed channel and floodplain encroachment at proposed crossing points, at material deposit areas and downstream impacts from storm outfall locations;
- Potential morphological changes to watercourses at channel crossings and proposed road outfall discharge locations;
- Potential impacts on sites of ecological importance in proximity to surface watercourses as noted in Chapter 7 (Biodiversity);

## 10.2 Methodology

### 10.2.1 Data Sources

This chapter has been prepared having due regard to relevant legislation and the following guidance documents:

- EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports, Draft August 2017;
- EPA Advice Notes for Preparing Environmental Impact Statements, Draft September 2015;
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (DHPLG, August, 2018);
- Environmental Impact Assessment of Projects: Guidance on the Preparation of Environmental Assessment Report (European Commission, 2017);
- TII Guidelines on Procedures for the Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- TII Environmental Impact Assessment of National Road Schemes – A Practical Guide, November 2008;

- DoEHLG (Nov 2009) The Planning System and Flood Risk Management – Guidelines for Planning Authorities;
- Transport Infrastructure Ireland (2008) Environmental Impact Assessment of National Road Schemes – A Practical Guide;
- Transport Infrastructure Ireland (2008) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;
- Transport Infrastructure Ireland (2015) DN-DNG-03065 - Road Drainage and the Water Environment (including Amendment No. 1 dated June 2015);
- Transport Infrastructure Ireland (2015) DN-DNG-03022 Drainage Systems for National Roads (including Amendment No. 1 dated June 2015);
- S.I. No. 296 of 2018, European Union (Planning and Development) (Environmental Impact Assessment) Regulations 2018;
- S.I. No. 473 of 2011, European Union (Environmental Impact Assessment and Habitats) Regulations 2011;
- S.I. No. 366/2016 - European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016;
- S.I. No. 366/2016 - European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016;
- S.I. No. 722 of 2003, European Community (Water Policy) Regulations, 2003;.
- S.I. No 272 of 2009, European Communities Environmental Objectives (Surface Waters) Regulations, 2009;
- S.I. No. 9 of 2010, European Communities Environmental Objectives (Groundwater) Regulations 2010;
- Directive 2000/60/EC – "The Water Framework Directive";
- Directive 2006/118/EC – "The Groundwater Directive";
- The Planning and Development Act, 2000, as amended;
- S.I. 600 of 2001 Planning and Development Regulations as amended;
- European Communities Environmental Objectives (Groundwater) Regulations 2010-2012;
- S.I. No. 122 of 2014 European Union (Drinking water) Regulations;
- European Communities (Water Policy) Regulations, 2003 (S.I. No. 722 of 2003);
- European Communities Environmental Objectives (Surface Waters) Regulations, 2009 (S.I. No. 272 of 2009).

The Hydrological Impact Assessment Methodology implements the guidance outlined in Section 5.6 of the TII Guidelines pertaining to the treatment of Hydrology. The impact category, duration and nature of impact have been taken into account in this assessment as per the guidelines. The range criteria for assessing the importance of hydrological features within the study area and the criteria for quantifying the magnitude of impacts follow the TII guidelines.

The hydrological assessment has been prepared by expanding and updating the desk study work carried out for the Constraints Study and Route Selection Report. It includes an assessment of published literature available from various sources including a web-based search for relevant material. Site specific topographical information and aerial photography has been reviewed to locate any potential features of hydrological interest, and these have been investigated on the ground by walkover surveys in order to assess the significance of any likely environmental impacts on them.

Available topographical and hydrometric information (field and desk based) has been used to perform hydrological impact assessments of all culvert crossings and proposed outfall locations. All watercourses and water bodies which could be affected directly (i.e. crossed or realigned/ diverted) or indirectly (i.e. generally lie within 250m of the road development boundary or would receive storm runoff from the proposed road development) were assessed through a series of initial walkover visits followed up by a more detailed survey and hydrological assessment. Due to the nature of the hydrological environment it is necessary to consider the larger river catchment environments that the proposed road development traverses.

The following list of data sources were reviewed as part of this assessment of the impacts on hydrology:

**Ordnance Survey Ireland (OSi)**

- Discovery Series Mapping (1:50,000)
- Six Inch Raster Maps (1:10,560)
- Six inch and 25inch OS Vector mapping
- Orthographic Aerial Mapping

**Environmental Protection Agency (EPA)**

- Teagasc Subsoil Classification Mapping
- Water Quality Monitoring Database and Reports
- Water Framework Directive Classification
- EPA Hydrometric Data System
- Water Framework Directive River Basin Management Plans

**Office of Public Works (OPW)**

- Arterial Drainage Scheme Land Benefitting Mapping for Ireland
- OPW and Drainage District Arterial Drainage Channels and Maintained Channels
- OPW Hydrometric Data Website
- OPW Flood-maps Site
- OPW FSU (Flood Studies Update) Web Portal Site for Flood Flow Estimation
- OPW Preliminary Flood Risk Assessment Mapping (PFRA)
- OPW Catchment Flood Risk Assessment and Management Mapping (CFRAM)
- Review of Office of Public Works (OPW) online mapping

**Limerick City & County Council**

- Limerick County Development Plan 2010-2016 (as extended)
- Planning Register
- Water Services Department – Abstractions, Discharges & Supply Schemes

**National Parks and Wildlife Service (NPWS)**

- Designated Areas Mapping
- Site Synopsis Reports

**Environmental Protection Agency (EPA)**

- Water Quality Monitoring Database and Reports
- Water Framework Directive Classification

**Other Sources**

- River Basin Management Plan for Ireland (2018 – 2021)
- Shannon River Basin Management Plan for Ireland
- Aerial survey photography
- Geological Survey of Ireland (GSI) Mapping
- Aerial survey photography (flown 2006, 2007, 2010, 2012 & 2015)
- LIDAR data (Light Detection and Ranging) (Flown Feb 2015)
- Met Eireann meteorological data

### 10.2.2 Consultation with Regulatory and Other Bodies

Consultation took place with all relevant regulatory bodies including various departments of Limerick City and County Council, the OPW, National Parks and Wildlife (NPWS), GSI and Inland Fisheries Ireland (IFI).

### 10.2.3 Field Surveys

Field surveys and walkover assessments were carried out to assess the hydrological impacts of the proposed road development. Detailed stream surveys (including topographical surveys where required) were made at areas where hydrological impacts were likely to occur without appropriate mitigation. Specifically, all culvert and bridge crossing locations, proposed outfall locations and ecologically sensitive areas were visited, and field measurements carried out along with reconnaissance of potential flood risk areas.

## 10.3 Existing Environment for Hydrology

### 10.3.1 Regional Overview of Hydrology

The rivers and lakes along the proposed road development are located entirely within the Shannon International River Basin District (Shannon IRBD) and have been classified by the Water Framework Directive as Poor to Moderate water quality status along the entire proposed road development. The groundwater status for this region is classified primarily as Good with localised areas classified as Poor to the north of Adare and at Mulderricksfield.

The proposed road development crosses several watercourses which are part of the Lower River Shannon Estuary Catchment. The rivers in the eastern section of the Study Area which are traversed by the proposed road development flow to the Shannon Estuary via the River Maigue catchment. Those in the middle section flow via the River Deel and the remaining western section flows directly to the Shannon Estuary. The proposed road development is in Hydrometric Area No.24, Shannon Estuary South Unit of Management (UoM).

The locations of each of the major watercourses along the proposed road development are given in Figure 10.1 in Volume 3 of this EIAR, with each of the outfall locations and their proximity to sensitive ecological receptor locations indicated on Figures 10.2 – 10.6 in Volume 3 of the EIAR. Figure 10.7 in Volume 3 shows the upstream catchment sections and subsections to the various watercourse crossings and outfalls. There are 21 watercourse crossings and 32 surface water outfall discharge locations proposed along the route and these are summarised in Table 10.1 below. A watercourse is defined as a channel that a flowing body of water follows and includes rivers, streams, tributaries and canals. All other culvert crossings proposed as part of this development traverse local or arterial drainage channels or drainage ditches. In general, all watercourses in the area flow from south to north towards the Lower Shannon Estuary.

The minor watercourses in Section A, the Robertstown and Ahacronane Rivers, discharge into the Churchfield Creek approx. 1.2km and 1.6km downstream of the proposed road development crossings, respectively. The Churchfield Creek is tidal and confluences with the Shannon Estuary a further 2.5km along between Foynes Island and Aughinish Island.

Section B crosses over the Ballycullen Stream only.

Section C of the proposed road development crosses the River Deel in the townland of Milltown North, which continues northward passing through Askeaton and discharging to the Shannon Estuary.

Section D of the proposed road development crosses the Greanagh River twice and also its tributary the Clonshire River, in the townland of Clonshire More and Rower More. The proposed road development crosses the River Maigue to the north of Adare which is the largest watercourse crossed. The Greanagh River confluences with the River Maigue approximately 1km north of the proposed road development before discharging to the Shannon Estuary a further 10km north. The Maigue and Greanagh (B) Rivers are tidal at the proposed road development crossing points.

**Table 10.1 Road Section and Associated Catchments**

| Section No. | Chainage: | | Section Length, km | No. of Watercourse Crossings | No. of Outfalls |
|---|---|---|---|---|---|
| | From | To | | | |
| A | 1+000 | 7+350 | 7.35 | 6 | 5 |
| B | 10+000 | 11+950 | 1.95 | 3 | 3 |
| C | 20+000 | 29+950 | 9.95 | 6 | 9 |
| D | 50+000 | 65+550 | 15.55 | 6 | 15 |
| **Total** | | | **34.80** | **21** | **32** |

### 10.3.2 River Catchments

The following sections provide a general description of the principal river catchments in the area. Detailed descriptions of the individual watercourses and their sub-catchments which are crossed by, or act as receiving waters from, the proposed road development are also provided.

Please note there are differences in some of the parameters quoted below between the Flood Studies Report (FSR; 1975) and Flood Studies Update Report (FSU, 2014) due to the differences in the varying mapping techniques used. It is generally considered that the areas calculated in the FSR method are more accurate than those within the FSU as they take into account the drainage network as well as the Digital Terrain Mode (DTM) contours. The FSU only considers the DTM model and has been shown for various catchments to be inconsistent with respect to the watershed.

#### *10.3.2.1 Robertstown River*

The Robertstown River is a minor watercourse with a catchment area of approximately 30 $km^2$ where it traverses the proposed road development. It rises in the hills to the south west of Shanagolden village and flows typically south to north and discharges into the Churchfield Creek which is a tidal inlet of the Shannon Estuary. There are no sources of gauged flood flow information for this River.

**Table 10.2 FSR Catchment Characteristics of the Robertstown River**

| Catchment Characteristic | Measurement |
|---|---|
| AREA ($km^2$) | 30.4 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,100 |
| Winter Rainfall Acceptance potential SOIL Index | 0.37 |
| Channel Flood Slope S1085 (m/km) | 9.10 |
| URBAN – fraction of catchment | 0.000 |

**Table 10.3 FSU Catchment Descriptors of the Robertstown River**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA ($km^2$) (OPW DTM model) | 32.0 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,097 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 1.0 |
| Baseflow Index of Soils (BFISOIL) | 0.637 |
| Drainage Density (DRAIND) km per $km^2$ | 1.086 |
| Channel Flood Slope (S1085) (m/km) | 13.124 |
| Arterial Drainage Factor (ARTDRAIN2) | 0.000 |
| URBEXT (Urban Extent) | 0.017 |

#### *10.3.2.2 Ahacronane River*

The Ahacronane River has a catchment area of approximately 22$km^2$ upstream of where it traverses the proposed road development. It rises in the hills near Kilcolman, flowing north through Creeves before discharging into the Churchfield Creek. There are no sources of gauged flood flow information for this River.

**Table 10.4 FSR Catchment Characteristics of the Ahacronane River**

| Catchment Characteristic | |
|---|---|
| AREA ($km^2$) | 21.7 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,100 |
| Winter Rainfall Acceptance potential SOIL Index | 0.31 |
| Channel Flood Slope (S1085) (m/km) | 5.90 |
| URBAN – fraction of catchment | 0.000 |

**Table 10.5 FSU Catchment Descriptors of the Ahacronane River**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA ($km^2$) (OPW DTM model) | 22.6 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,085 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 1.0 |
| BFISOIL Baseflow Index of Soils | 0.674 |
| Drainage Density DRAIND km per $km^2$ | 1.313 |
| Channel Flood Slope (S1085) (m/km) | 7.64 |
| Arterial Drainage Factor ARTDRAIN2 | 0.000 |
| URBEXT | 0.000 |

#### *10.3.2.3 Ballycullen (Lismakeery) Stream*

The Ballycullen Stream (also known as the Lismakeery Stream) rises near Kilquane and flows north towards Lismakeery and Ballycullen before discharging to the Shannon Estuary at Tomdeely North. It is crossed twice by the proposed road development, upstream in Section C at Ch.20+950 and downstream in Section B at Ch.10+300. It has a catchment area of approximately $12km^2$ upstream of where it traverses Section B of the proposed road development. There are no sources of gauged flood flow information for this River.

**Table 10.6 FSR Catchment Characteristics of the Ballycullen Stream**

| Catchment Characteristic | |
|---|---|
| AREA ($km^2$) | 11.1 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,100 |
| Winter Rainfall Acceptance potential SOIL Index | 0.17 |
| Channel Flood Slope (S1085) (m/km) | 2.50 |
| URBAN – fraction of catchment | 0.00 |

**Table 10.7 FSU Catchment Descriptors of the Ballycullen Stream**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA ($km^2$) (OPW DTM model) | 13.5 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,062 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 1.0 |
| BFISOIL Baseflow Index of Soils | 0.635 |
| Drainage Density DRAIND km per $km^2$ | 0.910 |
| Channel Flood Slope (S1085) (m/km) | 0.18 |
| Arterial Drainage Factor ARTDRAIN2 | 0.078 |
| URBEXT | 0.000 |

#### *10.3.2.4 River Deel*

The River Deel rises in the Mullaghareirk Mountains near Dromina. It flows roughly in a north-westerly direction through the mountains, where it is joined by numerous tributaries, including the Finglasha River and the Ahavarragh Stream which drains the lands upstream of Dromcolliher. Downstream of Newcastle West, the River Deel is joined by the rivers Arra, Dooally and Daar, which drain the steep topography of the Knockanimpaha Mountains which bound the west of the catchment.

Downstream of this confluence the River Deel flows north east, through agricultural plains and roughly follows the direction of the N21 towards and through the western end of the town of Rathkeale. Flowing north from Rathkeale the Deel flows through Askeaton, and on to the Shannon Estuary. It has a catchment area of approximately 484km$^2$ upstream of where it traverses the proposed road development at Milltown North.

The River Deel catchment drainage scheme was completed in 1968 and focused on improving drainage for agricultural purposes.

**Table 10.8 FSU Catchment Descriptors of the River Deel**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA (km$^2$) (OPW DTM model) | 484.1 |
| Standard Average Annual Rainfall (SAAR) (mm) | 1,068 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 0.998 |
| BFISOIL Baseflow Index of Soils | 0.466 |
| Drainage Density DRAIND km per km$^2$ | 1.157 |
| Channel Flood Slope S1085 (m/km) | 1.84 |
| Arterial Drainage Factor ARTDRAIN2 | 0.405 |
| URBEXT | 0.016 |

The River Deel is a gauged river with multiple hydrometric gauging stations along its length. The closest station to the proposed crossing point is located upstream at Rathkeale, ref.24013 (the river having a catchment at that point of 438.8km$^2$). The Rathkeale gauging station has a good A2 Rating Classification for its flood flow-stage relationship. The record period available for the station is from 1953 to 2009.

#### *10.3.2.5 Clonshire and Greanagh Rivers*

The River Greanagh and Clonshire catchments drain an area of approximately 122km$^2$. The source of the Greanagh catchment originates to the north of Ballingarry. It flows north towards the townland of Gortnagrour, where it meets the River Clonshire. The River Greanagh then joins the River Maigue just north of Adare.

A drainage improvement scheme has been undertaken on the lower reaches of the Greanagh with flood embankments, back drains and flapped outlets present, however, it is not known when this was undertaken (likely 1960s/1970s).

These catchments are crossed three times by the proposed road development, all in Section D at Ch.56+550, Ch.58+180 and Ch.59+260. The catchment area upstream of the final crossing is circa 84km$^2$. There are no sources of gauged flood flow information for this river.

**Table 10.9 FSU Catchment Descriptors of the Greanagh River (at Ch.59+260)**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA (km²) (OPW DTM model) | 84.2 |
| Standard Average Annual Rainfall (SAAR) (mm) | 948 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 0.994 |
| BFISOIL Baseflow Index of Soils | 0.713 |
| Drainage Density DRAIND km per km² | 0.793 |
| Channel Flood Slope S1085 (m/km) | 5.32 |
| Arterial Drainage Factor ARTDRAIN2 | 0.646 |
| URBEXT | 0.010 |

#### *10.3.2.6 River Maigue*

The River Maigue catchment drains an area of approximately 1,122km². The source of the catchment originates in the Ballyhoura Mountains (County Limerick/County Cork). From North Cork, the River Maigue flows east until it joins the River Loobagh and then continues north from Bruree. Upstream of Croom, the Camoge River joins the River Maigue from the east. Downstream of Croom, the River Maigue flows to the northwest towards Adare and is joined by the Greanagh River. Tides become influential once the river crosses through Adare. It has a catchment area of approximately 840km² where it traverses the proposed road development.

Multiple drainage improvement schemes have been undertaken throughout the catchment area. In the lower reaches of the River Maigue, flood embankments, back drains and flapped outlets are present which was undertaken between 1973 and 1986.

**Table 10.10 FSU Catchment Descriptors of the River Maigue**
(Source OPW FSU Web Portal Site)

| Catchment Characteristic | |
|---|---|
| AREA (km²) (OPW DTM model) | 840.1 |
| Standard Average Annual Rainfall (SAAR) (mm) | 939 |
| Flood Attenuation from Reservoirs and Lakes (FARL) | 0.999 |
| BFISOIL Baseflow Index of Soils | 0.547 |
| Drainage Density DRAIND km per km² | 1.056 |
| Channel Flood Slope S1085 (m/km) | 2.002 |
| Arterial Drainage Factor ARTDRAIN2 | 0.521 |
| URBEXT | 0.007 |

The River Maigue is a gauged river having multiple hydrometric gauging stations along its length. The closest station near the proposed crossing point is located upstream at Castleroberts, ref.24008 (the river having a catchment at that point of 806km²). This gauging station has a good A2 Rating Classification for its flood flow-stage relationship. The record period available for the station is from 1975 to 2009. There is also a station at Adare Quay, ref.24062, however this recorded levels only from 1993 to 2009 and is a tidal gauge.

### 10.3.3 Flood Risk Assessment (FRA)

A flood risk assessment has been undertaken for the proposed road development. All bridge structures will be designed with a capacity to pass the estimated 100-year flood flow with appropriate allowances for statistical error and climate change. A minimum freeboard allowance of greater than 0.3m between its soffit level and the design Flood level will be provided. However, at all significant river crossings there are access requirements along the banks which require significantly greater headroom such that the actual freeboard will be typically 2.5m to 4.5m and more above flood levels. Consideration of the following flood flows and flood levels were calculated using a number of methods including: FSR, FSR-3, FSSR-6, IH124/ICP and using the OPW FSU Web Portal and the appropriate design flow adopted.

To inform the Flood Risk Assessment (FRA) the website www.floodmaps.ie and the Preliminary Flood Risk Assessments (PFRA) and Catchment Flood Risk Assessment and Management (CFRAM) flood mapping were consulted as initial screening. Hydraulic flood modelling was carried out to estimate the design flood level and potential impact of the proposed road development at four locations along the proposed road development, namely:

1. Robertstown Area (Section A)
2. River Deel Crossing (Section C)
3. River Greanagh Crossing[1] (Section D)
4. River Maigue Crossing[1] (Section D)

**Table 10.11 Predicted Design Fluvial Flood Levels and Flood Flows for modelled watercourses (1% Annual Exceedance Probability)**

| River Name | Section | Chainage (m) | 1% AEP Flood Level (m OD) | 1% AEP Flood Flow ($m^3/s$) |
|---|---|---|---|---|
| Robertstown River | A | 2+600 | 6.83 | 17.22 |
| River Deel | C | 24+025 | 19.90 | 172.35 |
| Greanagh River | D | 59+260 | 4.10 | 27.10 |
| River Maigue | D | 60+950 | 4.24 | 246.33 |

The flood risk is scored as low, medium or high with no further mitigation measures proposed for low, minor mitigation for medium and re-design recommended for high risk. All of the proposed culvert/bridge crossings were assessed and found to have a low residual flood risk being generously sized for flood flows and culvert/bridge soffit freeboard clearance. The findings of the Flood Risk Assessment in relation to the road vertical alignment are summarised in Table 10.12 below. Refer to Section 10.4 for further details and the assessment of impacts.

This assessment indicates minimal flood risk to the proposed road development.

[1] Due to the proximity and floodplain connectivity between the River Greanagh and the River Maigue, a combined hydraulic model of both watercourses was developed.

**Table 10.12 Flood Risk Assessment Summary: Road Vertical Alignment**

| Section | Chainage | Comment on Flood Risk Areas | Overall Flood Risk | Mitigation |
|---|---|---|---|---|
| A: Robertstown | 2+050 to 2+950 | Minimal Flood Risks | Low | None |
| C: River Deel | 23+875 to 25+975 | Minimal Flood Risks | Low | None |
| D: Greanagh River | 58+750 to 61+675 | Minimal Flood Risks | Low | None |
| D: River Maigue | | Minimal Flood Risks | Low | None |

### 10.3.4 Surface Water Quality

*EPA Monitoring River Programme*

The Environmental Protection Agency (EPA) carries out water quality assessments of rivers as part of a nationwide monitoring programme. Data is collected from physio-chemical and biological surveys, sampling both river water and the benthic substrate (sediment) in contact with the water.

Water sampling is carried out throughout the year and the main parameters analysed include conductivity, pH, colour, alkalinity, hardness, dissolved oxygen, biochemical oxygen demand (BOD), ammonia, chloride, ortho-phosphate, oxidised nitrogen and temperature.

Biological surveys are normally carried out between the months of June and October. These examine the relationship between water quality and the relative abundance and composition of the macro-invertebrate communities in the sediment of rivers and streams. The macro-invertebrates include the aquatic stages of insects, shrimps, snails and bivalves, worms and leeches. It is generally found that the greater the diversity of species recorded, the better the water quality is.

The collated information relating the water quality and macro-invertebrate community composition is condensed to a numerical scale of Q-values or Biotic Index. The indices are grouped into four classes based on a river's suitability for beneficial uses such as water abstraction, fishery potential, amenity value, etc. (refer to Table 10.13 below).

Water quality in watercourses is generally moderate (Q3-4) with most showing evidence of nutrient enrichment or high sediment loads as a result of intensive land management within the catchment.

**Table 10.13 Biological River Water Quality Classification System**

| Biotic Index (Q value) | Quality Status | Quality Class | Condition |
|---|---|---|---|
| Q5, Q4-5, Q4 | Unpolluted | Class A | Satisfactory |
| Q3-4 | Slightly Polluted / Eutrophic | Class B | Transitional |
| Q3, Q2-3 | Moderately Polluted | Class C | Unsatisfactory |
| Q2, Q1-2, Q1 | Seriously Polluted | Class D | Unsatisfactory |

### 10.3.5 Ecological Receptors

A number of key ecological receptors (KERs) and Ecological Receptors (ERs) adjacent to the proposed road development have also been identified and discussed in detail in Chapter 7 (Biodiversity).

Special Areas of Conservation (SAC) and Special Protection Areas (SPA) are afforded legal protection under European Legislation for the conservation of natural habitats and of wild flora and fauna. SAC's and SPA's form part of the NATURA 2000 network of European wide protected sites. A number of priority habitats are also listed which afford special conservation status and attract stricter protection.

The River Maigue within the Lower River Shannon SAC is traversed by the proposed road development. In addition, all of the other watercourse crossings eventually discharge to the Shannon Estuary and the SAC.

The worst-case scenario would be a major pollution incident within the proposed road development which would discharge either directly to the River Maigue, or through a sequence of waterbodies before potentially affecting the SAC.

### 10.3.6 Water Supply Sources from Rivers

There are no water supply abstraction points from rivers downstream of the crossing points on the proposed road development.

## 10.4 Impact Assessment for Hydrology

### 10.4.1 Introduction

Road projects, given their scale and nature, have significant potential for impacting on the hydrological environment, both during their construction and on-going operation, and consequently require careful planning and detailed assessment to ensure the best solution is attained.

### 10.4.2 Methodology

The assessment of hydrological impacts for the proposed road development has been based on the analysis and interpretation of the data acquired during the Constraints Study and Route Selection phase, as well as site specific investigations undertaken in support of this EIAR, including the biodiversity assessments, intrusive site investigations, agricultural surveys, topographical surveys and hydrological walkover surveys. The procedure follows the guidelines set out in the publication 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes', TII.

Key hydrological attributes identified along the proposed road development include:

- Ecologically sensitive surface water features and catchment systems, fishery streams either locally or downstream, Fens, flushes and wetlands etc.;
- Flood Risk Areas; and
- Karstic Areas as described in Chapter 8 Soils and Geology, and Chapter 9 Hydrogeology.

The individual importance of these attributes has been then assessed with respect to their quality, extent / scale and rarity as set out in Table 10.14 below.

For the purposes of this assessment and particularly with reference to the identified KERs and ERs and how their importance was rated, from the hydrological perspective consistent with the approach used for rating ecological sites - see Chapter 7 Biodiversity, the following rating criteria were used:

- Local Importance Lower value – Low

- Local Importance Higher value – Medium
- County/ Regionally Important – High
- National Importance – Very high
- European Importance – Extremely Important

**Table 10.14 Criteria for Rating Site Attributes**

| Importance | Criteria |
|---|---|
| Extremely High | Attribute has a high quality or value on an international scale |
| Very High | Attribute has a high quality or value on a regional or national scale |
| High | Attribute has a high quality or value on a local scale |
| Medium | Attribute has a medium quality or value on a local scale |
| Low | Attribute has a low quality or value on a local scale |

### 10.4.3 Types of Hydrological Impact

Types of hydrological impact fall into two broad categories of quantitative and qualitative impacts.

#### *10.4.3.1 Quantitative Hydrological Impacts*

Hydraulic structures such as bridges, culverts, channel diversions and outfalls can, if not appropriately designed, impact negatively on upstream water levels and downstream flows. If a bridge or culvert opening is too narrow or a diversion channel undersized it may impede flow during times of floods thus causing water levels upstream of the structure to be raised above what would occur in the absence of the structure.

In the design of the proposed road development, the adequacy of culvert sizes for local drainage areas and small river catchments is based on providing conveyance for the 1% Annual Exceedance Probability (AEP) return period flood event with recommended climate change allowance. Blockage potential and maintenance requirements are also considered and are often the overriding design factor for small stream crossings. In this respect the design flow used is based on gauged flow data, where available, or the upstream catchment characteristics of the crossing including:

- Catchment area,
- Annual average rainfall for the catchment,
- Mean channel slope (S1085),
- Soil type,
- Flood Studies Report (FSR)100-year flood growth factor of 1.96.

Each method included the standard factorial allowance for the related estimation method (Institute of Hydrology Report No. 124 3-variable equation (IH-124) =1.65, Flood Studies Report 6 variable equation (FSR) (Ireland) =1.47). A climate change allowance of 1.2 was included in all estimations. In addition, where a channel is maintained under a drainage district or arterial drainage scheme, an arterial drainage factor of 1.6 was also included. The Flood Studies Update (FSU) Research Programme was implemented by the OPW and provides a substantial update of the Flood Studies Report. The FSU is an upgraded method for providing estimates at a network of hydrometric nodes throughout Ireland and has a factorial allowance of 1.38.

The method uses a pooled growth curve of hydraulically similar catchments as the subject catchment which differs from the FSR (which uses a single national growth curve).

Surface water drainage from the carriageway, grassed margins and embankment slopes can lead to localised increased flows and flooding in the receiving streams. The proposed mainline road drainage system is a combination of piped drains, surface water channels and filter drains where permitted, which convey storm runoff to one of the various surface outfall locations along the proposed road development.

#### *10.4.3.2 Qualitative Hydrological Impacts*

Depending on the hydrological and ecological sensitivities of the proposed outfall receiving waters, treatment of the storm water via online or offline detention / water quality improvement ponds are required upstream of the outfall to protect the water quality particularly from spillage and first flush runoff events. The potential contaminant load and accidental spillage risk for a single outfall and sub-catchment area is a function of the Design Traffic Volume and road paved area/length.

#### *10.4.3.3 General Hydrological Impacts*

*General Construction Impacts for Hydrology*

Construction activities pose a significant risk to watercourses particularly contaminated surface water runoff from construction activities entering nearby watercourses.

Construction activities within and alongside surface waters associated with bridge and culvert construction, outfalls and channel diversions can contribute to the deterioration of water quality and can physically alter the stream/river bed and bank morphology with the potential to alter erosion and deposition rates locally and downstream. Activities within or close to the watercourse channels can lead to increased turbidity through re-suspension of bed sediments and release of new sediments from earthworks. Consequently, instream works can potentially represent a severe disruption to aquatic ecology.

The main contaminants arising from construction runoff include:

- Elevated silt/sediment loading in the construction site runoff. Elevated silt loading can lead to long-term damage to aquatic ecosystems by smothering spawning grounds and gravel beds and clogging the gills of fish. Increased silt load in receiving watercourses stunts aquatic plant growth, limits dissolved oxygen capacity and overall reduces the ecological quality with the most critical period associated with low stream flow conditions. Chemical contaminants in the watercourse can bind to silt which can lead to increased bioavailability of these contaminants;
- Spillage of concrete, grout and other cement-based products. These cement-based products are highly alkaline (releasing fine highly alkaline silt) and extremely corrosive and can result in significant impacts to watercourses altering the pH, smothering the stream bed and physically damaging fish through burning and clogging of gills by fine silt;
- Accidental Spillage of hydrocarbons from construction plant and at Storage depots / construction compounds; and
- Faecal contamination arising from inadequate treatment of on-site toilets and washing facilities.

*General Operational Impacts for Hydrology*

- Permanent interference with river, streams and floodplains at bridge and culvert crossing points. These structures can, if not appropriately designed create an obstacle to flow, particularly under flood conditions resulting in increased flood risk and damage as a result of afflux by such structures. Such structures can locally alter bed levels and channel dimensions resulting in changes in flow velocity and water depth which can, during low flow periods, represent a barrier to fish passage. These structures can result in localised bed and bank erosion resulting in long-term changes to the morphology of the stream channel.
- Removal of flood storage as a result of the road footprint encroaching on the floodplain area. This can result in slight to moderate reduction in the flood attenuating function of a floodplain.
- Potential diversion of water between drainage catchments as a result of the proposed road development and associated drainage network and outfalls. At some locations, the proposed road development may be perpendicular to the natural drainage path and so may lead to the interception of overland flow into the road drainage system (surface drainage or toe drainage / cut off drains) that will convey it to the nearest associated outfall. This may lead in some cases to permanent diversion of flow resulting in an increase in the rate and volume of flow in one watercourse and a corresponding reduction in the other, with potential implications for flood risk and water quality/ dilution.
- Interference with local drainage, relocation, discontinuation and combination of existing land drains as a result of the road footprint and its associated drainage system including toe drains and attenuation/detention drainage ponds. This can lead to local changes in the hydrological regime and can lead to a concentration of flows where a number of smaller drains are discontinued / diverted. This can lead potentially to a deterioration of the hydraulic capacity and exacerbation of flood risk. In the event of the realignment of watercourses this will effectively remove a section of channel reach including its channel and bank-side ecology.
- Increased runoff to watercourses at proposed storm outfalls due to the road pavement (impervious area), reduced transmission time and increased point loading associated with the road and drainage system. This can, particularly in the smaller receiving watercourses/drains, lead to increased flood flow magnitudes and increased frequency of flooding.
- Water quality impact on receiving watercourses at storm outfalls from routine road runoff (generally sediment associated contaminants, heavy metals, hydrocarbons and suspended solids, de-icing agents (salt and grit) and to a lesser extent nutrients, organics, and coliforms). A wide range of heavy metals are known to occur in road drainage waters, the primary metals of concern are Cadmium (Cd), Lead (Pb), Copper (Cu) and Zinc (Zn). All of these metals are included in the EU substances Directive (76/464/EEC), the EU Directive on Pollution Caused by Certain Dangerous Substances (2006/11/EC), the EU Water Framework Directive (2000/60/EC) and the proposed EU priority Contaminating Substances Directive. In particular Cadmium is a List 1 substance included in the EU Blacklist of dangerous substances; all other compounds are List 2 substances.

The road drainage and associated storm outfalls provide a direct pathway for contaminant from accidental spillages associated with Heavy Goods Vehicles (HGVs) (agricultural, oil/chemical spillages, bulk liquid, cement, etc.) to gain rapid un-attenuated access to receiving watercourses.

Salt and grit applications to road surfaces to mitigate icy conditions, will result in an increased salinity, pH, conductivity and total dissolved solids concentrations to the receiving aquatic system. Increased salinity of watercourses can alter the ecological balance of the aquatic system and increase the bioavailability of chemical contaminants.

### 10.4.4 Impact of Hydraulic Structures and Interference with Drainage Paths

This sub-section considers the hydraulic impact of the proposed watercourse culvert crossings along the proposed road development. The preliminary drainage design has identified that a large number of minor drains/watercourses are intercepted by the proposed road development. A large number of these smaller field drains can, from a hydraulic and fisheries perspective, be truncated and the upstream portion diverted either to another existing drain close by or connected into the road embankment drainage ditch.

### 10.4.5 Watercourse Bridge and Culvert Crossings

Tables 10.15 and 10.16 below present a summary of the proposed watercourse bridge and culvert crossings including upstream contributing catchment area and the proposed sizes taking into account the biodiversity requirements for mammal passage and fisheries. Where both mammal passage and fisheries requirements apply a bottomless structure will be provided with appropriate lateral clearances from the watercourse channel banks as detailed in Chapter 7 (Biodiversity).

As can be seen from the tables, many of the streams intercepted are relatively small in respect to catchment area and the proposed dimensions support the existing stream channel dimensions and will not result in any contraction of the stream flow at the crossing point. These sizes ensure that the design flow barrel velocity is of the order of 0.75m/s to 2m/s and thus potential upstream afflux is minimised.

In some cases, the watercourse crossing is included within a larger structure that may also span over a public road or access tracks for farmers or anglers. Flood plain clearances may also apply in addition to the hydraulic clearances, for example at Robertstown where an approx.140m long bridge will span over the river floodplain and the existing N69 road.

Where a watercourse is to be regraded or diverted, the material forming the bed will be recovered and reused to line the realigned channel. Watercourse diversion channels will be constructed to the inlet and outlet of culverts and will be excavated to provide an even grade between culvert headwalls and existing watercourses, with no obstructions or hollows which would impede the flow of water.

A low-flow channel will be constructed in the bedding material to allow fish passage during dry rainfall periods. Rock scour protection or rock armour will be constructed from natural stone with the properties conforming to TII Publication CC-SCD-00550 Rock Armour Scour Protection.

**Table 10.15 Proposed Watercourse Bridge and Culvert Crossings – Sections A, B & C[2]**

| Ref. No. | Location | Watercourse | Ch. | Catchment Area, $km^2$ | Length (m) | Min. Hydraulic Size W (m) | Min. Hydraulic Size H (m) | Adjusted Size W x H (m) |
|---|---|---|---|---|---|---|---|---|
| FR-C1 / FR-C1A | Ardaneer | Stream | 1+100 | 0.3 | 34 / 10 | 2.0 | 2.4 | N/A |
| FR-C2 | Sroolane North | Stream | 2+150 | 1.4 | 36 | 6.6 | 3.7 | N/A |
| FR-C3 | N69 / Sroolane North | Stream | 2+500 | 0.6 | 17 | 1.5 | 1.5 | 1.95 x 2.0 (match existing) |
| FR-C4 | N69 / Robertstown | Robertstown | 2+650 | 30.4 | 18 | 6.5 | 2.4 | 3.5 x 2.4 (match existing) |
| UB01 | Robertstown | Robertstown | 2+650 | 30.4 | 142 | Bridge Structure | | Bridge Structure |
| FR-C5 | Rincullia | Ahacronane | 4+440 | 21.7 | 43 | 5.3 | 2.4 | 8.0 x 3.9 |
| FR-C6 | Ballyclogh | Stream | 7+160 | 0.8 | 37 | 1.4 | 1.3 | 2.0 x 2.5 |
| FR-C7 / FR-C7A | Ballyclogh | Stream | 10+150 | 1.1 | 26 / 32 | 1.4 | 1.3 | 2.0 x 2.5 |
| FR-C8 | Ballycullen | Ballycullen | 10+300 | 11.1 | 32 | 1.6 | 2.2 | 7.0 x 3.1 |
| FR-C8A | L1220 / Ballycullen | Ballycullen | 20+200 | 10.2 | 18 | 2.5 | 1.8 | 8.0 x 2.1 |
| FR-C9 | Ballycullen | Stream | 10+950 | 6.3 | 40 | 1.65 Ø | | 7.0 x 3.4 |
| FR-C10 | Cloonreask | Stream | 11+650 | 0.5 | 32 | 1.20 Ø | | 2.0 x 3.0 |
| FR-C11 | Ballyclogh | Ballycullen | 20+950 | 9.9 | 48 | 1.8 | 2.1 | 8.0 x 6.5 |
| FR-C12 | Baunreagh | Stream | 21+950 | 4.5 | 40 | 1.65 Ø | | 2.0 x 3.5 |
| FR-C12A | L1236 / Lismakeery | Stream | 22+500 | 0.8 | 10 | 1.20 Ø | | 1.20 Ø |

[2] Notes:
Height is measured above watercourse bed level. Ø = diameter.
All box culverts are to be constructed to an invert level 500mm below that of the existing channel.
All piped culverts are to be constructed to an invert level minimum 300mm below that of the existing channel.
The sizes indicated above are full sizes inclusive of any increases required to accommodate depressed inverts or mammal ledges

| Ref. No. | Location | Watercourse | Ch. | Catchment Area, $km^2$ | Length (m) | Min. Hydraulic Size | | Adjusted Size W x H (m) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | W (m) | H (m) | |
| FR-C13 / RVB01 | Milltown / Boolaglass | River Deel | 24+000 | 486.0 | 87 | Bridge Structure | | Bridge Structure |
| FR-C14 | Boolaglass | Stream | 24+350 | 0.2 | 48 | 1.35 Ø | | 1.8 x 3.2 |
| FR-C15 | Bullaun | Doohyle Stream | 24+500 | 16.1 | 32 | 4.0 | 3.3 | 15.6m span combined with underpass |
| FR-C16 | Bullaun | Stream | 24+935 | 0.4 | 42 | 1.8 | 1.6 | 6.0 x 5.5 |
| FR-C23 | Feeagh | Stream | 25+680 | 0.3 | 46 | 3.2 | 1.4 | 1.80 Ø |
| FR-C24 | Graigeen | Stream | 26+325 | 0.6 | 47 | 1.6 | 1.8 | 1.6 x 3.0 |
| FR-C25 / UB04 | Graigeen | Doohyle Stream | 26+950 | 9.6 | 43 | 4.5 | 2.9 | Incorporated in UB04 |
| FR-C26 / UP08 | Kyletaun | Doohyle Stream | 28+220 | 7.7 | 44 | 3.1 | 2.8 | Incorporated in UP08 |
| FR-C27 | Kyletaun | Stream | 28+670 | 0.6 | 43 | 1.6 | 1.7 | 7.0 x 7.0 |
| FR-C28 | Kyletaun | Stream | 29+000 | 0.4 | 50 | 1.5 | 1.5 | 6.0 x 7.5 |
| FR-C28A | Kyletaun | Stream | 29+000 | 0.3 | 10 | 1.5 | 1.5 | 2.0 x 3.0 |

**Table 10.16 Proposed Watercourse Bridge and Culvert Crossings – Section D**[2]

| Ref. No. | Location | Watercourse | Ch. | Catchment Area, $km^2$ | Length (m) | Min. Hydraulic Size | | Adjusted Size, W x H (m) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | W (m) | H (m) | |
| M21-C1 | Wolfesburgess East | Stream to Doohyle Lough | 50+750 | 0.5 | 56 | 1.2 | 1.5 | Incorporated in underpass |
| M21-C1A | Blossomhill | Stream to Doohyle Lough | 50+780 | 1.0 | 14 | 2.0 | 2.0 | 2.0 x 2.8 |
| M21-C2 | Rathkeale Commons / Blossomhill | Stream to Doohyle Lough | 51+075 | 1.0 | 18 | 2.0 | 2.0 | 2 x 2.9 |
| M21-C3 | Clonshire More | Clonshire River | 56+575 | 50.7 | 75 | 3.7 | 3.1 | Bridge Structure |
| RVB02 | Clonshire Beg /Rower More | Greanagh River | 58+175 | 73.5 | 36 | Bridge Structure | | Bridge Structure |
| RVB03 | Kilknockan | Greanagh River | 59+250 | 84.2 | 81 | Bridge Structure | | Bridge Structure |
| M21-C6 | Kilknockan | Stream | 59+635 | 0.2 | 50 | 1.35 Ø | | 2.0 x 3.6 |
| M21-C6A, 6B and 6C | Kilknockan | Stream | 59+635 | 0.2 | 12 / 10 | 1.35 Ø | | 1.80 Ø |
| M21-C7 | Islandea | Stream | 60+695 | 0.1 | 50 | 1.2 | 1.2 | 6.0 x 6.9 |
| M21-C7A | Islandea | Stream | 60+695 | 0.1 | 8 | 1.35 Ø | | 1.35 Ø |
| M21-C8 | Islandea | Stream | 60+835 | 0.2 | 12 | 1.50 Ø | | 1.50 Ø |
| M21-C9 | Islandea | Stream | 60+835 | 0.1 | 8 | 1.20 Ø | | 1.20 Ø |
| RVB04 | Islandea / Adare | River Maigue | 60+925 | 840.1 | 210 | Bridge Structure | | Bridge Structure |
| M21-C11 | Mondellihy | Stream | 62+310 | 1.4 | 90 | 1.8 | 1.6 | 1.8 x 2.8 |
| M21-C12 | Kilgobbin | Stream | 63+550 | 0.2 | 45 | 1.35 Ø | | 6.0 x 4.0 |
| M21-C13 | Kilgobbin | Stream | 63+750 | 0.5 | 45 | 1.2 | 1.5 | 1.2 x 1,.5 |

The proposed culvert sizes allow for pipe culverts and box section inverts to be buried beneath the existing bed level by depths of 300mm in respect to pipes and 500mm in respect to the box sections.

All other watercourses traversed by the proposed mainline are minor in flow requirements and, therefore, will be culverted using a standard nominal 1,200mm diameter concrete pipe or equivalent.

Under the Arterial Drainage Act 1945, culverting of streams by either new, upgraded or extended culverts/bridges require Section 50 approval from the OPW. This enables the OPW, who are responsible for Flood Risk Management and Arterial Drainage, to assess the implications of the proposed works. Section 50 applications for all culvert and diversion arrangements have been submitted to the OPW as part of the design process. The minimum culvert size to be used in relation to the natural drainage is a 1200mm diameter pipe culvert which facilitates burying of the pipe by 300mm. From a hydraulic capacity, blockage potential and maintenance point of view, this minimum culvert size is acceptable and meets the OPW requirement.

The proposed culverting of watercourses will have a slight to imperceptible local impact on flooding and flood risk.

### 10.4.6 Stream Diversions Associated with Road Alignment and Proposed Culverts

It is often beneficial in terms of minimising the lengths of culverts and to enable ease of construction to divert a minor stream or drainage ditch to suit a right-angled crossing rather than a longer skew crossing. Thus a culvert may be constructed in dry conditions on a good foundation rather than in wet conditions on a soft foundation at the existing location.

The construction of watercourse crossings through the proposed road embankment will necessitate in some cases the localised diversion/realignment of the existing non-fishery sensitive watercourse in order to:

a) Allow construction of culverts to be undertaken outside of the watercourses;
b) Facilitate the construction of culverts at different orientations in order to minimise culvert lengths and to tie-in with the road alignment and drainage network;
c) Relocate the watercourses away from the embankment construction footprint.

Where feasible these minor watercourse diversions/realignments will be carried out in the dry and when the channel has established the watercourse will be diverted. The principal impact on a watercourse by a diversion is the change in the watercourse morphology. The general potential impacts are summarised as follows:

- Slacker gradients: Slower flow velocities with resulting increased flow area and deposition, siltation promoting vegetation and weeds to grow in channels during periods of low flow;
- Steeper gradients: Faster flow velocities, increased local bed erosion, shallower low flow depth;
- Sharp bends and change in direction: Erosion and deposition with subsequent changes to the river channel morphology;
- Lack of natural flood plains: Increase in upstream flood levels.

Other potential impacts of watercourse diversions include:

- Change to natural low flow channels: Impact on fisheries and other animals;
- Change to existing foliage and vegetation: Impact on fisheries and other species (otters, badgers etc.).

Where possible, stream diversions/realignments are not proposed on watercourses with biodiversity value. Refer to Chapter 7 for assessment of biodiversity impacts. Watercourse diversions have been identified along the proposed road development involving either diversion in parallel with or at right angles to the existing channels. Table 10.17 summarises the proposed watercourse diversion locations and mitigation measures are discussed in more detail in Section 10.5.

**Table 10.17 Proposed Diversions of Watercourses**

| Chainage From | Chainage To | Ref. | Length (m) |
|---|---|---|---|
| 1+100 | 1+200 | FR-WD01 | 112 |
| 2+130 | 2+150 | FR-WD02 | 31 |
| 2+400 | 2+575 | FR-WD03 | 252 |
| 10+025 | 10+150 | FR-WD05A<br>FR-WD05B<br>FR-WD05C | 47<br>65<br>82 |
| 10+275 | 10+410 | FR-WD06 | 130 |
| 10+950 | 10+975 | FR-WD07 | 15 |
| 20+225 | 20+300 | FR-WD09A<br>FR-WD09B | 77<br>15 |
| 20+980 | 21+050 | FR-WD10 | 75 |
| 21+825 | 21+970 | FR-WD11 | 145 |
| 22+245 | 22+450 | FR-WD12 | 220 |
| 22+475 | 22+525 | FR-WD13 | 177 |
| 24+500 | 24+700 | FR-WD14A<br>FR-WD14B | 220<br>20 |
| 24+915 | 25+000 | FR-WD15 | 82 |
| 25+475 | 25+550 | FR-WD16 | 86 |
| 25+600 | 25+600 | FR-WD17 | 15 |
| 26+850 | 27+020 | FR-WD18 | 210 |
| 28+550 | 28+750 | FR-WD20A<br>FR-WD20B | 82<br>167 |
| 50+775 | 51+060 | M21-WD01 | 300 |
| 56+550 | 56+715 | M21-WD02 | 170 |
| 59+270 | 59+625 | M21-WD03 | 320 |
| 60+600 | 60+700 | M21-WD04 | 90 |
| 60+690 | 60+810 | M21-WD05 | 127 |
| 62+575 | 62+305 | M21-WD07A<br>M21-WD07B | 150<br>76 |

### 10.4.7 Drainage Outfalls

The proposed road development has 32 separate drainage outfall discharges along its 35 km mainline length, which represents on average of one outfall for every 1.1 km of road length. All of these outfalls discharge to surface watercourses. These outfalls have the potential to adversely impact water quality in the receiving watercourse from routine contaminants that are contained in road drainage waters. The water quality and ecological status of the receiving watercourse is also potentially threatened by contamination arising from large liquid spillages as a result of an accident on the proposed road development. These impacts are assessed by using the guidelines provided in the appropriate TII document DN-DNG-03065 – "*Road Drainage and the Water Environment*".

The storm outfalls also have the potential to impact on the flood and morphological regime of the receiving water by increasing the volume and rate of runoff during storm events. The morphology of the stream is significantly influenced by ambient flow and flooding conditions in the stream. The potential increase in flow arises from increased runoff from the road pavement area, the provision of road and embankment drainage with a direct pathway to the receiving watercourse and potential interception of groundwater and diversion of drainage waters that would not otherwise have reached the outfall point. The hard-paved areas and the road drainage system reduces the time of concentration for rainwater to arrive at the outfall and thus increases the rate of runoff over the natural greenfield condition.

It is anticipated that the proposed road drainage outfalls will give rise to an overall slight improvement in water quality of the receiving watercourses as it will generally improve the existing situation of untreated storm drainage from the existing N21 and N69 roads being discharged. A large portion of the existing traffic on the national roads will divert to the new route which will reduce the pollutant load on the existing roads with lower residual traffic flows. In addition, the risk of serious contamination of water courses will be significantly reduced as all proposed outfalls will be fitted with pollution control facilities.

### 10.4.8 Water Quality Impact - Accidental Spillage Risk Assessment

The risk of pollution to both surface and groundwater resulting from accidental spillage is an issue considered in the development of road infrastructure projects. Trying to predict the occurrence of a spill with any degree of certainty is difficult. One can conclude that the risk is influenced by the type of roadway, length of road, the traffic volume, and proportion and type of heavy goods vehicles (HGVs). A Spillage Risk Assessment for the proposed road development has been carried out in accordance with the TII standard DN-DNG-03065.

The spillage risk assessment shows the proposed road development to have a very low magnitude of risk for individual or grouped catchment outfalls and shows the overall spillage risk for the entire development to be less than 0.4%. This very low spillage risk (1 in 250-year probability) consequently does not require any specific mitigation measures to reduce the risk with the overall impact classified as negligible.

In fact, the improved road alignment and design, when compared with the existing N69 and N21, is anticipated to reduce the number of accidents and will therefore reduce the spillage risk associated with accidents. In addition, all storm outfalls will include pollution control facilities in the attenuation ponds. The outflows will be fitted with a penstock or similar restriction at the outfall to the receiving channel. In the event of a serious spill, these controls can be put in place to block the outflow of contaminants allowing time for clean up to take place.

### 10.4.9 Predicted impact of Storm Discharge on Flooding / Morphology

The outfall discharges and the magnitude of impact to the receiving watercourses have been assessed using flood flow estimation methods, stream channel capacity assessment and evaluation of the importance of the attribute. The potential impact magnitude has been assessed at all outfall locations and all are categorised as 'slight local'. Generally, it is found that the flood impact of the road storm discharge is classified as slight to moderate adverse impact where the receiving watercourse catchment is small i.e. Moderate Impact catchment area <1km$^2$, Slight to Moderate Impact where the catchment area is 1 to 10km$^2$ and Slight to Negligible Impact where the catchment area exceeds 10km$^2$. The reason for this reduced potential storm-water flood impact in larger catchment sizes is due to the smaller storm-water volume relative to the natural stream and river flood volume. The potential increase in the ambient flood levels arising in larger catchment sizes is, therefore, reduced.

### 10.4.10 Impact of Routine Road Runoff on Receiving Waters

Research has found that a broad band of potential pollutants are associated with routine runoff from road schemes arising from road traffic and road maintenance. These contaminants are generally associated with the particulate phase and are principally heavy metals, hydrocarbons and suspended solids and de-icing agents (salt and grit) and to a lesser extent nutrients, organics and faecal coliforms. In terms of potential impact to receiving watercourses research has found the first flush runoff (10 to 15mm) can produce elevated concentrations locally in the receiving water. The impact of contaminants within routine road runoff depends on the loading (associated with traffic numbers) and the available dilution in the receiving watercourse.

The high density of discharge points disperses and reduces the pollutant point load from road drainage waters. The design traffic volume in conjunction with the relatively small contributing road areas will not give rise to significant hydraulic or pollutant loads on the receiving waters. The potential impact of routine runoff represents a slight to moderate local impact on water quality in the receiving environment. The overall loading of heavy metals, sediment and hydrocarbons on the receiving waters will be significantly reduced through the provision of grassed channels, filter drains where permitted and storm attenuation/water quality improvement ponds.

TII DN-DNG-03065 gives guidance and assessment tools for the impact of road projects on the water environment, including the effects of runoff on surface waters. The Highways Agency Water Risk Assessment Tool (HAWRAT) is the tool used to assess the effects of road runoff on surface water quality and uses toxicity thresholds based on UK field research programmes which are consistent with the requirements of the WFD and appropriate for assessment of National Road Schemes in Ireland. The UK research programme has shown that pollution impacts from routine runoff on receiving waters are broadly correlated with Annual Average Daily Traffic (AADT).

A HAWRAT assessment has been carried out for all 32 proposed drainage outfalls along the proposed road development. The HAWRAT assessment has tested for the 10,000 - 50,000 vehicles/day range which is well above the projected traffic figures for the Foynes to Limerick Road and thus actual pollutant concentrations are expected to be considerably lower than the estimates from the HAWRAT assessment.

All of the outfalls passed the HAWRAT assessment. In general, the most likely impact of untreated road runoff from the proposed road development is the increased total suspended solids loading to receiving waters and associated trace amounts of heavy metals (Cu, Zn) and hydrocarbons. Anticipated traffic volumes on each section of the proposed road development are detailed in Chapter 5 Traffic Analysis.

### 10.4.11 Impact on Natural Heritage

#### *10.4.11.1 European Designated Sites*

An assessment of the potential impact for European designated sites was carried out. Only the River Maigue within the Lower River Shannon SAC is directly affected by surface water discharge from the proposed road development and, as the river is tidal at the crossing point, it is not sensitive to hydrological impact in terms of water quality.

The nature of the proposed road development will result in only small localised changes in surface water flow. All hydrologically sensitive designated sites are located outside the zone of influence and the proposed road development will, therefore, have an imperceptible impact. In some cases, they are not hydraulically linked to the road or are located sufficiently downstream so as to achieve sufficiently large dilution as to have an imperceptible impact.

In addition, some of these sites are located downstream of the existing N69 and N21; the proposed road development would therefore result in a net improvement in water quality at these locations due to the provision of treatment prior to outfall. In the event of a worst-case scenario (i.e. in the event of a serious surface water contamination spillage), the proposed road development could still have an impact downstream at one of the above listed sites. The spillage risk assessment has identified this as a very low probability and the inclusion of penstocks in the attenuation pond design will reduce the potential impacts to imperceptible.

### 10.4.12 Impact on Water Supply Sources from Rivers

There are no predicted impacts in relation to water supply sources from rivers.

### 10.4.13 Impacts of Material Deposition Areas

A relatively small volume of unsuitable material will be excavated under the proposed road embankments in a number of locations as described in Chapter 4 Description of the proposed road development. Specific sites for deposition areas have not been identified in this EIAR as the small volume can be easily absorbed within non-structural fill and landscaping areas.

Any material deposition sites for very soft alluvium or peat materials will be bunded sites and will have double erosion control fencing (silt fence) and a sediment settlement pond at the outlet. These facilities will be constructed in advance of their use as deposition areas.

Runoff from the material deposition areas will be contained and treated in temporary settlement ponds upstream of its outfall to the receiving watercourses. These ponds will be maintained until the material deposition areas have stabilised and become adequately vegetated. In addition, the specific construction sequence for these areas (described below) will allow for settlement of sediment prior to discharge to the receiving watercourse.

The construction sequencing and design of the material deposition areas will ensure that there will be negligible impact on adjacent watercourses. An Environmental Operation Plan has been developed which deals specifically with environmental protection/mitigation measures for the material deposition areas and this is attached in Appendix 4.1.

## 10.5 Mitigation Measures for Hydrology

### 10.5.1 Overview of Mitigation Measures

Mitigation measures follow the principles of avoidance, reduction and remedy. The most effective measure of avoidance is dealt with during the Route Selection stage and the Design stage, by moving the proposed road development either laterally or vertically, so as to ensure that it does not traverse or come in close proximity to sensitive hydrological attributes.

Where avoidance of the feature has not been possible, consideration has been given to modifying the proposed road development locally so as to reduce / minimise the extent of the impact and / or the exposure to human contact e.g. via groundwater supply usage. If any modifications are proposed to reduce hydrological impact, it is necessary to also consider any associated impacts to the hydrological and ecological regimes.

### 10.5.2 Construction Stage Mitigation for Hydrology

An Environmental Operating Plan (EOP) has been prepared for the proposed road development and is attached to the EIAR as Appendix 4.1. Reference should be made in the first instance to this Plan for specific construction mitigation proposals – a summary of the key mitigation is also given below. The EOP will include the following:

- An Emergency Response Plan detailing the procedures to be undertaken in the event of spillage of chemical, fuel or other hazardous wastes, any incidence of non-compliance with any permit or license or other such risks that could lead to a pollution incident, including flood risks.
- A Water Quality Management Plan to ensure compliance with environmental quality standards specified in the relevant legislation (i.e. European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations 1989 and European Communities (Quality of Salmonid Waters) Regulations 1988). This plan will include details and method statements for the control, treatment and disposal of potentially contaminated surface water.
- All necessary permits and licenses for in-stream construction works for the provision of culverts and bridges including new and widening of existing structures will be obtained prior to commencement of construction of same. OPW Section 50 approval has been applied for in the case all culverts and bridges proposed for this road development.

Construction operations will be required to take cognisance of the following guidance documents for construction work on, over or near water:

- Shannon Regional Fisheries Board – Protection and Conservation of Fisheries Habitat with Particular Reference to Road Construction.
- Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites (Eastern Regional Fisheries Board)
- Central Fisheries Board Channels and Challenges – The Enhancement of Salmonid Rivers.
- CIRIA C532 Control of Water Pollution from Construction Sites Guidance for Consultants and Contractors.
- CIRIA C648 Control of Water Pollution from Constructional Sites.

- Guidelines for the Crossing of Watercourses during the Construction of National Road schemes (TII, 2006).
- Guidelines on Protection of Fisheries During Construction Works in and adjacent to Waters (IFI, 2016)

Based on the above guidance documents concerning control of constructional impacts on the water environment, the following outlines the principal mitigation measures that will be prescribed for the construction phase in order to protect all catchment, watercourse and ecologically protected areas from direct and indirect impacts:

- All construction compound areas will be required to be set back a minimum of 10m from river and stream channels and out of potential floodplain areas;
- Surface water flowing onto the construction area will be minimised through the provision of berms, diversion channels and cut-off ditches;
- Management of excess material stockpiles to prevent siltation of watercourse systems through runoff during rainstorms will be undertaken. This may involve allowing the establishment of vegetation on the exposed soil and the diversion of runoff water off these stockpiles to the construction settlement ponds;
- Where construction works are carried out adjacent to turloughs, fens, stream and river channels and lakes, protection of such waterbodies from silt load will be carried out through use of grassed buffer areas, timber fencing with silt fences or earthen berms to provide adequate treatments of runoff and construction site runoff waters to the watercourses. Locations for silt fences are outlined in the EOP;
- Use of settlement ponds, silt traps and bunds and minimising construction within watercourses. Where pumping of water is to be carried out, filters will be used at intake points and discharge will be through a sediment trap;
- All watercourses will be fenced off at a minimum distance of 5 m from site compounds/storage facilities. In addition, measures will be implemented to ensure that silt laden or contaminated surface water runoff from the compound does not discharge directly to the watercourse. Compounds will not be constructed on lands designated as Flood Zone A or B in accordance with the OPW Flood Risk Management Guidelines (November 2009);
- The storage of oils, fuel, chemicals and hydraulic fluids will be in secure areas within the site compounds and will not occur within a minimum of 10m from watercourses. Storage tanks will have secondary containment provided by means of an above ground bund to capture any oil leakage. Storage tanks and associated provision, including bunds, will conform to the current best practice for oil storage and will be undertaken in accordance with *Best Practice Guide BPGCS005 – Oil Storage Guidelines* (Enterprise Ireland).
- Foul drainage from all site offices and construction facilities will be taken off-site and disposed of by a licensed contractor in accordance with legislation to prevent pollution of rivers and local water supply.
- The construction discharge will be treated such that it will not reduce the environmental quality standard of the receiving watercourses.
- Riparian vegetation along the identified sensitive watercourse will be fenced off to provide a buffer zone for its protection to a minimum distance of 5m with the exception of proposed crossing points.
- Any surface water abstracted from a river for use during construction will be through a pump fitted with a filter to prevent intake of fish.

- The use and management of concrete in or close to watercourses will be carefully controlled to avoid spillage which as stated earlier has a deleterious effect on water chemistry and aquatic habitats and species. Alternate construction methods are encouraged, for example, where reasonably possible, use of pre-cast or permanent formwork will reduce the amount of in-situ concreting required. Where on-site batching is proposed, this activity will be carried out well away from watercourses. Washout from such mixing plants will be carried out only in designated contained impermeable areas.

### 10.5.3 General Operational Stage Mitigation for Hydrology

#### *10.5.3.1 Water Quality Impact Mitigation*

All road pavement runoff water will be collected in a road drainage system and discharged to receiving surface waters. Spillage containment in excess of $50m^3$ and pre-treatment in terms of silt traps will be provided upstream of all road drainage outfalls. These treatment and spillage containment facilities are proposed to be provided within the storm attenuation ponds.

The proposed drainage system incorporates a range of pollution control features to limit the water quality impact to receiving waters. These include the use of filter drains, closed drainage systems and the use of a vegetated lined wetland system upstream of all road drainage outfalls. Each of the attenuation ponds include a wetland system/treatment forebay which has been sized to cater for the first flush volume from the road runoff (this is 10% of the pond area as per the Sustainable Drainage Systems (SUDs) Manual). Further detention storage (for the 100-year storm event) is available within the overall attenuation storage which includes the pond for settlement of suspended pollutants. The vegetated system will allow for the take up of nutrients in the drainage water.

These facilities will also operate as spill containment facilities and hydrocarbon interceptors will also be incorporated where the drainage from the ponds will discharge directly to a large or sensitive watercourse, including the River Maigue, the River Deel, and both the Ahacronane River and Robertstown Stream which discharge into the Churchfield Estuary within the Lower River Shannon SAC. On the basis of the design and mitigation measures proposed, the operation of the proposed road development will present no significant risk of impacting on water quality within the aquatic environment.

A sealed road drainage system will be used to prevent pollutants infiltrating to groundwater in areas of Regionally Important karst Bedrock Aquifer which have a High or Extreme Vulnerability. Refer to Chapter 9 Hydrogeology for further details.

To facilitate emergency response to serious spillages all pond and storage systems will be fitted with a manual penstock so as to close off the outfall and contain the spillage water within the pond/storage system for pumping out and appropriate treatment and disposal.

#### *10.5.3.2 Storm Runoff Mitigation*

In order to minimise local flooding and associated channel morphological impacts all outfall storm discharges to watercourses will undergo storm attenuation reducing outflow so that there is a negligible increased risk of flooding in the receiving watercourse due to construction of the road up to the 100 year return period and attenuating the 100 year critical storm event within the pond storage area which will then be released at greenfield runoff rates or lower.

The attenuation pond for each of the outfalls will be sited outside of flood plain areas in order to avoid any residual flood storage loss to the receiving river / stream. These attenuation ponds provide a dual function of attenuation and primary water quality treatment through physical settlement of suspended sediments.

##### *10.5.3.3 Culverts and Bridges*

All culverts and bridges are designed to prevent permanent impact to the river morphology. A short-term temporary impact may occur whilst on-line bridges and culverts are being put in place. These impacts will be minimised through the incorporation of strict control procedures – refer to the Environmental Operating Plan in Appendix 4.1. Permanent impacts on river morphology will be prevented by ensuring the river width is not exceeded or contracted by the proposed culvert or bridge and that reasonable transition to and from the bridge or culvert is provided where approach and exit channels are skewed to the culvert alignment. In all watercourses the proposed culvert will be embedded into the channel to a depth of 500mm for box sections and a minimum of 300mm for pipe culverts (depending on hydraulic size requirements).

All crossings identified as potential Salmonid rivers/streams and important for mammalian (otter) migration have been designed to maintain the existing migratory routes as far as possible, in accordance with Guidelines for the Crossing of Watercourses during the Construction of National Road Schemes, TII 2008.

##### *10.5.3.4 Watercourse Diversions*

For the proposed stream and drain diversions, localised mitigation measures have been identified to prevent bank erosion at sites of bends which were found often to coincide with the proposed culvert. This protection may be in the form of large boulders or rip-rap along the outer bank with a suitable filter material or geotextile placed inside the armouring to protect the native soil bank. All diversion channels will include fishery friendly requirements where they are identified as having fishery potential. The flood capacity will be enhanced while importantly preserving the low flow channel characteristics. The inclusion of shoals and pools in the channel will assist the rehabilitation of the low flow channel at crossing and diversion sites.

## 10.6 Residual Impacts

The residual hydrological impacts associated with the proposed road development can be grouped as follows:

- Flood Risk;
- Water Quality;
- Watercourse Morphology; and
- Impacts on Key Ecologically Receptors (KERs).

### 10.6.1 Flood Risk

##### *10.6.1.1 Road Runoff*

There is a potential to increase peak flow rates and runoff volumes due to the increased impermeable area associated with the proposed road development and the collecting drainage system which discharges at outfall points. The implementation of sustainable drainage systems (SUDs) through the incorporation of engineered attenuation ponds and controlled discharges at all outfalls will control storm runoff rates to greenfield flood runoff rates so as not to exacerbate flooding and flood risk in the receiving watercourses.

This will mitigate negative impacts on flood risk in the receiving streams from road runoff. Attenuation storage has been sized to accommodate the 100-year storm event. There will be an imperceptible residual impact from the proposed road development.

#### *10.6.1.2 Diversion of Runoff between catchments and sub-catchments*

At some locations the creation of the proposed road development and its associated road drainage system will lead to the interception of overland flow into the road drainage system and its subsequent discharge to nearby watercourses. Without mitigation, this may lead in some cases to a diversion and concentrating of overland flow that would otherwise have discharged to a different watercourse.

At all other locations along the proposed road development, intercepted runoff water continues to discharge to watercourses and drains within its original catchment and sub-catchment. There will therefore be a slight to imperceptible residual impact from the proposed road development due to the diversion of runoff.

#### *10.6.1.3 Flood Conveyance*

No negative residual impacts on flood risk due to loss of conveyance are anticipated at river and stream crossings. All culvert design flows include large factors for uncertainty associated with flood estimation in small ungauged catchments and thus the proposed culvert sizes are considered to be conservatively large and, in the majority of cases, substantially exceed the existing culvert sizes on such streams and, therefore, avoid any conveyance capacity issues. There will be a slight to imperceptible residual impact from the proposed road development.

#### *10.6.1.4 Floodplain Storage*

The loss of floodplain storage where the proposed road development crosses such areas is minor relative to the catchment flood flows and will result in no perceptible impact on flood levels either locally upstream or downstream and therefore will have negligible impact on flood risk at these locations. There will be a slight to imperceptible residual impact from the proposed road development.

### 10.6.2 Water Quality

The proposed road drainage will be collected and discharged to watercourses resulting in localised water quality impact at the outfall sites. This impact will be minimised through the use of filter drains where permitted, closed drainage systems and the use of a vegetated lined wetland system upstream of all road drainage outfalls with further detention storage provided within the attenuation pond system for settlement of suspended pollutants.

It is anticipated that the proposed road drainage outfalls will give rise to an overall slight positive impact on water quality of the receiving watercourses as it will generally improve the existing situation of untreated storm drainage from the existing N69 and N21 roads. On the catchment scale such mitigation meets the objectives of the River Basin Management Plan of protecting and improving the water quality status.

#### *10.6.2.1 Accidental Spillage*

All pollution control facilities and attenuation areas will be fitted with a penstock or similar restriction at the outfall to the receiving channel. The overall risk assessment to quantify the likelihood of a serious accidental spillage indicates a cumulative risk for the entire road length to be very small at 1 in 250-year risk and with individual outfalls having a considerably lower risk (DMRB Volume II Section 3 Part 10).

The impact from accidental spillages on stream outfalls will be reduced by the use of treatment forebays incorporated within the attenuation pond upstream of the outfall and the provision of a penstock on the pond outflow which can be closed off in the event of a serious pollution incident arising. There will be a positive residual impact from the proposed road development due to these measures.

#### *10.6.2.2 Water Abstraction*

Not applicable.

### 10.6.3 Watercourse Morphology

No negative residual impacts to surface water feature morphology are anticipated, as all practicable mitigation measures for drainage, bridges and culverts and channel realignments as stated in the mitigation section are to be implemented. There will be no residual impact from the proposed road development.

### 10.6.4 Impacts on Key Ecological Receptors

No residual impact from the proposed road development is anticipated at the designated European Sites located at some distance to the north of the route, or at the River Maigue crossing which is designated as part of the Lower River Shannon SAC. No residual impact from the proposed road development is anticipated on the locally sensitive sites identified as Key Ecological Receptors within the proposed road development.